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# The interrelationship between exercise, sleep and social networks

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## Abstract

The aim of this paper is to explore whether there is a positive interrelationship between exercise, sleep and social networks. The goal of establishing this positive relationship is to find whether these three factors, which are all beneficial to health, can stimulate each other in order to find new ways of efficiently reducing overall health care costs. Previous research was mostly focused on the relationship between two of these three factors, rather than combining all three together. The analysis was performed using the Add Health survey database. A logistic regression was performed to establish whether there was a positive relationship between the three aforementioned factors. The results were mixed. When combined, the analysis on exercise, sleep and social networks indeed gathered a significant positive interrelationship. However, the analysis on only sleep and social networks did not conclude a significant positive relationship. Furthermore, the robustness check of using a different definition of sleep gathered mixed results, which on one occasion contradicted with the main research results. A recommendation for combining the use of the three variables in the battle against rising health care costs can be made, although future research on how these three factors cooperate in the health care field for specific health problems still has to be performed.

## Introduction

The relationship between sleep and exercise has been broadly studied in the literature. These two factors seem to be intertwined and affect each other (Chennaoui et al., 2015). Sleep and exercise are of importance in everyone’s daily lives and are vital factors in living a healthy lifestyle, especially in young adults (Wickham et al., 2020). Whether it is professional athletes who wish to maximize physical performance by following a strict sleeping schedule or ‘normal’ people who exercise in order to better overcome sleeping problems, both factors are often considered together.

Another key factor in health is the strength of one’s social network. Gottlieb and Green (1984) have found that negative life events are directly associated with picking up negative health behaviours such as smoking. Furthermore, they found that life events in the social network directly affected health, most likely due to picking up these behaviours. If this is true for health, to what extent does one’s social network affect sleep and exercise? This research will therefore try to answer the following research question: What is the interrelationship between exercise, sleep and social networks?

## Literature review

A large part of current research focuses extensively on how proper sleep affects exercise performance. A paper by Martin (1981) shows how insufficient sleep significantly reduces endurance during prolonged exercise. In his study, several participants had been awake for thirty-six hours before undergoing prolonged heavy exercise on a treadmill. This group was compared to another group that underwent a normal amount of sleeping hours, after which the same exercise task was performed. Martin (1981) found that the group with insufficient sleep reduced time until the point of exhaustion by 11% on average. This can most likely be contributed to the fact that sleep loss affects cardiorespiratory function, which is a key factor during exercise (Plyley et al., 1987). Another paper by Martin and Gaddis (1981) has found comparable results. In this paper the group with acute sleep deprivation performed significantly worse than a group with normal sleep hours during moderate and heavy exercise, due to the change in psychological response caused by insufficient sleep. This goes to show that sleep has a considerable influence on exercise through both physical and psychological changes caused by lack of sleep.

However, there seems to be a reversed relationship between sleep and exercise as well. Singh, Clements and Fiatarone (1997) found that exercise improved subjective sleep quality in elders. Furthermore, depression and quality of life measures also greatly increased, though it is not clear whether this can be attributed to exercise, the higher quality of sleep or a combination of both. In a study by Vuori et al. (1988), it was reported by participants that exercise improved their subjective quality of sleep as well. These improvements included ease of falling asleep, deepness of sleep and the sense of wellbeing. The positive effects were mostly found under participants who performed light to moderate levels of exercise, especially at morning time. Only participants who performed heavy exercise during the late time of day reported some discomfort in terms of sleep quality, though a large subgroup still reported positive effects as well. Therefore, sleep does not only seem to improve exercise performance, but exercise performance seems to improve perceived quality of sleep as well.

How does one's social network tie into all of this? According to Lei & Zeng (2020), increased perceived social support can increase exercise performance. In their study, people who perceived greater social support were prepared to take a larger quantity of steps per day as a form of exercise. Furthermore, Resnick et al. (2002) have found that friend support indirectly affects exercise quantity. This effect stems from the increase in self-efficacy and outcome expectations due to increased social support. The elderly in their study who perceived a high quantity of social support had more belief in their ability to complete exercises, thus increasing the amount of exercise performed. This effect can not only be found in elderly, but under adolescents as well. Hsu et al. (2011) found that family and friend support can take away internal barriers and decrease the perceived negative meanings of physical activity. Therefore, social support seems vital to one’s perception of exercise, thus possibly increasing the amount of exercise performed.

Social networks seem to have a mixed relationship with sleep behaviour. In terms of sleep quantity, one might expect that adolescents with a substantial social network might sleep less, due to going out or as a result of other social events Furthermore, Vernon, Barber and Modecki (2015) have found that social media usage, which is a common contemporary way of maintaining close social networks, is directly related to sleep disturbances. During adolescence, maintaining large social networks can thus lead to sleeping problems. However, other studies argue that social networks have a positive effect on sleep. Child et al. (2020) argue in favour of this positive relationship. They found that support from social networks both directly and indirectly improves sleep quality. The indirect role stems from the fact that social networks can play a buffering role during stressful life events; discussing these stressful life events prevents trouble falling asleep due to less worrisome pondering on these events. Multiple studies find that the positive relationship between social support and sleep originates from the mediating role that social support plays between symptoms of depression and sleep quality (Cui et al., 2020). However, Mesas et al. (2020) have found that this positive relationship exists independently of mental state as well.

The economic impact of both sleep- and exercise related issues is immense. On the topic of sleep, Hillman et al. (2018) state the following: “The financial and nonfinancial costs associated with inadequate sleep are substantial. The estimated total financial cost of $17.88 billion represents 1.55 per cent of Australian gross domestic product. The estimated nonfinancial cost of $27.33 billion represents 4.6 per cent of the total Australian burden of disease for the year." Whilst this study was performed in Australia, the findings can be projected externally to other countries as well. The largest expenses caused by inadequate sleep are health care costs and productivity costs (Hillman et al., 2018). The remark must be made that part of the costs are caused by non-behavioural related sleeping disorders, which are also responsible for a large quantity of the economic costs of inadequate sleep (Hillman et al., 2006). However, the behavioural related component of economic costs due to inadequate sleep is still substantial enough to be of interest, as these could be treated with interventions.

The economic impact of exercise related issues is quite substantial as well. The economic costs caused by lack of exercise and obesity make up around 9,4% of the United States' national health care costs. Whilst this is partly due to non-behavioural related illnesses, around 2,4% of the United States' national health care expenditures were due to lack of leisure-time physical activity (Colditz, 1999). Another part of decreased physical activity has occurred in the everyday workplace. This is actually due to technological advancements in contemporary society. Work has shifted from focusing more on physically demanding work outdoors to stationary desk work indoors. The current less physically strenuous work standard has been a major factor in increased obesity rates (Lakdawalla, Philipson & Bhattacharya, 2005). The economic effects of increasing obesity will be even greater in the future. According to Zhang et al. (2010), the global health care expenditure on diabetes in 2030 is expected to be around 490 billion USD. Whilst this full amount cannot be attributed to type 2 diabetes, a substantial figure can still be attributed to this illness associated with obesity and lack of exercise.

## Data & Methodology

In order to answer the research question, two datasets from Add Health will be used. The Add Health study, or The National Longitudinal Study of Adolescent to Adult Health in full, is a study conducted in the United States under adolescents in the years 1994-1995. The datasets from this country were chosen because the United States' national health care expenditures are extremely high. Papanicolas, Woskie, and Jha (2018) have concluded the following about this: "In 2016, the United States spent nearly twice as much as 10 high-income countries on medical care and performed less well on many population health outcomes." Therefore, finding more efficient measures to decrease national health care costs and increase effectiveness would be a very welcome solution for the United States. Using this dataset will hopefully provide some first steps in the right direction to find that solution.

The first dataset used in this paper consists of an in-school questionnaire on social networks under adolescents. There was a total of 90,118 participants spread out over 145 schools. The second dataset consists of an in-home interview where a variety of questions on health were asked. For this dataset, there were a total of 6,504 participants that fully completed the interview. All participants attended the University of North Carolina at Chapel Hill at the time. The participants from the second dataset also completed the in-school questionnaire from the first dataset. In this paper, only the data on the participants that were also involved in the second dataset will be used. The dataset used in this paper's analysis consists of 4,388 participants. The 2,116 omitted participants who completed both Add Health surveys had one or more variables of interest missing. Therefore, these participants were omitted from the analysis. The 4,388 participants in the analysis had no missing values.

There are multiple variables of interest in the datasets. Each variable from the dataset which was used in the analysis can be found in the variable index under Appendix B. For the dataset on the in-school questionnaire, a variable which indicates how many people a participant's social network consists of is of interest. This is a numeric variable. However, for the analysis this variable will be transformed into a binary variable. The mean for this variable in the analysed sample is 8.2. In order to use this variable in the analysis, a new binary variable was created for network size. Any participant whose network size was bigger than 8.2 was considered to have an 'above average network size', these participants were assigned the value '1'. Similarly, any participant whose network size was smaller than 8.2 was considered to have a 'below average network size', these participants were assigned the value '0'. Because people's social network nodes could not directly be linked using this dataset, the participants' social network size is used as an estimate for the social network in the analysis.

For the dataset on the in-home interviews, five variables will be of interest. Firstly, there is a variable which shows the mean hours of sleep a participant undergoes during a day. This variable is numeric. However, for this research it is of interest whether someone achieves enough sleep, generally speaking. Therefore, this variable will be transformed into a binary variable. The average recommended sleeping time for adolescents is seven to nine hours of sleep (CDC, 2020). Therefore, every participant who has more than or equal to seven hours of sleep will receive a value of '1'. Every participant who sleeps less than seven hours of sleep will receive a value of '0'. However, the analysis will be performed using another variable of sleep as well. This second variable shows whether the participants usually get enough sleep. This variable is a 'yes' or 'no' question and it is self-reported, meaning there is a component of subjectivity to it. Every participant who answers 'Yes' to this will receive a value of '1'; all responses with 'No' will receive the value '0'. The analysis using this variable will act as a robustness check, as the average recommended minimum of seven hours of sleep may differ in effectiveness for each person.

The other variables of interest in the second dataset are three variables which indicate whether someone has performed any form of exercise in the past week. Each of these variables indicates a separate set of sports. Therefore, another variable will be added to perform the analysis in order to assess whether someone has exercised during the past week. This variable will have the value '1' if one of the three variables from the original dataset has the value of 1-3. A value of 1-3 within these variables means that the participant has exercised during the past week. Therefore, the extra variable of whether someone has exercised will be '1' if one of the three aforementioned variables has a value of 1-3. If a participant did not perform any form of exercise during the week, they will receive a value of '0'.

With this dataset, logistic regression analysis will be performed to find the association between the three variables of interest. The aim of this analysis is not focused on finding a causal relationship; the aim is to find whether there is a positive association between the three factors of interest. The logistic regression analysis will show if there is an association between the variables and whether this association is positive. Therefore, this is the most well-suited analysis method to answer the research question. In total, seven different regression analyses will be run.

Firstly, an analysis will be run where the ‘sleep’ variable will be regressed on the ‘social network’ variable. In the second regression, the ‘exercise’ variable will be regressed on the ‘social network’ variable. The third regression will consist of regressing the ‘exercise’ variable on the ‘sleep’ variable. After this, all three variables will be combined. The ‘exercise’ variable will be run on both the ‘sleep’ variable and the ‘social network’ variable. For all analyses involving the ‘sleep’ variable, there will be a robustness check involving the second approximation method of getting enough sleep. All regressions will also include the demographic variables age and gender as control variables. Furthermore, there is a variable in the dataset which shows whether a participant suffers from a permanent physical impairment when it comes to using their hands, arms, legs, or feet. Because physical impairment impacts one's sleep, exercise capabilities and arguably one’s social network size, this variable will also be used as a control variable in the regressions. All of this leads to the following four hypotheses in this order:

H1: The regression of sleep on social network will show a positive association, controlling for age, gender and physical impairment.

H2: The regression of exercise on social network will show a positive association, controlling for age, gender and physical impairment.

H3: The regression of exercise on sleep will show a positive association, controlling for age, gender and physical impairment.

H4: The regression of exercise on sleep and social network will show a positive association, controlling for age, gender and physical impairment.

The descriptive statistics of the 4,388 participants who were part of the analysis, can be found in Table 1.

**Table 1**

*Descriptive statistics*

| Variable Name | Number of Observations | Mean | Standard Deviation | Minimum | Maximum |
|---|---|---|---|---|---|
| Exercise | 4,388 | 0.952 | 0.214 | 0 | 1 |
| Sleep – Average Recommended | 4,388 | 0.739 | 0.439 | 0 | 1 |
| Sleep – Self-Reported | 4,388 | 0.850 | 0.358 | 0 | 1 |
| Network Size | 4,388 | 0.445 | 0.497 | 0 | 1 |
| Physical Impairment | 4,388 | 0.020 | 0.139 | 0 | 1 |
| Age | 4,388 | 18.943 | 1.724 | 15 | 24 |
| Gender | 4,388 | 0.525 | 0.499 | 0 | 1 |

*Note.* Table 1 shows the descriptive statistics of the dataset used in this paper's analysis. The age variable is a continuous variable, all other variables are binary variables.

Table 1 shows that on average, around 52.5% of the dataset was female. Furthermore, the mean age in the dataset is around 18 years and 11 months old. The youngest participant was 15 years old, whilst the oldest participant was 24 years old at the time of the survey. Only around 2% of the participants had a physical impairment. On average, 44.5% of the participants had a 'large' network size. Around 85% of the participants got enough sleep when using the estimation method of the self-reported 'Yes' or 'No' answer; this number drops to around 73.9% when considering the estimation method of average recommended hours of sleep. Lastly, around 95.2% of the participants in the dataset exercise at least once a week.

## Results

As mentioned, all logistic regressions where the 'sleep' variable was included were ran twice; once using the variable derived from the self-reported 'Yes' or 'No' estimation method and once using the variable derived from the average recommended hours of sleep estimation method. For all tables labelled 'A', whether a participant got enough sleep depends on the self-reported hours of sleep. Participants who slept 7 hours or more were designated the value ‘1’, participants with less than 7 hours of sleep were designated the value ‘0’. For all tables labelled ‘B’, whether a participant got enough sleep depends on the self-reported answer ‘Yes’ or ‘No’. Participants who answered ‘Yes’ got designated the value 1, participants who answered ‘No’ got designated the value 0. All tables labelled ‘B’ where the robustness check did not provide different results from the original analysis can be found under Appendix A. The odds ratio for the coefficients is calculated by taking $e^{\beta coefficient}$.

**Table 2A**

*Logistic regression of sleep on network size*

| Variable Name | Odds Ratio | Standard Error | 95% Confidence Interval | |
|---|---|---|---|---|
| | | | Lower Bound | Upper Bound |
| Network Size | 1.115 | 0.088 | -0.057 | 0.286 |
| Physical Impairment | -0.315 | 0.274 | -0.851 | 0.222 |
| Age | -0.309*** | 0.026 | -0.361 | -0.258 |
| Gender | -0.185** | 0.087 | -0.355 | -0.016 |
| Constant | 7.743*** | 0.525 | 6.713 | 8.772 |

*Note*. Table 2A shows the logistic regression where sleep is the dependent variable and network size, physical impairment, age and gender are the independent variables. Network size, physical impairment and gender are binary variables. Age is a continuous variable. For the p-value, * denotes p<0.10, **denotes p<0.05 and *** denotes p<0.01.

Table 2A shows the logistic regression where sleep is the dependent variable and network size, physical impairment, age and gender are the independent variables. The coefficient of network size is 1.115. The P-value of 0.189 is greater than 0.050, meaning that this coefficient is not significant at the 95% confidence level. Therefore, it cannot be concluded from these results that there is a significant positive association between getting enough sleep and social network size.

**Table 3**

*Logistic regression of exercise on network size*

| Variable Name | Odds Ratio | Standard Error | 95% Confidence Interval | |
|---|---|---|---|---|
| | | | Lower Bound | Upper Bound |
| Network Size | 0.502*** | 0.153 | 0.203 | 0.800 |
| Physical Impairment | -0.475 | 0.406 | -1.271 | 0.320 |
| Age | -0.332*** | 0.044 | -0.419 | -0.245 |
| Gender | -0.263* | 0.144 | -0.546 | 0.019 |
| Constant | 9.390*** | 0.895 | 7.637 | 11.144 |

*Note*. Table 3 shows the logistic regression where exercise is the dependent variable and network size, physical impairment, age and gender are the independent variables. Network size, physical impairment and gender are binary variables. Age is a continuous variable. For the p-value, * denotes p<0.10, **denotes p<0.05 and *** denotes p<0.01.

Table 3 shows the logistic regression where exercise is the dependent variable and network size, physical impairment, age and gender are the independent variables. The coefficient of network size is 0.502. The P-value of 0.001 is smaller than 0.050, meaning that this coefficient is significant at the 95% confidence level. The odds ratio of network size is 1.651, meaning that on average the odds of exercising are 1.651 times higher when having a big network size, adjusting for physical impairment, age and gender. Therefore, it seems that there is indeed a significant positive relationship between exercising and social network size.

**Table 4A**

*Logistic regression of exercise on sleep*

| Variable Name | Odds Ratio | Standard Error | 95% Confidence Interval | |
|---|---|---|---|---|
| | | | Lower Bound | Upper Bound |
| Sleep – Average Recommended | 0.472*** | 0.127 | 0.222 | 0.721 |
| Physical Impairment | -0.472 | 0.301 | -1.062 | 0.119 |
| Age | -0.307*** | 0.034 | -0.374 | -0.241 |
| Gender | -0.413*** | 0.112 | -0.633 | -0.192 |
| Constant | 8.680*** | 0.704 | 7.301 | 10.060 |

*Note*. Table 4A shows the logistic regression where exercise is the dependent variable and sleep, physical impairment, age and gender are the independent variables. Sleep, physical impairment and gender are binary variables. Age is a continuous variable. For the p-value, * denotes $p<0.10$, **denotes $p<0.05$ and *** denotes $p<0.01$.

Table 4A shows the logistic regression where exercise is the dependent variable and sleep, physical impairment, age and gender are the independent variables. The coefficient of sleep is 0.472. The P-value of 0.000 is smaller than 0.050, meaning that this coefficient is significant at the 95% confidence level. The odds ratio of sleep is 1.602, meaning that on average the odds of exercising are 1.602 times higher when getting enough sleep, adjusting for physical impairment, age and gender. Therefore, it seems that there is indeed a significant positive relationship between exercising and getting enough sleep.

**Table 5A**

*Logistic regression of exercise on sleep and network size*

| Variable Name | Odds Ratio | Standard Error | 95% Confidence Interval | |
|---|---|---|---|---|
| | | | Lower Bound | Upper Bound |
| Sleep – Average Recommended | 0.600*** | 0.163 | 0.281 | 0.920 |
| Network Size | 0.486*** | 0.153 | 0.187 | 0.786 |
| Physical Impairment | -0.448 | 0.408 | -1.247 | 0.351 |
| Age | -0.307*** | 0.045 | -0.396 | -0.218 |
| Gender | -0.244* | 0.145 | -0.528 | 0.039 |
| Constant | 8.420*** | 0.940 | 6.578 | 10.261 |

*Note*. Table 5A shows the logistic regression where exercise is the dependent variable and sleep, network size, physical impairment, age and gender are the independent variables. Sleep, network size, physical impairment and gender are binary variables. Age is a continuous variable. For the p-value, * denotes p<0.10, **denotes p<0.05 and *** denotes p<0.01.

Table 5A shows the logistic regression where exercise is the dependent variable and sleep, network size, physical impairment, age and gender are the independent variables. The coefficient of sleep is 0.600. The P-value of 0.000 is smaller than 0.050, meaning that this coefficient is significant at the 95% confidence level. The odds ratio of sleep is 1.823, meaning that on average the odds of exercising are 1.823 times higher when getting enough sleep, adjusting for network size, physical impairment, age and gender. The coefficient of network size is 0.486. The P-value of 0.001 is smaller than 0.050, meaning that this coefficient is significant at the 95% confidence level. The odds ratio of network size is 1.627, meaning that on average the odds of exercising are 1.627 times higher when having a big network size, adjusting for sleep, physical impairment, age and gender. Therefore, it seems that there is indeed a significant positive relationship between exercising, getting enough sleep and social network size.

**Table 5B**

*Logistic regression of exercise on sleep and network size*

| Variable Name | Odds Ratio | Standard Error | 95% Confidence Interval | |
|---|---|---|---|---|
| | | | Lower Bound | Upper Bound |
| Sleep – Self-Reported | 0.243 | 0.152 | -0.055 | 0.540 |
| Network Size | 0.499*** | 0.153 | 0.199 | 0.798 |
| Physical Impairment | -0.469 | 0.406 | -1.266 | 0.328 |
| Age | -0.324*** | 0.045 | -0.412 | -0.236 |
| Gender | -0.250* | 0.145 | 0.533 | 0.034 |
| Constant | 9.053*** | 0.920 | 7.249 | 10.857 |

*Note*. Table 5B shows the logistic regression where exercise is the dependent variable and sleep, network size, physical impairment, age and gender are the independent variables. Sleep, network size, physical impairment and gender are binary variables. Age is a continuous variable. For the p-value, * denotes p<0.10, **denotes p<0.05 and *** denotes p<0.01.

Table 5B shows the logistic regression where exercise is the dependent variable and sleep, network size, physical impairment, age and gender are the independent variables. The coefficient of sleep is 0.243. The P-value of 0.110 is greater than 0.050, meaning that this coefficient is not significant at the 95% confidence level. The coefficient of network size is 0.499. The odds ratio of network size is 1.646, meaning that on average the odds of exercising are 1.646 times higher when having a big network size, adjusting for sleep, physical impairment, age and gender. The P-value of 0.001 is smaller than 0.050, meaning that this coefficient is significant at the 95% confidence level.

Tables 5A and 5B differ from each other in terms of significance for the sleep variable. In table 5B the sleep variable is insignificant at the 95% confidence level, whereas table 5A indicated that the sleep variable was significant at the 95% confidence level when using the approximation of the sleep variable based on the average recommended hours of sleep. Therefore, the two methods of approximation seem to give contradicting evidence when it comes to the positive relationship between exercise and sleep, controlling for network size, physical impairment, age and gender. When it comes to the network size variable, it seems that there is indeed a significant positive relationship between exercising and social network size. This is in line with the results of table 5A.

## Conclusions

The interrelationship between sleep, exercise and social networks found in this paper seem to be mostly in line with current research. Sleep and exercise appear to have a positive association between each other, reporting a positive and significant result in each logistic regression. When adding in the network variable, this positive association remains. In fact, there even is a slight increase in the odds ratio for both sleep and exercise when the social network variable is taken into account. Furthermore, social networks do seem to be positively associated with exercise as well. Both with and without the sleep variable, the social network has a positive and significant coefficient in the analysis. The odds ratio remains relatively similar under the presence of the sleep variable. In addition to this, the positive association between exercise and social network does not change depending on which definition of enough sleep is used. Whether using the self-reported ‘yes or no’ answer or the average recommended hours approach, the positive association between exercise and social network remains positive, significant and relatively unchanged in magnitude. All of these results are in line with what would be expected from the findings, based on the existing literature.

However, there are some anomalies in the analysis. Firstly, sleep and social network do not seem to be positively associated with each other. The analysis showed that there was no significant positive association between these two factors. This goes against the findings of Child et al. (2020) that social networks improve sleep both directly and indirectly. A possible explanation for this is the fact that the approximations within the analysis are more based on quantity rather than quality. Having variables that would approximate the latter better might gather results that would be more in line with current research.

Besides the absence of a positive association between sleep and social network, the relationship between exercise and sleep when controlling for social network differs depending on the definition used for 'having enough sleep'. When taking into account social network, using the average recommended sleep approximation yields a significant positive association between exercise and sleep. However, using the self-reported 'yes or no' answer approximation does not present a significant positive association between exercise and sleep. This difference might arise due to the fact that these two approximations differ slightly in terms of their definition of enough sleep. It may be that the self-reported 'yes or no' answer does not reflect whether a participant has gotten enough sleep correctly. A participant answering 'yes' might actually feel like they have had enough sleep, whereas this is in fact not true and their body is actually physically suffering from the lack of sleep more so than they are mentally aware of (and vice versa). However, it could also be that the average recommended hours of sleep do not reflect whether or not someone has received enough sleep correctly. As mentioned before, the physical need for sleep might differ for each participant. Therefore, someone with six hours of sleep might physically receive enough sleep, whereas another participant might actually physically need more than the eight hours of sleep he or she has already gotten.

## Discussion

There are some limitations to this research. As mentioned before, most of the existing literature covering the relationship between exercise, sleep and social network focuses on the quality of these factors. On the contrary, this paper uses mostly quantitative measures to analyze these factors. Another limitation to do with the dataset is the fact that the Add Health dataset consists of a wave of adolescents from the years 1994-1995. Whilst most factors in this paper's analysis are relatively independent of the time frame, factors such as uprising online social media usage might cause the results from this research to be less applicable to contemporary society. Lastly, the analysis techniques used in this paper merely show the sign and magnitude of the association between the three factors of interest. Whilst this information is most certainly valuable, no certain causal relationships can be concluded from these results.

Nevertheless, this research provides some useful insights regarding policy implications. The apparent positive association between social network and exercise might be of interest in policies trying to use increased exercise as a measure of fighting obesity. The positive impulse from social networks gives rise to possible new ways of stimulating exercise. These new exercise policies could shift the focus to more group-based activities, as the level of social support received from the group might increase exercise performance, thus creating a more effective measure in the battle against obesity. Furthermore, the positive association between sleep and exercise might be of interest in health policies against chronic sleeping problems. Whilst sleeping pills might be effect, using exercise as a measure to battle sleep deprivation could be an interesting avenue to explore as a less costly solution with lower addiction risks.

In order for these policy implications to be introduced, further research on the interrelationship between exercise, sleep and social networks is required. This future research could focus on analyzing the relationship between these factors using more qualitative rather than quantitative measures. Furthermore, future research could focus on combining the use of these three factors for specific health problems. If research can prove that these factors can be used in battling health problems at a lower cost than certain types of medication, this could be a helpful solution in the battle against rising national health care costs.

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## Appendix A

**Table 2B**

*Logistic regression of sleep on network size*

| Variable Name | Coefficient | Standard Error | 95% Confidence Interval | |
|---|---|---|---|---|
| | | | Lower Bound | Upper Bound |
| Network Size | 0.014 | 0.070 | -0.123 | 1.152 |
| Physical Impairment | -0.357 | 0.232 | -0.812 | 0.099 |
| Age | -0.193*** | 0.021 | -0.234 | -0,153 |
| Gender | -0.274*** | 0.070 | -0.412 | -0.137 |
| Constant | 4.874*** | 0.405 | 4.081 | 5.667 |

*Note*. Table 2B shows the logistic regression where sleep is the dependent variable and network size, physical impairment, age and gender are the independent variables. Network size, physical impairment and gender are binary variables. Age is a continuous variable. For the p-value, * denotes p<0.10, **denotes p<0.05 and *** denotes p<0.01.

Table 2B shows the logistic regression where sleep is the dependent variable and network size, physical impairment, age and gender are the independent variables. The coefficient of network size is 0.014. The P-value of 0.838 is greater than 0.050, meaning that this coefficient is not significant at the 95% confidence level. Therefore, it cannot be concluded from these results that there is a significant positive association between getting enough sleep and social network size.

**Table 4B**

*Logistic regression of exercise on sleep.*

| Variable Name | Odds Ratio | Standard Error | 95% Confidence Interval | |
|---|---|---|---|---|
| | | | Lower Bound | Upper Bound |
| Sleep – Self-Reported | 0.258** | 0.116 | 0.031 | 0.485 |
| Physical Impairment | -0.474 | 0.301 | -1.063 | 0.115 |
| Age | -0.321*** | 0.033 | -0.387 | -0.256 |
| Gender | -0.415*** | 0.112 | -0.634 | -0.196 |
| Constant | 9.148*** | 0.684 | 7.806 | 10.489 |

*Note*. Table 4B shows the logistic regression where exercise is the dependent variable and sleep, physical impairment, age and gender are the independent variables. Sleep, physical impairment and gender are binary variables. Age is a continuous variable. For the p-value, * denotes $p<0.10$, **denotes $p<0.05$ and *** denotes $p<0.01$.

Table 4B shows the logistic regression where exercise is the dependent variable and sleep, physical impairment, age and gender are the independent variables. The coefficient of sleep is 0.258. The P-value of 0.026 is smaller than 0.050, meaning that this coefficient is significant at the 95% confidence level. The odds ratio of sleep is 1.293, meaning that on average the odds of exercising are 1.293 times higher when getting enough sleep, adjusting for physical impairment, age and gender. Therefore, it seems that there is indeed a significant positive relationship between exercising and getting enough sleep.

# Appendix B

## Variable index

**NESR** Indicates how many people a participant's social network consists of.

**H1GH51** The self-reported mean hours of sleep a participant undergoes during a day.

**H1GH52** Whether the participants usually get enough sleep. This variable is a self-reported 'yes' or 'no' question.

**H1DA4** How many times a participant went roller-blading, roller-skating, skate-boarding, or bicycling during the past week.

**H1DA5** How many times a participant played an active sport, such as baseball, softball, basketball, soccer, swimming, or football during the past week.

**H1DA6** How many times a participant did exercise, such as jogging, walking, karate, jumping rope, gymnastics or dancing during the past week.

**H1PL1** Whether the participant had difficulty using their hands, arms, legs, or feet because of a permanent physical condition.