Undergraduate Economic Review

Volume 14 | Issue 1 Article 7

2017

Time Allocation, Sleep, and Academic Achievement in the Student Population

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Abstract

I analyze survey data from the American Time Use Survey and expand the field of research on sleep behaviors and time use in the student population. In my sample, I include respondents with ages ranging from 15-25 years to capture the high school and college populations. Sleep loss, increased stress, and greater extracurricular participation in student populations warrants further research into quantity and perceived quality of sleep in these groups. My analysis utilizes regression models to determine what activities take away the most time from human capital accumulation.

Keywords

sleep, academic achievement, time use

Cover Page Footnote

Special thanks to Dr. Laura M. Crispin, professor of Economics at Saint Joseph's University for the continued help and support throughout the entirety of this research. Additional thanks to Dr. Jodi Mindell, professor of Psychology at Saint Joseph's University for assistance in sleep psychology resources.

1 Introduction

The study of economics focuses on the allocation of resources under the assumption of scarcity. Perhaps the scarcest resource to the human race is time. Sleep occupies roughly a third of a person's life (Kovacs & Balint, 2014) and for this reason, the importance of understanding sleep cannot be underestimated. Guanghai (2016) found that consistently sleeping less than 8 hours a night puts students at an increased risk for obesity and impairments in executive functioning. Van Heugten, van der Kloet, Giesbrecht, and Merckelbach (2014) came to another alarming conclusion -- sleep deprivation is linked to increased dissociative signs and deterioration of emotional memory. These recent findings warrant further research into student participation and whether students are substituting extracurricular activities for sleep time and thus putting themselves at greater risk for the negative impacts of sleep loss.

Due to the negative effects associated with sleep loss and sleepiness, it is important to understand the implications of a sleepy student population. Summary statistics demonstrate that while the average student in this survey slept roughly 8.37 hours each day, 44.34% of the student population sleep less than eight hours per night on school nights. The goal of this research paper is to understand what activities may be taking time away from sleep, and sleep's relationship to academic pursuits.

In my analysis, I investigate tradeoffs between sleep, work, academic time, and other human capital building activities in both the high school and college student populations. I use data from the American Time Use Survey (ATUS) from 2003 to 2014 to analyze time diary data for respondents ages 15 to 25 years old. Through both descriptive analysis and regression analysis, I find that sleeping eight hours on a school night negatively impacts time spent on school work by roughly two hours. This research adds to literature on the benefits and/or drawbacks of later school starts times by documenting the overarching sleep loss and sleepy behaviors throughout high school and college students. The results of this paper are not causal; however, I hope to provide empirical analysis that can spur further research in the subject. Additional analysis could address issues such as how to incentivize sleep in the student population so as to maximize academic productivity.

This paper proceeds as follows. In Section 2, I discuss the current literature in the fields of Economics and Psychology. I discuss the data for my analysis and statistics of key variables in Section 3. I provide results of my analysis in Section 4 and conclude with discussion in Section 5.

2 Related Literature

Sleep and academic achievement tend to be studied in isolation. The effects of sleep loss and sleepiness on productivity in the workforce have received some attention; however, very few studies have addressed the disadvantages associated with lack of sleep for students. Due to the importance of academic achievement in predicting future labor and wage outcomes (French et al., 2015), more attention should be given to sleep in the student population.

2.1 Sleep Psychology

Sleep is a necessary biological process that helps to improve memory, sharpen attention, and spur muscle growth and recovery, among other things. (American Academy of Sleep Medicine

and Sleep Research Society, 2015). It is commonly mentioned that an adult should sleep eight hours a night to allow adequate time for rest and recovery. In fact, the American Academy of Sleep Medicine and Sleep Research Society (2015) found that the minimum optimal level of sleep for a healthy adult is seven hours per night. Despite the knowledge of these benefits, many people still find themselves sleeping less than the prescribed amount of sleep time. One study found that a large portion of Americans sleep less than six hours per night (Luckhaupt, Tak, & Calvert, 2010). In the workplace, sleep loss and sleepiness leads to increased stress, loss of creativity, and poorer decisions among other things. Other portions of the general population that are more likely to sleep for shorter periods are minority groups and those that are socioeconomically disadvantaged (Whinnery, Rattanaumpawan, & Grandner, 2014).

Wu, Acebo, & Seifer (2015) found that feelings of sleepiness and cognitive performance can be negatively affected by homeostatic forces and circadian factors. Furthermore, younger adolescents are at a higher risk for having circadian factors negatively impact academic success (Owens, Adolescent Sleep Working Group & Committee on Adolescence, 2014). In the adolescent population, some groups are affected by sleep deprivation more than others. Lusher & Yasenov (2016) uncovered that boys are biologically predisposed to fall asleep later and, consequently, wake up later than girls during primary and secondary school. Moreover, girls tend to endure sleep deprivation better than boys. These sleep differences account for one sixth of the gender performance gap in academic achievement. More research on gender and sleep shows that men's sleep is more likely vary due to their role in work (Cha & Eun, 2014).

Many previous studies have researched and documented some of the effects that sleep deprivation has on the student population and the greater population. Owens et al. (2014) found that a lack of sleep leads to a higher risk of obesity and is also accompanied with more depressive symptoms. In the workplace, negative effects of sleep loss systematically contribute to negative interpretations of situations and impulsive responses (Budnick & Barber, 2015). As a result, certain strategies that have the intention of enhancing the effect of human capital on work performance often do the opposite (Barnes, Jiang & Lepak, 2015). These strategies include, but are not limited to, overtime shifts and night shifts. Overtime shifts and night shifts have very similar qualities to behaviors exhibited by students (i.e. cramming for finals/pulling 'all-nighters').

A leading cause of sleep loss and sleepiness in the student population is possessing an evening chronotype -- people with this trait are often referred to as "night owls." Post puberty, sleep patterns often undergo significant changes making the likelihood of someone falling asleep later and waking later more common (Carskadon & Tarokh, 2014). Peszka, Mastin & Harsh (2009) found that evening chronotypes underperformed morning and intermediate chronotypes in terms of first year college GPA. Moreover, this research determined that night owls slept 41 minutes less, on average, on school nights. These findings further supplement the relationship between sleep and academic achievement. Additional research by Woolems, Peszka, and Mastin (2008) focused on sleep disparities and found that nighttime gaming led to maladaptive sleep behaviors. The most intense gamers slept 1.6 hours less on weekdays and reported excessive sleepiness.

With excessive sleepiness and social influence, many students resort to caffeine in order to attempt to stay vigilant throughout the academic day. Indeed, caffeine has been shown to increase cognitive functioning to overcome symptoms of sleep loss (Alhaider & Alkadhi, 2015). However, the relationship between caffeine and sleep quality remains largely unknown. Many advise using caution with regards to adolescents and caffeine (Carskadon & Tarokh, 2014). A

recent study demonstrates that this caution is well-founded. Clark and Landolt (2016) found that caffeine lengthened the period of sleep latency, reduced sleep time, and led to worse perceptions of sleep quality.

While Alhaider and Alkadhi (2015) showed that caffeine can overcome symptoms of sleep loss, it is not a perfect substitute. For academic purposes, REM (rapid eye movement) sleep is particularly important for ingraining procedural learning (Cartwright, 2004). REM cycles become more common as sleep continues so sleep loss and reliance on caffeine can erase an extremely important component of the learning cycle -- REM sleep. In fact, Buboltz and Brown (2001) found that the last two hours of REM sleep focus on integrating new information. This information is particularly important to note for those individuals not receiving adequate sleep each night. Buboltz and Brown also found that most people do sleep in the range of eight to nine hours a night, yet they perceive themselves as sleeping less than this amount. The sentiment of poor sleep could be considered a self-fulfilling prophecy. The feeling of not receiving adequate sleep could cause worse sleep which could reinforce the notion that the general population feels that they are sleeping less than they were in previous decades -- despite contradictory time diary data.

2.2 Economics of Sleep

As seen in the previous section, anywhere in the range of seven to nine hours of sleep per night is necessary for peak cognitive performance and a fully functional body. Yet, sleep is more than just a necessity. In modeling sleep behaviors, it has been found that people gain utility from sleeping (Yaniv, 2004). When determining how much to sleep each night, the rational agent must consider both the utility gained from sleeping and the foregone productivity of that time period. This sleep/productivity tradeoff is a delicate balance to strike. Kleitman (1963) discovered a wide variance of sleeping patterns across the population which suggests that the general population is not optimizing their time when it comes to sleep. In their pioneering research, Biddle and Hamermesh (1990) took a closer look at sleep patterns and determined that the marginal price of sleep differs from marginal prices of other activities since sleeping has a positive impact on productivity. Essentially, since a certain amount of sleep is required for productivity, an increase in sleep by one hour has the possibility of increasing your productivity or decreasing productive time (depending on how much sleep you receive). Moreover, Biddle and Hamermesh determined that a variance in sleep time of up to an hour per night is normal. This variance is a result of the relationship of sleep being inversely related to wages *and* time in the labor market.

Similar contrasts in sleep behavior have been found in the student population. An inverse relationship between sleep time per night and grade point average was found in one study (Trujillo, Carlos, Pinedo, & Wilman, 2010) pointing to similar tradeoffs in sleep time each night in order to dedicate more time to academics (a human capital building activity). In studying student part-time work, work time was inversely related to homework time -- but it also decreased unproductive screen time (Kalenkoski & Pabilonia, 2011). Thus, the effect of paid work overall on human capital is minimal due to cancelling out of opposite effects.

Research up to this point has shown that sleep is rarely, if at all, significantly decreased by activities such as academic time and work. Yet, media outlets continually publish stories characterizing society as losing more and more sleep each year. When taking a look at the data, Michelson (2010) found that media sentiment is incorrect. Over a seven year period, sleep has

actually increased about 14 minutes a day. This dichotomy between reality and sentiment could lead to a variety of interpretations. Research shows that the public sentiment of sleep loss could be a result of a "time crunch" which is caused by increased stressors; thus, people could feel more tired despite sleeping more than previous years. This time crunch seems to be more evident in those that are involved in a variety of activities and often find themselves 'multitasking' (Michelson, 2014). Yet, a further investigation into this notion of a time crunch shows that people tend to grossly underestimate the amount of free time and overestimate paid work time (Robinson & Michelson, 2010).

2.3 Student Population & Differences

This discovery of the 'time crunch' affecting sleep is particularly important when looking at the student population. Not only are daily stressors constantly arising in academic life, but students are also becoming more and more involved in other extracurricular activities (Snellmen et al., 2015). Brint and Cantwell (2010) took a look at student involvement to try and determine which nonacademic uses of time translate most into academic success. They found that activities such as physical exercise and volunteering increase academic conscientiousness, which in turn can positively impact academic performance. Other research has found that sleep time has a significant impact on test scores in high school students. A decrease in one-hour deviation of sleep time leads to an average decrease in test scores of .045 standard deviations (Edie & Showalter, 2012). Carrell, Maghakian, and West (2011) found that 50 minutes less sleep each school night has an estimated effect of -.031 to-.076 standard deviations on student grades.

As proposed by the "time crunch", stress can negatively impact feelings of being well-rested. This in turn, could lead to poorer academic conscientiousness and performance. Charles, Dinwiddie, and Massey (2004) researched segregation and stressors related to segregation and found that African American and Latino students were more likely to encounter stressful life events which both directly takes time away from academics and secondarily has the opportunity to decrease overall academic conscientiousness. In further research regarding race and sleep quality, Whinnery et al. (2014) discovered that African Americans, Latinos, and Asians are more likely to report sleeping less than five hours per night -- having the potential to severely impact academic outcomes.

While the data do not support the notion that society is sleeping less, increased stress (dependent upon an individual's situation) can have an impact on sleep quality which may be just important as sleep time. Additionally, increased participation in all extracurricular activity and part-time work outside of the classroom can lead to feelings of less free time and legitimately take time away from academics, putting academic success at risk. With this in mind, the core of my research will focus on what activities students partake in that affect their sleep time and academic time -- thus having the opportunity to derail academic success and human capital accumulation.

3 Data Description

3.1 Overview and Sample Selection

In my analysis, I use a sample of the population from the most recent American Time Use Survey (ATUS) published by the Bureau of Labor Statistics and completely updated for the years 2003-2014. ATUS commenced in 2003 and is recorded through the U.S. Census Bureau. The

primary goal of this dataset is to have respondents account for all 1,440 minutes in a day to better understand the allocation of time throughout the country as a whole.

ATUS data is a reliable source for time use analysis for a variety of reasons. Primarily, respondents are asked to recall only the previous day's activities so they are less susceptible to recall bias[1]. Additionally, aggregation bias[2] is less prominent because respondents to ATUS sequentially account for each activity throughout the day, ensuring the total accounts for 1440 minutes[3].

To create my sample, I begin with 7,501,084 respondents who participated in the survey up to 2015. To focus on the student population, I exclude anyone for whom school enrollment was "missing", "not in universe", or "not enrolled". Since the focus of this study is particularly on high school and college students, I exclude any member of the population under the age of 14 or over the age of 25. Of the sample remaining, I removed three outliers that recorded sleep time for the previous day as zero minutes due to the likelihood of misreporting. The final sample used for analysis is 9,238 students (3,568 university students, 5,670 high school students).

3.2 Descriptive Statistics

In Table 1, I provide the breakdown of my selected sample for analysis. This table includes the breakdown of the population by age, gender, race, education status, and employment status. Roughly 61% of the population is in high school, with the remaining 39% attending a college or university. Table 2 illustrates the difference in time allocation of students on weekdays versus the weekends. Increases in sleep time, sports time, and volunteer time are seen on the weekends.

Tables 4, 5, and 6 illustrate the correlations between different activities that students engage in on a daily basis on weekdays, weekends, and during the summer, respectively. These tables show that correlations shift on weekends and in the summer for students. Statistically significant correlations are marked by an asterisk in these tables. There are several notable correlations. There is a clear negative tradeoff between work time and education time ($r = -.39$). Additionally, sleep is negatively impacted by education time, homework time, and work time. The most significant of these three variables on impacting sleep is education time ($r = -.22$). Sex is also strongly correlated to education and homework time. There is a positive correlation between sex and education and homework time, demonstrating females tend to spend more time on these activities (Sex is a dummy variable; 1=female).

Given the results from these introductory correlations, this research seeks to quantify the tradeoffs between sleep and extracurricular participation in the student population. The correlations noted above seem to demonstrate that students have a fixed amount of free time after accounting for school activities. Due to this constraint, it is plausible that students could take time away from sleep time in order to keep up to date with homework, work, and other activities. The implications of decreasing sleep time due to over participation is that a student could have

[1] Recall bias relates to the inaccuracy in documenting time spent on activities that were completed more than 24 hours prior (Robinson and Michelson, 2010).

[2] Aggregation bias relates to overstating time spent on a single activity. This bias is minimized in ATUS data since respondents account for each minute of the day (Robinson and Michelson, 2010).

[3] It is important to remember that this data set over represents certain demographics as a result of the process of obtaining the information for the survey. In order to account for this overrepresentation, I utilize sample weights which balance the representative weights of each respondent so that all demographics are represented appropriately in my analysis.

consequences of impaired cognitive functioning. My estimation controls for the sex and age of participants as well as the day, month, and year that the participant responded to the survey in order to develop a general picture of student time allocation patterns across the last 10 years. The dependent variable in the primary analysis is sleep time as a function of education time, work time, sport time, and volunteer time. In a secondary analysis, the dependent variable homework time is estimated using the independent variables of work (yes/no), sex, and age.

4 Results

4.1 Main Results

In Table 7, I show the results from regressing age, sex, gender, race, homework time, volunteer time, and work time on the amount of sleep a student will get on a given school night during the school year. Controlling for student's age, gender, and race in all specifications; I find that all time use variables included are statistically significantly related to sleep time, along with age, while there are not statistically significant differences in sleep time by race or gender. For this regression model, R^2=15.03% (Adjusted R^2=14.87%). Holding age, sex, gender, and race constant; the results demonstrate that education time is the activity that takes away the most time from sleep time for the student population. The R^2 value for a regression estimate not including education time as an independent variable is 4.33%. In the final model (equation 1a), by adding education time as an independent variable, the R^2 value increases to 15.03%. These changes in R^2 demonstrate the strong impact that education time has on the variance of sleeping habits. In estimating the effect that working (a dummy variable) has on the amount of time a student dedicates to homework on a school night, my analysis finds that working decreases homework time by 50 minutes (equation 2a) as opposed to time spent on homework if not working.

(1a) $$SLEEP = 604.23 - .17(EDUCATION\ TIME) - .19(WORK\ TIME) - .14(SPORT\ TIME) - .27(VOLUNTEER\ TIME)$$

(2a) $$HOMEWORK\ TIME = -97.65 - .13(WORK) + 13.63(SEX) + 8.83(AGE)$$

In testing for multicollinearity between dependent variables, a Variance Inflation Factor (VIF) test was utilized. The results of this test can be found in Table 8. The results highlight that none of the descriptive variables have high multicollinearity.

4.2 Extensions

These results of my regression analysis highlight a paradox of sorts. As seen in the literature review, sleep is seen to have positive impacts on cognitive functioning, and thus, positive impacts on academic achievement. Additionally, it is well documented that time dedicated to academics increases academic achievement. The negative relationship between sleep and education time (as seen in the correlation tables as well as the regression model) highlights a trade off in the student population. Relationships found in this research have significant repercussions in student life and school organization. These findings reinforce the benefits of sleep and may have an impact on class start time, emphasis on better time balance for students, and many other facets of student life.

5 Conclusion and Discussion

Students are becoming increasingly more involved in extracurricular activity and part-time work during the school year. Participation in these additional activities increases the need for efficient time management and allocation. In order to maintain satisfactory academic standing, students are often caught substituting sleep time for study time ('overtime shifts') -- despite the fact that both of these activities are necessary activities for achievement.

Key takeaways from this analysis revolve around the negative impact on sleep and homework time as a result of average extracurricular participation. I find that students who participate in extracurricular activity and work for the average amount of time across the student population see a decrease in sleep time of nearly 70 minutes each night compared to the sleep time assuming no extracurricular participation. It is naive and most likely ill-advised to suggest that students should not dedicate any time to other activities besides academics. However, a small decrease in participation would have positive effects on sleep and cognitive functions as well as more time spent on homework. Additionally, a small decrease in participation is likely to reduce feelings of the 'time crunch' (Robinson & Michelson, 2010).

Another large take away from this research results from the relationship found between work time and time spent on homework in the student population. My analysis finds that there is a significant decrease in homework time that results from working. By working an hour and a half shift (the average shift), students spend 18.49% less time on homework on any given weekday. Given that the participation in working part time during the school time varies drastically across the student population, we find that the students that do work actually tend to work more than an hour and a half during the school week. Results of equation 2a illustrate that students who do work during the week likely spend 50 minutes less on homework each day (a considerable amount of time). This result is especially important to discuss given the rise of college tuition. As a result, many more students are finding part time jobs during the school year to offset costs (Rapacon, 2015). This decision may prove to be counterproductive due to the negative impacts it may have on academic achievement and consequently, earnings potential and human capital accumulation.

My analysis simply quantifies the relationship and tradeoffs between various activities and sleep time in the student population. Further research and advanced analysis are necessary to determine the exact combination of sleep time and education time that is optimal for the student population seeking to maximize academic achievement.

It is important to note that this research does not attempt to optimize time allocation in the student population or suggest the amount of time that students should be designating to different activities for a few reasons. The only facts that are certain in this area of research are that students need to sleep roughly seven to nine hours each night and that students generally have higher GPA (and thus, higher earnings potential) when they dedicate more time to academics. It does not make sense to attempt to optimize student time allocation because in order to do this one would need to have an objective function to be maximized. One suggestion would be to maximize the human capital that a student possesses; however, it is difficult, if not impossible, to truly understand exactly what a student gains from participating in a given extracurricular activity or part-time work. Therefore, this study seeks to demonstrate the general trends in student time allocation and study the impact that current time allocation patterns have on sleep and academic achievement -- two key factors in the building of human capital.

If nothing else, this research demonstrates the ever-complicated decisions and trade-offs that students must make as job markets are more competitive than ever before (Goodman, 2015). Students' time is becoming more expensive as competitiveness and costs of education continue to rise. Future research should search to better understand the impacts of certain types of extracurricular participation and their effects on future earnings potential. Additional research could also seek to optimize student time allocation in order to maximize human capital accumulation, academic achievement, future earnings potential, or other metrics of interest.

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Table 1: Demographic Characteristics of Participants

Characteristic	*Number*	*Percent*
Age		
Under 18	5,105	55.3
18 or older	4,133	44.7
Race		
Caucasian	7,400	80.1
African American	1,084	11.7
Asian	416	4.5
Other	338	3.7
Gender		
Male	4,421	47.9
Female	4,817	52.1
Education Status		
High School	5,668	61.4
Full time University	2,815	30.5
Part time University	753	8.1
Employment Status		
Part time	2,307	25.0
Not working	6,929	75.0

Table 2: Summary Statistics of Time Use for Participants

	Weekend (N=4,363)		Weekday (N=4,873)	
Time Use Variable	Mean	S.D.	Mean	S.D.
Education time	63.58	130.58	311.92	239.41
Homework time	51.15	111.75	63.28	105.16
Sports time	48.04	103.40	37.85	75.75
Volunteer time	11.45	57.14	8.58	41.50
Work time	79.27	172.05	93.86	183.06
Sleep Time	563.77	111.80	501.63	108.00

Note: All statistics are in minutes; analytical weights used

Table 3: Share of Students Engaged in Activities of Interest

	High School Students (N=5,158)	University Students (N=2,970)	Total (N=8,128)
Work Time	16.34	36.46	23.70
Sports Time	34.72	20.07	29.37
Study Time	41.80	39.90	41.10
Volunteer Time	9.07	4.98	7.58

Note: All values are in percent

Table 4: Correlation Between Student Activities on Weekdays during the School Year

Measure	Age	Sex	Race	Educ. Time	HW Time	Sport Time	Vol. Time	Work Time	Sleep Time
Age	--								
Sex	.04	--							
Race	-.01	.01	--						
Educ. Time	-.33*	-.01	.00	--					
HW Time	.15*	.06*	.03	.53*	--				
Sport Time	-.03*	-.19*	.00	-.02	-.11*	--			
Vol. Time	-.04*	.01	.01	.05*	-.03*	-.04*	--		
Work Time	.41*	.03*	-.03*	-.39*	-.14*	-.15*	-.04*	--	
Sleep Time	-.02	-.01	.01	-.22*	-.10*	-.03*	-.06*	-.17*	--

Note: Analytic weights used; times reported in minutes; * designates $p < .05$

Table 5: Correlation Between Student Activities on Weekends during the school year

Measure	Age	Sex	Race	Educ. Time	HW Time	Sport Time	Vol. Time	Work Time	Sleep Time
Age	--								
Sex	.04	--							
Race	-.03	-.01	--						
Educ. Time	.11*	.07*	.03*	--					
HW Time	.13*	.07*	.03*	.88*	--				
Sport Time	-.12*	-.18*	-.04*	-.11*	-.10*	--			
Vol. Time	-.06*	.00	.07*	-.02	-.02	-.06*	--		
Work Time	.15*	.01	-.02	-.11*	-.10*	-.13*	-.03	--	
Sleep Time	-.10*	-.02	.01	-.06*	.03*	-.09*	-.13*	-.21*	--

Note: Analytic weights used; times reported in minutes; * designates $p < .05$

Table 6: Correlation between Student Activities during Summer Months

Measure	Age	Sex	Race	Educ. Time	HW Time	Sport Time	Vol. Time	Work Time	Sleep Time
Age	--								
Sex	.01	--							
Race	-.03	-.04	--						
Educ. Time	-.16*	-.05	.07*	--					
HW Time	.05	-.04	.02	.65*	--				
Sport Time	-.10*	-.14*	-.04	-.04	-.03	--			
Vol. Time	-.07*	-.02	-.01	.03	-.03	.03	--		
Work Time	.33*	-.03	-.05	-.25*	-.18*	-.19*	-.10*	--	
Sleep Time	-.07*	.01	-.02	-.18*	-.08*	.03	-.06	-.26*	--

Note: Analytic weights used; times reported in minutes; * designates $p < .05$

Table 7: Regression Estimation of Sleep Time Including Interested Activities

Variable	**Beta**	***t***	**SE**
Education Time	-.1660*	-23.37	.0071
Work Time	-.1846*	-19.48	.0095
Sport Time	-.1475*	-6.88	.0215
Volunteer Time	-.2634*	-7.46	.0388
R^2	15.03		

* designates $p < .05$. N=4,344 students.

Table 8: Variance Inflation Factor Analysis for Multicollinearity

Variable	**VIF**	**1/VIF**
Work Time	1.23	.81
Age	1.19	.84
Education Time	1.14	.87
Sports Time	1.08	.92
Sex	1.03	.97
Volunteer Time	1.01	.99
Year	1.01	.99
Race	1.00	1.00
Mean VIF	1.09	