Can people make up their sleep by getting two full nights' sleep later?

21 college-aged people were divided into two groups, which 10 of them could get enough sleep in one group but 11 of them could only get not enough sleep in another group. They were trained and compared on the least time they could correctly describe the objects on a computer before the first day they slept. Then they got two nights of enough sleep and tested on the third day. The results on the third day were compared with the results before they slept, and the negative values means they took a longer time to react to the things on the screen. Scientists wanted to know if people can make up their sleep in two days after they got not enough sleep.

Table 1. Statistics of the group which got enough sleep and the group got not enough sleep.

Group name	Mean	Std deviation	Median	Q1	Q3	IQR	Range	95% Cl mean		95% Cl Std	
Enough sleep group	19.82	14.73	16.55	12.10	30.5	18.4	-7 to 45.6	9.29	30.35	10.13	26.88
Not enough sleep group	3.90	12.17	4.50	-10.7	10.0	20.7	-14.7 to 21.8	-4.28	12.08	8.50	21.36

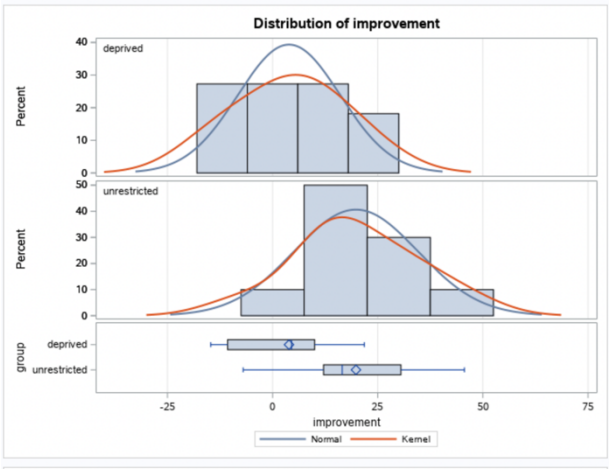

Figure 1. Distribution of improvement score of the group who had enough sleep (unrestricted) and the group who had not enough sleep (deprived).

According to **Figure 1.**, the mean improvement score of the group who got enough sleep is 19.82 with SD of 14.73. We are 95% confident that the interval from 9.29 to 30.35 contains the true mean improvement score of that group. The destitution is not normal (not Bell-shaped) and positively skewed which it has a long tail to the right. The center of the distribution is around the median (16.55) which is smaller than the mean (19.82). The distribution is unsymmetric. The variability is observed from the population of n=10. The mean improvement score of the group who did not get enough sleep is 3.90 with SD of 12.17. We are 95% confident that the interval from -4.28 to 12.08 contains the true mean improvement score of that group. The destitution is not normal (not Bell-shaped) and negatively skewed which it has a long tail to the left. The center of the distribution is around the mean (3.90) which is larger than the median (4.50). The distribution is unsymmetric. The variability is observed from the population of n=11. Comparing the two groups' improvement score, we found that the group that got enough sleep improved in the test while the group that did not get enough sleep might not improve as much as the group before since their overall improvement score is lower.

Table 2. t-test results of two sleep groups.

Difference (without enough sleep group's improvement score-with enough sleep group's improvement score)	95% Cl mean		Std dev	95% Cl std dev		T value	Pr>|t|	DF
-15.92	-28.21	-3.63	13.44	10.22	19.63	-2.71	0.0139	19

According to **Table 2**., we can say that with 95% confidence that the people who slept not enough over the people who slept enough will have a change in the mean improvement score between -28.21 and -3.63. The null value does not fall in the confidence interval that we have not enough evidence to say the true population value is different from the null value. Since the p value (0.0139) is smaller than 0.05, we have evidence against the null hypothesis. Statistically significant difference was found for the improvement scores' comparison. Thus, people cannot make up their sleep time for two nights after they did not get enough sleep. More people who did not sleep enough might not focus well comparing to those who got enough sleep even they slept enough for two days to make up their sleep time.

To summarize, people cannot make up sleep using two nights if they did not get enough sleep at one night. However, the study has limitation since the sample size is too small and it is not convincing to conclude that the result is accurate for everyone. Previous health issues including pressure levels and illnesses should be considered since those influence the results.

[1] Stickgold, R., James, L., & Hobson, J. A. (2000). Visual discrimination learning requires sleep after training. *Nature neuroscience*, *3*(12), 1237.

Appendix/Appendices

```
proc import
  DATAFILE = "/home/u59373588/My SAS/HW 2/SleepDeprivation.csv"
  OUT = SleepDeprivation
  DBMS = csv
  REPLACE;
  GETNAMES = yes;
run;
```

```
PROC CONTENTS DATA=SleepDeprivation; RUN;
%web_open_table(SleepDeprivation);

proc univariate data=SleepDeprivation;
Class Group;
VAR Improvement;
run;
```

Table 3. Statistics of deprived sleep group.

The UNIVARIATE Procedure
Variable: improvement
group = deprived

Moments			
N	11	Sum Weights	11
Mean	3.9	Sum Observations	42.9
Std Deviation	12.1718528	Variance	148.154
Skewness	-0.0823978	Kurtosis	-0.7633612
Uncorrected SS	1648.85	Corrected SS	1481.54
Coeff Variation	312.098789	Std Error Mean	3.6699517

Basic Statistical Measures			
Location		Variability	
Mean	3.9000	Std Deviation	12.17185
Median	4.5000	Variance	148.15400
Mode	-10.7000	Range	36.50000
		Interquartile Range	20.70000

Tests for Location: Mu0=0				
Test	Statistic		p Value	
Student's t	t	1.062684	Pr > |t|	0.3129
Sign	M	2.5	Pr >= |M|	0.2266
Signed Rank	S	9	Pr >= |S|	0.4512

[1] Stickgold, R., James, L., & Hobson, J. A. (2000). Visual discrimination learning requires sleep after training. *Nature neuroscience*, *3*(12), 1237.

Table 4. Statistics of unrestricted sleep group.

The UNIVARIATE Procedure
Variable: improvement
group = unrestricted

Moments			
N	10	Sum Weights	10
Mean	19.82	Sum Observations	198.2
Std Deviation	14.7253221	Variance	216.835111
Skewness	0.03631527	Kurtosis	0.44678707
Uncorrected SS	5879.84	Corrected SS	1951.516
Coeff Variation	74.2952679	Std Error Mean	4.65655571

Basic Statistical Measures			
Location		Variability	
Mean	19.82000	Std Deviation	14.72532
Median	16.55000	Variance	216.83511
Mode	.	Range	52.60000
		Interquartile Range	18.40000

Tests for Location: Mu0=0				
Test	Statistic		p Value	
Student's t	t	4.256365	Pr > |t|	0.0021
Sign	M	4	Pr >= |M|	0.0215
Signed Rank	S	26.5	Pr >= |S|	0.0039

```
proc ttest data=SleepDeprivation alpha=0.05 H0=0 sides=2;
VAR Improvement;
CLASS Group;
TITLE "T-test of H0: Population mean of derprived group = Population mean of unrestricted group";
run;
```

[1] Stickgold, R., James, L., & Hobson, J. A. (2000). Visual discrimination learning requires sleep after training. *Nature neuroscience*, *3*(12), 1237.

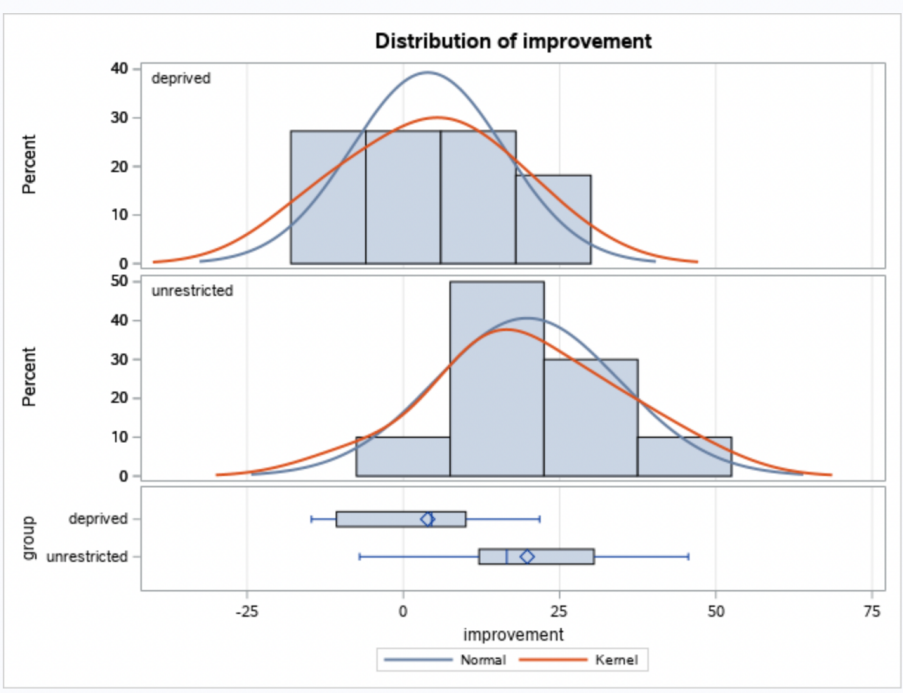

Figure 1. Distribution of Improvement score of deprived and unrestricted groups.

proc ttest data=SleepDeprivation alpha=0.05 H0=0 sides=2;
VAR Improvement;
CLASS Group;
TITLE "T-test of H0: Population mean of derprived group = Population mean of unrestricted group";
run;

Table 5. T-test outcome of deprived and unrestricted groups.

T-test of H0: Population mean of derprived group = Population mean of unrestricted group

The TTEST Procedure

Variable: improvement

group	Method	N	Mean	Std Dev	Std Err	Minimum	Maximum
deprived		11	3.9000	12.1719	3.6700	-14.7000	21.8000
unrestricted		10	19.8200	14.7253	4.6566	-7.0000	45.6000
Diff (1-2)	Pooled		-15.9200	13.4420	5.8732		
Diff (1-2)	Satterthwaite		-15.9200		5.9289		

group	Method	Mean	95% CL Mean		Std Dev	95% CL Std Dev	
deprived		3.9000	-4.2772	12.0772	12.1719	8.5047	21.3608
unrestricted		19.8200	9.2861	30.3539	14.7253	10.1286	26.8827
Diff (1-2)	Pooled	-15.9200	-28.2128	-3.6272	13.4420	10.2225	19.6330
Diff (1-2)	Satterthwaite	-15.9200	-28.3988	-3.4412			

Method	Variances	DF	t Value	Pr > |t|
Pooled	Equal	19	-2.71	0.0139
Satterthwaite	Unequal	17.557	-2.69	0.0153

Equality of Variances				
Method	Num DF	Den DF	F Value	Pr > F
Folded F	9	10	1.46	0.5601

quires sleep after

training. *Nature neuroscience*, 5(12), 1237.