Five-factor Personality Traits and Sleep: Evidence from Two Population-based Cohort Studies

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Objective: The current study examines associations between Five Factor personality traits and average sleep duration, sleep deficiency and sleep problems.

Methods: The participants were from two population-based samples from Australia (n = 1104, age range 31 - 41) and Finland (n = 1623, age range 30 - 45). Self-reports of sleep behavior, sleep problems (Jenkin's scale) and Five Factor Model personality traits (NEO-FFI) were collected. Associations between personality traits and sleep were analyzed with linear regressions.

Results: The results showed that higher extraversion, agreeableness and conscientiousness were, in general, associated with better sleep, whereas higher neuroticism was associated with sleeping less well. Openness was not associated with sleep. Most of the associations were replicable between the samples from the two countries, but personality traits explained only small part of the variance in sleep behavior.

Conclusions: Increasing the knowledge on personality and sleep may benefit more personalized treatment of sleep disorders and help in personnel selection to jobs in which it is critical to stay alert. However, longitudinal research is needed to confirm the current findings.

Key words: Personality; Five factor model personality; sleep deficiency; sleep duration; sleep problems.

INTRODUCTION

Approximately 20% of the adult population has sleep deficiency, i.e. they sleep insufficiently as compared to their subjective need for sleep ("The 2005 sleep in America poll," 2005; Hublin, Kaprio, Partinen, & Koskenvuo, 2001). Sleep deficiency has been associated with negative mood, mental and physical health problems and more frequent use of health-care services (Daley et al., 2009; Léger, Guilleminault, Bader, Lévy, & Paillard, 2002; Pilcher & Huffcutt, 1996). Sleep deficiency has also been associated with reduced productivity at work (Daley et al., 2009). Studies on experimental sleep deprivation have shown that sleep deprivation impairs performance especially in tasks demanding attention and vigilance, but memory function and processing speed are also compromised (Lim & Dinges, 2010; Pilcher & Huffcutt, 1996). These cognitive consequences may lead to increased risks in critical situations, e.g. when driving. Although sleep deficiency is harmful, extended sleep may also be detrimental as sleeping eight hours or more (as well as sleeping about six hours or less) is associated with increased mortality risk (Kripke, Garfinkel, Wingard, Klauber, & Marler, 2002; Tamakoshi & Ohno, 2004).

It has been suggested that to better understand individual variation in sleep and to discover neurophysiological and genetic mechanisms responsible for it, research should focus on discovering sleep related traits and markers for individual differences in sleep (Van Dongen, Vitellaro, & Dinges, 2005). Personality traits could offer a marker for individual differences in sleep. Personality traits reflect comparatively stable individual differences in emotional and cognitive processes and behavioral tendencies (McCrae & Costa, 1995). Personality traits show systematic variation between individuals, have relatively high stability (Josefsson et al., 2013; Roberts & DelVecchio, 2000), are in part heritable (Jang, Livesley, & Vernon, 1996) and fairly easily assessable. Since emotions and cognitions, and sleep-related behaviors and habits are thought to be among the major explaining factors

behind sleep problems (van de Laar, Verbeek, Pevernagie, Aldenkamp, & Overeem, 2010), it is likely that personality affects sleep quality and quantity.

One of the most recognized trait models of personality is the five factor model (Goldberg, 1993) which includes five traits: Neuroticism, extraversion, openness, agreeableness and conscientiousness (McCrae & Costa, 2003). Neuroticism can be described by characteristics such as self-consciousness, insecurity and tendency to worry (Costa, Jr, & McCrae, 1992; McCrae & Costa, 1987; McCrae & Costa, 1985). Extraversion reflects a tendency to be sociable, affectionate, cheerful, and assertive. Openness can be characterized by originality, open-mindedness and creativity, whereas agreeableness is characterized for instance by tendency to be softhearted, sympathetic and trusting. Conscientiousness reflects a tendency to be reliable, well-organized and hard-working (Costa, Jr, & McCrae, 1992; McCrae & Costa, 1987; McCrae & Costa, 1985).

Several of these traits have been associated with aspects of sleep (e.g. sleep duration, subjective sleep quality, sleep problems) (Danielsson, Jansson-Fröjmark, Linton, Jutengren, & Stattin, 2010; Friedman et al., 2007; Gray & Watson, 2002; Randler, 2008; Williams & Moroz, 2009; Vincent, Cox, & Clara, 2009) but the existing research has often focused only on certain traits (mostly neuroticism) (Danielsson et al., 2010; Friedman et al., 2007; Vincent et al., 2009) instead of all five traits and there are serious methodological limitations e.g. with insufficient control variables, small sample sizes and selected/narrow study populations (Danielsson et al., 2010; Friedman et al., 2007; Gray & Watson, 2002; Hill, Diemer, & Heaton, 1997; Randler, 2008; Williams & Moroz, 2009).

So far the most comprehensive and well conducted study on five factor model traits and sleep was conducted in a nationally representative sample of 5877 participants (Vincent et al., 2009). However, this study did not include agreeableness and conscientiousness and focused only on sleep duration leaving sleep deficiency and sleep problems unexamined.

There are no previous population-based studies on agreeableness and conscientiousness with sleep. The studies that have included all five traits have not taken into account any potential confounders except for age and gender. For instance socioeconomic status and depression, which may affect personality (Jonassaint, Siegler, Barefoot, Edwards, & Williams, 2011; Klein, Kotov, & Bufferd, 2011) as well as sleep (Alvaro, Roberts, & Harris, 2013; Green, Espie, Hunt, & Benzeval, 2012), have not been adjusted for. Potential mediators have also remained unexamined. Moreover, associations between any of the five factor model traits and sleep deficiency have not been examined previously.

The existing studies suggest that higher neuroticism is associated with sleep problems (Friedman et al., 2007; Gray & Watson, 2002; Williams & Moroz, 2009) and a tendency to sleep longer (Friedman et al., 2007; Randler, 2008; Vincent et al., 2009) although shorter sleep has also been associated with neuroticism (Vincent et al., 2009). Extraversion has been associated with shorter sleep latency (Williams & Moroz, 2009), better sleep quality (Gray & Watson, 2002) but not with sleep duration (Gray & Watson, 2002; Randler, 2008; Williams & Moroz, 2009; Vincent et al., 2009). A single study has linked openness with longer sleep (Williams & Moroz, 2009). Other studies have not found associations for openness with sleep duration or sleep problems (Gray & Watson, 2002; Randler, 2008; Vincent et al., 2009). Most studies on agreeableness have not found associations with sleep problems or sleep duration (Gray & Watson, 2002; Williams & Moroz, 2009), but one study has reported that higher agreeableness is related to longer sleep (Randler, 2008). Higher conscientiousness has been associated with better sleep quality, less daytime dysfunction and less sleep problems (Williams & Moroz, 2009) but also with more sleep problems (Gray & Watson, 2002). One study has reported that higher conscientiousness is related to longer sleep duration (Randler, 2008) while other studies have not found an association (Gray &

Watson, 2002; Williams & Moroz, 2009). Clearly, more research is needed to clarify the contradictory findings.

In the current study of two large population-based samples from Australia and Finland, we examine associations of five factor personality traits with sleep duration and sleep deficiency (i.e. discrepancy between sleep duration and self-perceived need for sleep). We chose Finland and Australia because data sets from these countries included same measures of personality and sleep. Our study offers comparatively strong evidence if we can replicate the results in two culturally differing countries. In the Finnish sample, we additionally examine the associations with sleep problems. Sleep duration and sleep deficiency have independent associations with health outcomes (Altman et al., 2012) so it seems important to examine whether personality traits have differential relations to sleep duration and sleep deficiency. Based on previous findings we hypothesize that higher neuroticism is associated with more sleep problems and shorter sleep, whereas higher extraversion is associated with less sleep problems. We also hypothesize that openness, agreeableness, and conscientiousness are associated with longer sleep and that the associations are similar in both countries.

METHODS

Study Sample - Australian Data (Childhood Determinants of Adult Health study)

The Childhood Determinants of Adult Health study (CDAH) is a follow-up of children who participated in the 1985 Australian Schools Health and Fitness Survey, a population-based study of 7- to 15-year-old children (Dwyer & Gibbons, 1994). The methods used have been described in detail elsewhere (Smith et al., 2009). Briefly, during 2001 to 2002, a total of 6,840 (80%) participants were successfully traced and 5,170 (61%) agreed to participate in the CDAH study. Between 2004 and 2006 (first follow-up) when the participants were 26 -

36 years old, self-administered questionnaires on sociodemographics and lifestyle were completed by participants. The second follow-up, again involving completion of mailed questionnaires, was conducted in 2009-2011 when the participants were aged 31 - 41 years. Personality traits were assessed in the first follow-up, whereas sleep and all other variables were assessed in the second follow-up. The eligible sample of the present study included 1531 participants who completed a full version of the questionnaire set in both follow-ups. Sufficient information on personality trait items was received from 1527 participants. Of these, 1501 had information on sleep variables. Full data on all study variables was received from 1104 participants, 687 (62.2%) women and 417 (37.7%) men. All the analyses were conducted on these participants. The study was approved by the Southern Tasmania Health and Medical Research Ethics committee. All participants gave informed consent.

Measures – Australian Data

Sleep measures. Hours and minutes of usual *Sleep duration* per night as well as hours and minutes of usual self-perceived *need for sleep* were reported by the participant. *Sleep deficiency* was calculated by subtracting sleep duration from self-perceived need for sleep reported in hours and minutes.

Personality. Personality was assessed by self-reports using the NEO-FFI questionnaire, which includes 60 items (P. T. Costa, Jr. & McCrae, 1989) , 12 items for each scale: Neuroticism ($\alpha = 0.88$), extraversion ($\alpha = 0.78$), openness ($\alpha = 0.75$), agreeableness ($\alpha = 0.75$), and conscientiousness ($\alpha = 0.85$). Answers were given on a five point scale (coded from 1 to 5) and personality traits were calculated with mean function and standardized. Missing values were imputed with Expectation-Maximization (EM) algorithm (Dempster, Laird, & Rubin, 1977), which is an iterative procedure that finds the maximum likelihood estimation using two steps: the expectation E-step and the maximization M-step. The E-step

calculates the expected complete-data log likelihood given the observed data and the parameter estimates. The M-step finds the parameter estimates to maximize the complete-data log likelihood from the E-step. These steps are iterated until the iterations converge. The maximum amount of imputed values in each personality item was 1.0%. Those who originally had more than 50% of missing values on a trait were excluded.

Control variables. Socioeconomic status was indicated by *educational level* which was self-reported with a written questionnaire. Educational level was coded as (1) school only, (2) undergraduate diploma, associate diploma, skilled and basic vocational training (apprenticeships), (3) higher degree, post-graduate diploma, bachelor's degree. *Employment status* was coded as follows: (1) full-time workers (0) others. W*orking schedule* was coded as follows: (0) regular daytime work or not working outside of home, (1) other than regular daytime work. Health-related behaviors included *alcohol consumption* (how often do you have five or more standard drinks of alcohol on one occasion: ranging from 1=never to 5=more than once a week), *smoking status* (daily smokers vs. others), and *physical activity.* Leisure time physical activity was assessed with the International Physical Activity Questionnaire (Craig et al., 2003) assessing participant reports of duration (minutes) and frequency (times/week) of physical activity. The resulting variable was skewed and was transformed with square root transformation. *Body-mass index* was calculated from self-reported weight and height (kg/m^2) and a correction factor was applied (Venn et al., 2007). *Depression* was assessed with Composite International Diagnostic Interview (CIDI). CIDI-Auto (ver. 2.1) is a computerized version which was administered as a telephone interview (Wittchen, 1994). Depression (mild, moderate or severe) during last 12 months was assessed and coded as: (0) no depression, (1) depression. The length of time between the follow-ups (number of days) was also included as a control variable.

Study Sample - Finnish Data (the Young Finns Study)

The participants were derived from the ongoing prospective Young Finns study, which began in 1980. The subjects for the original sample in 1980 (n = 3 596) were selected randomly from six age cohorts (aged 3, 6, 9, 12, 15, and 18 years) in the population register of the Social Insurance Institution, a database that covers the whole population of Finland. The design of the study and the selection of the sample have been described in detail by Raitakari et al. (2008). The assessments of the present study were carried out in 2007 when the participants were aged 30, 33, 36, 39, 42, and 45 years. The eligible sample of the present study included 2058 participants who took part in the psychological data collection in 2007. Sufficient information on personality trait items was received from 2054 participants. Of these, 1712 had information on sleep variables. Full data on all study variables including the covariates was received from 1623 participants, 942 (58.0%), women and 681 (42.0%) men. All the analyses were conducted on these participants. The study was approved by local ethics committees. All participants gave informed consent.

Measures – Finnish Data

Sleep measures. Usual *Sleep duration* per 24 hours as well as self-perceived usual *need for sleep* were reported by the participant by selecting from 10 alternatives: 5 hours or below, 6 hours, 6.5 hours, 7 hours, 7.5 hours, 8 hours, 8.5 hours, 9 hours 9.5 hours, or 10 hours or more. Sleep duration was subtracted from self-perceived need for sleep calculated in hours ("5 hours or below" was coded as 5 and "10 hours or more" was coded as 10) in order to form a variable representing *Sleep deficiency. Sleep problems* ($\alpha = 0.76$) were assessed with Jenkins's scale, which is reliable and valid measure (Crawford, Piault, Lai, & Sarzi-Puttini, 2010; Halonen et al., 2012; Jenkins, Stanton, Niemcryk, & Rose, 1988; Lallukka et al., 2012). The scale includes four items assessing problems in falling to sleep, awakenings during sleep,

difficulties to stay in sleep (including too early awakenings) and feelings of tiredness after a night's sleep (Jenkins et al., 1988). These correspond to the insomnia symptoms in the fourth edition of Diagnostic and Statistic Manual of Mental Disorders (DSM-IV). The response alternatives were: (1) "not at all", (2) "in 1-3 nights in a month", (3) "about 1 night a week", (4) "in 2-4 nights a week", (5) "in 5-6 nights a week", (6) "every night". The level of sleep problems was coded according to the most frequent symptom as in previous research (Salo et al., 2010).

Personality. Personality was assessed with self-reports with the Finnish version of NEO-FFI including 60 items (Rantanen, Metsäpelto, Feldt, Pulkkinen, & Kokko, 2007). Items corresponding to the English 60-item NEO-FFI (P. T. Costa, Jr. & McCrae, 1989) were selected from the Finnish version of NEO-PI questionnaire (Pulver, Allik, Pulkkinen, & Hamalainen, 1995). Some items had been modified so that they better fit Finnish language. There were 12 items for each trait: Neuroticism ($\alpha = 0.88$), extraversion ($\alpha = 0.81$), openness ($\alpha = 0.73$), agreeableness ($\alpha = 0.80$), and conscientiousness ($\alpha = 0.84$). Answers were given on a five point scale (1 – 5) and personality traits were calculated with mean function and standardized. Missing values were imputed with EM algorithm and the maximum amount of imputed values in each item was 0.9%. Those who originally had more than 50% of missing values on a trait were excluded.

Control variables. Socioeconomic status was indicated by self-reported *educational level* in 2007 classified as (1) comprehensive school, (2) secondary education (high school, vocational school), (3) bachelor's level (including those with university studies but no degree) (4) master's degree, and (5) licentiate's or doctoral degree. *Employment status* was coded as follows: (1) those active in working life (0) those inactive or unemployed. W*orking schedule* was coded as follows: (0) regular daytime work or not working outside of home, (1) other than regular daytime work. Health-related behaviors included *smoking status* (daily

smokers vs. others), *alcohol consumption* [how often beer, wine, or spirits was used at least six portions at a time (one portion equals 12 g): ranging from 1=once a year or never to 6=at least twice a week], and *physical activity* (an index formed of five items as in Hintsanen et al. (2005) describing intensity, frequency, hours/week, average duration, and participation in structured sports) (Telama, Yang, Laakso, & Viikari, 1997). High scores indicate high physical activity. *Body-mass index* (BMI) was calculated from weight and height: kg/m^2. Weight was measured with a Seca weight scale and height was measured with a Seca anthropometer. Severity of *depressive symptoms* was assessed with Beck's Depression Inventory II (BDI-II) (Beck, Steer, & Brown) ($\alpha = 0.92$) which includes 21 items, each consisting of four response alternatives that are coded from 0 to 3. Missing values were imputed with EM algorithm and the maximum amount of imputed values in each item was 0.6%. Those who originally had more than 50% of missing values were excluded. A dichotomous score was calculated based on standardized cut-off scores: 1 = those with presence of depressive symptoms (BDI-II score >=14) and 0 = those with minimal or no symptoms (BDI-II score < = 13).

Statistical Analyses

Linear regression analyses were conducted to examine associations of personality traits with sleep duration and sleep deficiency. The associations between personality traits and sleep problems were examined with ordinal regression analyses. Each personality trait was first examined separately as a predictor of each of the sleep variables. Five models were formed. In addition to the personality trait, the following variables were included: Model 1 - age and gender, Model 2 - age gender educational level, working status, and regularity of working time, Model 3 - age, gender, BMI, smoking, alcohol consumption, physical activity, and depression, Model 4 - all aforementioned variables, Model 5 – all aforementioned variables

and all personality trait variables at the same time. In addition, in the Australian data set, a variable on the time between the measurements of first and second follow-up was included in all models. The models 2, 3 and 4 are presented only in the supplementary tables on the website. To take into account the multiple analyses, the critical alpha value of 0.05 was divided by five (the number of personality traits), which resulted in new alpha of 0.01. All analyses were conducted with PASW 18 software.

RESULTS

Table 1 presents the characteristics of the study sample. The differences between included and excluded participants were analyzed with t-test and χ^2-test. Regarding the sleep measures and control variables in the Australian data, the included participants were compared to those who took part in the second follow-up. Regarding personality measures, the included participants were compared to those who took part in first follow-up. The attrition analyses showed that in the Australian data, included participants were slightly younger (36.5 vs. 36.8, $p = 0.001$) had higher education (2.3 vs. 2.2, $p < 0.001$) openness (3.3 vs. 3.2, $p < 0.001$), physical activity (10.6 vs. 9.7, $p = 0.017$), and lower BMI (25.9 vs. 26.8, $p < 0.001$) as compared to the excluded. The included also had slightly shorter time (fewer days) between the follow-ups (1805 vs. 1838, $p < 0.001$), were more likely to be full-time workers (58.6% vs. 51.9%, $p =0.006$), and less likely to be smokers (10.1% vs. 13.9%, $p = 0.003$).

In the Finnish data, included participants were compared to those who took part in the collection of psychology data in 2007. Included participants were slightly older (37.7 vs.37.1, $p = 0.031$), more educated (2.8 vs. 2.5, $p < 0.001$), lower in neuroticism (2.4 vs.2.5, $p < 0.001$), higher in agreeableness (3.7 vs.3.6, $p = 0.019$), less likely to smoke (16.1% vs. 23.4%, $p = 0.027$) or be depressed (10.3% vs. 14.0%, $p = 0.028$), and more likely to be active

in working life (82.0% vs. 58.6%, p < 0.001) as compared to those who were excluded from the analyses.

Insert Table 1 about here

In addition to models presented in the Tables 2-4 corresponding Supplementary tables present the models 2, 3 and 4.

Sleep Duration

Table 2 presents the associations between personality traits and sleep duration. In both data sets, high agreeableness was related to longer sleep in the model that included age and gender (Australian data: B = 0.081, *p* = .007; Finnish data: B = 0.091, *p* < .001). As personality traits were standardized before analysing the data, the results indicate the change in the outcome variable per one standard deviation change in the personality variable. This means that an increase of one standard deviation in agreeableness represents an increase of approximately 5 minutes in sleep duration. In the Finnish data, this association was significant also in the other models and the fully adjusted model that included all covariates and the other personality traits. In the Australian data, the association was only marginally significant in the fully adjusted model (p = 0.017). The other traits were not associated with sleep duration. The final model explained 4.4% of the variance in sleep duration in the Australian data and 5.1% in the Finnish data.

Insert Table 2 about here

Sleep Deficiency

Table 3 present the associations of personality traits with sleep deficiency. Higher neuroticism was systematically related to higher sleep deficiency in Australian (Model 1: B = 0.162, *p* < .001) as well as in Finnish data (Model 1: B = 0.150, *p* < .001). In both data sets,

lower extraversion was related to higher sleep deficiency (Australian data: B = -0.092, p = .003; Finnish data: B = -0.095, p < .001) although the association was not significant when all the control variables and other personality traits were included in the analysis. Openness was not associated with sleep deficiency. Lower agreeableness was related to higher sleep deficiency in the Finnish data (B = -0.093, p < .001), and similar marginally significant associations were found in the Australian data set (B = -0.055, p = .082). In terms of interpretation these results imply that an increase of one standard deviation in e.g. neuroticism increases sleep deficiency by 9 - 10 minutes. These associations were not attenuated when control variables were added to the analyses (see models 2-4 in the Supplementary tables) but when all other personality traits were additionally added (model 5), the associations attenuated to non-significant (p > 0.01). Lower conscientiousness was related to sleep deficiency in the Australian data (B = -0.097, p = .002) and similar marginally significant association was found in the Finnish data (B = -0.052, p = .015). In the Australian data, the association was not attenuated when control variables were added (see models 2-4 in the supplementary tables) except in the final model which included the other personality traits (model 5). The final model explained 3.5% of the variance in sleep deficiency in the Australian data and 4.3% in the Finnish data.

Insert Table 3 about here

Sleep Problems

Table 4 presents the associations between personality and sleep problems, which were examined only in the Finnish data. Higher neuroticism was related to higher sleep problems (Model 1: Odds ratio (OR) = 1.645, p < .001) so that an increase of one standard deviation in neuroticism increased the odds for gaining a higher score on sleep problems by 64.5%. This result remained significant irrespective of the control variables. Higher extraversion (Model

1: OR = 0.696, $p < .001$), agreeableness (Model 1: OR = 0.784, $p < .001$), and conscientiousness (Model 1: OR = 0.822, $p < .001$) were associated with less sleep problems. When control variables were added, the association of extroversion remained significant. Agreeableness and conscientiousness also remained significant in all other models (see models 2-4 in the supplementary tables) except for the final model that included all control variables and the other personality traits (model 5). In the final model, agreeableness was marginally significant (p = 0.044) and conscientiousness was non-significant.

Insert Table 4 about here

DISCUSSION

Data from these Australian and Finnish cohort studies showed that except for openness all the personality traits of the Five Factor Model were associated with aspects of sleep experiences although the effect sizes were quite modest. The findings were highly similar in both cohorts. Taken together, higher neuroticism was related to poorer sleep, whereas higher extroversion, agreeableness and conscientiousness were associated with better sleep in terms of amount and quality.

More specifically, higher neuroticism was related to higher sleep deficiency in both data sets. Sleep problems were only assessed in the Finnish data which showed that higher neuroticism was linked with higher sleep problems. In sum, high neuroticism seemed to be linked to poorer sleep in terms of amount and quality. These findings are in agreement with previous research showing that high neuroticism is related to stress sensitivity (Gunthert, Cohen, & Armeli, 1999; Schneider, 2004) which is a predisposing factor for insomnia (Morin, Rodrigue, & Ivers, 2003). There are also findings implying that sleep deprivation might increase neuroticism (Franzen, Siegle, & Buysse, 2008) and one study suggests that

sleep onset problems are predictive of neuroticism but not vice versa (Danielsson et al., 2010).

Contrary to our findings, some earlier studies have found that higher neuroticism is associated with longer sleep (Friedman et al., 2007; Randler, 2008). In one study, the association between neuroticism and sleep duration was found to be non-linear; both short-sleepers and long-sleepers being overrepresented among those with higher neuroticism (Vincent et al., 2009). These findings may point to two different patterns of sleep in high neuroticism. Insomniacs typically have shorter sleep (Sivertsen et al., 2009). Thus those who suffer from sleep problems may have shorter sleep while those who sleep longer may either compensate their poor quality of sleep or they may be more vulnerable to daily stressors which may increase their need for recovery via sleep.

Higher extraversion was linked to less sleep problems, which confirmed our hypothesis. This is in line with earlier studies that have found that higher extraversion is related to shorter sleep latency (Williams & Moroz, 2009) and better sleep quality (Gray & Watson, 2002). We observed higher extraversion to be associated with less sleep deficiency, although the association disappeared in the fully adjusted model. In sum, higher extraversion and sleeping well seemed to be connected. This is in accordance with previous research that has linked higher extraversion with indicators of lower stress (Schneider, Rench, Lyons, & Riffle, 2012). However, it should be noted that although higher extraversion may be related with better sleep and lower sleep deficiency, individual differences in tolerance to sleep deprivation may have a counterbalancing effect: There is evidence that higher extroversion is related to lower resilience to sleep deprivation, which is manifested as stronger decrease in cognitive performance (Killgore, Richards, Killgore, Kamimori, & Balkin, 2007). Thus, extroverts have a lower sleep deficiency but when it occurs, the consequences might be more detrimental for them than for introverts.

Opposite to our hypothesis, openness was not associated with sleep duration. Openness was not associated with sleep deficiency or sleep problems either. With one exception (Williams & Moroz, 2009), most previous research has not been able to find associations between openness and sleep behavior (Gray & Watson, 2002; Randler, 2008; Vincent et al., 2009). It seems that openness may not be meaningful for sleeping well or sleeping poorly. In addition, openness seems to be a personality trait important for social behavior rather than for health behavior (Connelly, Ones, & Chernyshenko, 2014).

In both data sets, those with high agreeableness had longer sleep duration, which is in line with our hypothesis. In the Finnish data, higher agreeableness was associated with lower sleep deficiency although this association was attenuated to marginally significant in the fully adjusted model. Similar tendency, although non-significant, was also found in the Australian data. Higher agreeableness was linked to less sleep problems although, in the fully adjusted model, only marginally significantly. Overall, high agreeableness seemed to be a trait related to good and sufficient sleep. Those with high agreeableness may be better at adhering to sleep-related recommendations. Lower stress in more agreeable individuals (Schneider, 2004; Törnroos et al., 2012) may also be an explanation.

Against our hypothesis, conscientiousness was not associated with sleep duration in this study. However, only one previous study has shown associations between conscientiousness and sleep duration (Randler, 2008) and two others, although with much smaller sample sizes, have not (Gray & Watson, 2002; Williams & Moroz, 2009). Higher conscientiousness was related to less sleep deficiency in the Australian data except in the fully adjusted model. Similar marginally significant association was found in the Finnish data in some models. Higher conscientiousness was also rather consistently associated with less sleep problems. Drawn together, high conscientiousness, similarly to agreeableness, was associated with good sleep in terms of amount and quality. This is not surprising since high

conscientiousness is characterized by being responsible and organized and is associated with better health, longevity, and good coping skills in the face of difficulties (Connor-Smith & Flachsbart, 2007; Kern & Friedman, 2008). These qualities may help those with high conscientiousness to follow better sleep hygiene which supports sleeping well. As our analyses were cross-sectional, reverse causation is also possible. It has been suggested that longer sleep could lead to higher agreeableness and to higher conscientiousness (Randler, 2008).

Personality is only one predictor among many others (genetic, biological, environmental, social, and psychological factors) and as expected, the effect sizes between personality traits and sleep behavior were rather modest. In general, personality traits explained 1-3% of the variation in sleep behavior in the age and gender adjusted models. Neuroticism had the strongest associations explaining 2-3% of the variation in sleep deficiency and increasing the odds for gaining a higher score on sleep problems by 64.5% (per one standard deviation increase in neuroticism). It should be noted that these are average effect sizes. If the extreme ends of each trait would be compared, the effect sizes would be likely to be larger.

Examining personality traits may contribute to knowledge base that can be used for mapping phenotypes related to individual variations in sleep. Discovering sleep-related phenotypes may help examine the underlying physiological mechanisms and genetic background (Van Dongen et al., 2005). Furthermore, knowledge on associations between personality and sleep may be useful in targeting those with increased risk for sleep problems and related fatigue. This kind of information would be important for example in recruiting personnel for jobs in which not staying vigilant may lead to serious consequences (e.g. air traffic controllers). Furthermore, for instance, shift work may cause greater sleep-related problems for some individuals than others and these individuals are more likely to cause

safety risks. Moreover, increasing the knowledge on personality and sleep may benefit more personalized treatment of sleep disorders. For instance, those with high neuroticism might benefit the most from stress reduction interventions, whereas those with low conscientiousness might benefit especially from education and motivating directed at improving sleep hygiene. However, our results offer only a starting point and longitudinal research that confirm our findings, is needed before considering moving to applications.

Limitations and Strengths

The most important limitations were the lack of objective measures of sleep and the cross-sectional design which prevents examining temporal associations. Use of self-reports for measuring sleep has been common also in previous studies (Danielsson et al., 2010; Gray & Watson, 2002; Hill et al., 1997; Randler, 2008; Williams & Moroz, 2009; Vincent et al., 2009) and we are aware of only one study that has included objective sleep measures and five factor model personality trait (only neuroticism) (Friedman et al., 2007). There is need for more studies that include objective assessments of sleep. This would be most important in the case of neuroticism, since neuroticism-like characteristics have been suggested to affect the responses to self-report questionnaires, high neuroticism increasing negativity (Costa, Jr, & McCrae, 1990). However, subjective assessments of sleep are important as such. Insomnia diagnoses are most often based on self-reported symptoms and it is important to know how personality may be related to them. In addition, subjective experiences of sleep are closely related to quality of life (Ishak et al., 2012).

Our assessments of sleep duration and sleep deficiency were not based on validated measures of self-reported sleep. Therefore, our results may not be directly comparable to previous research using such measures. However, our measure of sleep problems (Jenkins's

scale) is a validated clinically relevant scale which consists of items that correspond to the insomnia symptoms in the fourth edition DSM-IV.

There were also other limitations. Missing values reduced the sample size. Attrition analyses showed some differences between the included and excluded participants and our results are likely to be better generalized to a population characterized by somewhat higher socio-economic position. Another limitation was that in the Finnish data, we assessed personality and sleep in the same data collection, whereas in the Australian data, we assessed them in different follow-ups a few years apart. The study designs were, thus, not entirely comparable, which may have led to some differences in the results between the samples.

The current study was the first to examine associations between five factor model traits and sleep deficiency. With one exception (Vincent et al., 2009), previous research on five factor traits and sleep behavior has used non-representative samples. A strength of the present study was to include relatively large population-based samples from two different countries that assess personality and sleep variables with the same questionnaires and, therefore, offer a possibility for cross-cultural comparison and replication. Although there was significant time-lag between personality and sleep assessments in the Australian data, overall, the two data sets were highly similar, which increases comparability between these samples. Another strength was that we included a full personality model assessed by a golden standard questionnaire reflecting one of the most prominent personality models to date. We were also able to include several measures assessing different aspects of sleep. Lastly, we included a wide variety of potential confounders and mediators. Our approach allowed examining associations between personality and sleep behavior more systematically and comprehensively than in any of the previous studies. Since majority of our findings were significant even when all potential mediators were included in the analyses (model 4), our

results imply that there are other pathways from personality traits to sleep behavior then those examined here.

To conclude, the current study showed that all five factor model personality traits had some associations with sleep variables. Most of the associations were highly replicable between the Australian and Finnish samples. Especially high neuroticism, low extraversion, low agreeableness and low conscientiousness seemed to be associated with poorer sleep.

REFERENCES

The 2005 sleep in America poll. (2005) Retrieved 13.11.2012, from http://www.sleepfoundation.org/sites/default/files/2005_summary_of_findings.pdf

Altman, N. G., Izci-Balserak, B., Schopfer, E., Jackson, N., Rattanaumpawan, P., Gehrman, P. R., . . . Grandner, M. A. (2012). Sleep duration versus sleep insufficiency as predictors of cardiometabolic health outcomes. *Sleep Medicine, 13*, 1261-1270. doi: 10.1016/j.sleep.2012.08.005

Alvaro, P. K., Roberts, R. M., & Harris, J. K. (2013). A systematic review assessing bidirectionality between sleep disturbances, anxiety, and depression. *Sleep, 36*, 1059-1068. doi: http://dx.doi.org/10.5665/sleep.2810

Beck, A. T., Steer, R. A., & Brown, G. K. Beck Depression Inventory - 2nd Edition Retrieved 10.9.2012, from http://www.cps.nova.edu/~cpphelp/BDI2.html

Connelly, B. S., Ones, D. S., & Chernyshenko, O. S. (2014). Introducing the Special Section on Openness to Experience: Review of Openness Taxonomies, Measurement, and Nomological Net. *Journal of Personality Assessment, 96*, 1-16. doi: 10.1080/00223891.2013.830620

Connor-Smith, J. K., & Flachsbart, C. (2007). Relations between personality and coping: A meta-analysis. *Journal of Personality and Social Psychology, 93*, 1080-1107. doi: 10.1037/0022-3514.93.6.1080

Costa, P. T., Jr,, & McCrae, R. R. (1990). Personality: Another "hidden factor" in stress research. *Psychological Inquiry, 1*, 22-24.

Costa, P. T., Jr,, & McCrae, R. R. (1992). *Professional Manual Revised NEO Personality Inventory (NEO PI-R) and NEO Five-Factor Inventory (NEO-FFI)* Florida: Psychological assessment resources

Costa, P. T., Jr., & McCrae, R. R. (1989). *The NEO-PI/NEO-FFI Manual Supplement*. Odessa, FL: Psychological Assessment Resources.

Craig, C. L., Marshall, A. L., Sjöström, M., Bauman, A. E., Booth, M. L., Ainsworth, B. E., . . . Oja, P. (2003). International Physical Activity Questionnaire: 12-country reliability and validity. *Medicine and science in sports and exercise 35*, 1381-1395. doi: 10.1249/01.MSS.0000078924.61453.FB

Crawford, B. K., Piault, E. C., Lai, C., & Sarzi-Puttini, P. (2010). Assessing sleep in fibromyalgia: investigation of an alternative scoring method for the Jenkins Sleep Scale based on data from randomised co ntrolled studies. *Clinical and Experimental Rheumatology 6*, S100-S109. doi: -

Daley, M., Morin, C. M., LeBlanc, M., Grégoire, J. P., Savard, J., & Baillargeon, L. (2009). Insomnia and its relationship to health-care utilization, work absenteeism, productivity and accidents. *Sleep Medicine, 10*, 427-438. doi: 10.1016/j.sleep.2008.04.005

Danielsson, N. S., Jansson-Fröjmark, M., Linton, S. J., Jutengren, G., & Stattin, H. (2010). Neuroticism and sleep-onset: What is the long-term connection? *Personality and Individual Differences, 48*, 463-468. doi: 10.1016/j.paid.2009.11.023

Dempster, A. P., Laird, N. M., & Rubin, D. B. (1977). Maximum likelihood from incomplete data via the EM algorithm. *Journal of the Royal Statistical Society. Series B (Methodological), 39*, 1-38.

Dwyer, T., & Gibbons, L. E. (1994). The Australian Schools Health and Fitness Survey: Physical fitness related to blood pressure but not lipoproteins. *Circulation, 89*, 1539-1544. doi: 10.1161/01.CIR.89.4.1539

Franzen, P. L., Siegle, G. J., & Buysse, D. J. (2008). Relationships between affect, vigilance, and sleepiness following sleep deprivation. *Journal of sleep research, 17,* 34-41. doi: 10.1111/j.1365-2869.2008.00635.x

Friedman, E. M., Love, G. D., Rosenkranz, M. A., Urry, H. L., Davidson, R. J., Singer, B. H., & Ryff, C. D. (2007). Socioeconomic status predicts objective and subjective sleep quality in aging women. *Psychosomatic Medicine, 69,* 682-691. doi: 10.1097/PSY.0b013e31814ceada

Goldberg, L. R. (1993). The structure of phenotypic personality traits. *American Psychologist, 48,* 26-34.

Gray, E. K., & Watson, D. (2002). General and specific traits of personality and their relation to sleep and academic performance. *Journal of Personality, 70,* 177-206. doi: 10.1111/1467-6494.05002

Green, M. J., Espie, C. A., Hunt, K., & Benzeval, M. (2012). The longitudinal course of insomnia symptoms: Inequalities by sex and occupational class among two different age cohorts followed for 20 years in the west of Scotland *Sleep, 35,* 815-823. doi: 10.5665/sleep.1882

Gunthert, K. C., Cohen, L. H., & Armeli, S. (1999). The role of neuroticism in daily stress and coping. *Journal of personality and social psychology 77,* 1087-1100. doi: -

Halonen, J. I., Vahtera, J., Stansfeld, S., Yli-Tuomi, T., Salo, P., Pentti, J., . . . Lanki, T. (2012). Associations between nighttime traffic noise and sleep: The Finnish Public Sector Study. *Environmental Health Perspectives, 120* 1391-1396 doi: 10.1289/ehp.1205026

Hill, C. E., Diemer, R. A., & Heaton, K. (1997). Dream interpretation sessions: Who volunteers, who benefits, and what volunteer clients view as most and least helpful. *Journal of Counseling Psychology, 44,* 53-62.

Hintsanen, M., Kivimäki, M., Elovainio, M., Pulkki-Råback, L., Keskivaara, P., Juonala, M., . . . Keltikangas-Järvinen, L. (2005). Job strain and early atherosclerosis: The Cardiovascular Risk in Young Finns study. *Psychosomatic Medicine, 67*, 740-747. doi: 10.1097/01.psy.0000181271.04169.93

Hublin, C., Kaprio, J., Partinen, M., & Koskenvuo, M. (2001). Insufficient sleep - A population-based study in adults. *Sleep 24*, 392-400. doi: -

Ishak, W. W., Bagot, K., Thomas, S., Magakian, N., Bedwani, D., Larson, D., . . . Zaky, C. (2012). Quality of life in patients suffering from insomnia. *Innovations in Clinical Neuroscience, 9*, 13-26. doi: -

Jang, K. L., Livesley, W. J., & Vernon, P. A. (1996). Heritability of the big five personality dimensions and their facets: A twin study. *Journal of Personality, 64*, 577-591. doi: 10.1111/1467-6494.ep9703132895

Jenkins, C. D., Stanton, B.-A., Niemcryk, S. J., & Rose, R. M. (1988). A scale for the estimation of sleep problems in clinical research. *Journal of Clinical Epidemiology, 41*, 313-321.

Jonassaint, C. R., Siegler, I. C., Barefoot, J. C., Edwards, C. L., & Williams, R. B. (2011). Low life course socioeconomic status (SES) is associated with negative NEO PI-R personality patterns. *International Journal of Behavioral Medicine, 18*, 13-21. doi: 10.1007/s12529-009-9069-x

Josefsson, K., Jokela, M., Cloninger, C. R., Hintsanen, M., Salo, J., Hintsa, T., . . . Keltikangas-Järvinen, L. (2013). Maturity and change in personality: Developmental trends of temperament and character in adulthood. *Development and Psychopathology, 25*, 713-727. doi: 10.1017/S0954579413000126

Kern, M. L., & Friedman, H. S. (2008). Do conscientious individuals live longer? A quantitative review. *Health Psychology, 27*, 505-512. doi: 10.1037/0278-6133.27.5.505

Killgore, W. D. S., Richards, J. M., Killgore, D. B., Kamimori, G. H., & Balkin, T. J. (2007). The trait of Introversion–Extraversion predicts vulnerability to sleep deprivation. *Journal of Sleep Research, 16*, 354-363. doi: 10.1111/j.1365-2869.2007.00611.x.

Klein, D. N., Kotov, R., & Bufferd, S. J. (2011). Personality and depression: Explanatory models and review of the evidence. *Annual Review of Clinical Psychology, 7*, 269-295. doi: 10.1146/annurev-clinpsy-032210-104540

Kripke, D. F., Garfinkel, L., Wingard, D. L., Klauber, M. R., & Marler, M. R. (2002). Mortality associated with sleep duration and insomnia. *Archives of General Psychiatry, 59*, 131-136. doi: -

Lallukka, T., Ferrie, J. E., Kivimäki, M., Shipley, M. J., Rahkonen, O., & Lahelma, E. (2012). Economic difficulties and subsequent sleep problems: Evidence from British and Finnish occupational cohorts. *Sleep Medicine, 13*, 680-685. doi: 10.1016/j.sleep.2011.10.036

Léger, D., Guilleminault, C., Bader, G., Lévy, E., & Paillard, M. (2002). Medical and socio-professional impact of insomnia. *Sleep, 25*, 625-629. doi: -

Lim, J., & Dinges, D. F. (2010). A meta-analysis of the impact of short-term sleep deprivation on cognitive variables. *Psychological Bulletin, 136*, 375-389. doi: 10.1037/a0018883375

McCrae, R. R., & Costa, P. T. (1987). Validation of the 5-factor model of personality across instruments and observers. *Journal of Personality and Social Psychology, 52*, 81-90.

McCrae, R. R., & Costa, P. T., Jr. (2003). *Personality in adulthood: A five factor theory perspective*. New York: The Guilford Press.

McCrae, R. R., & Costa, P. T., Jr. (1995). Trait explanations in personality psychology. *European Journal of Personality, 9,* 231-252. doi: 10.1002/per.2410090402

McCrae, R. R., & Costa, P. T. J. (1985). Updating Norman's adequate taxonomy - intelligence and personality dimensions in natural-language and in questionnaires. *Journal of Personality and Social Psychology 49,* 710-721.

Morin, C. M., Rodrigue, S., & Ivers, H. (2003). Role of stress, arousal, and coping skills in primary insomnia. *Psychosomatic Medicine, 65,* 259-267. doi: 10.1097/01.PSY.0000030391.09558.A3

Pilcher, J. J., & Huffcutt, A. (1996). Effects of sleep deprivation on performance: A meta-analysis. *Sleep, 19,* 318-326.

Pulver, A., Allik, J., Pulkkinen, L., & Hamalainen, M. (1995). A Big Five personality inventory in two non-Indo-European languages. *European Journal of Personality, 9,* 109-124.

Raitakari, O. T., Juonala, M., Rönnemaa, T., Keltikangas-Järvinen, L., Räsänen, L., Pietikäinen, M., . . . Viikari, J. S. A. (2008). Cohort profile: The Cardiovascular Risk in Young Finns Study. *International Journal of Epidemiology, 37,* 1220-1226. doi: 10.1093/ije/dym225

Randler, C. (2008). Morningness-eveningness, sleep-wake variables and big five personality factors. *Personality and Individual Differences, 45,* 191-196. doi: 10.1016/j.paid.2008.03.007

Rantanen, J., Metsäpelto, R.-L., Feldt, T., Pulkkinen, L., & Kokko, K. (2007). Long-term stability in the Big Five personality traits in adulthood. *Scandinavian Journal of Psychology, 48,* 511-518. doi: 10.1111/j.1467-9450.2007.00609.x

Roberts, B. W., & DelVecchio, W. F. (2000). The rank order consistency of personality traits from childhood to old age: A quantitative review of longitudinal studies. *Psychological Bulletin, 126,* 3-25. doi: 10.1037//0033-2909.126.1.3

Salo, P., Oksanen, T., Sivertsen, B., Hall, M., Pentti, J., Virtanen, M., . . . Kivimäki, M. (2010). Sleep disturbances as a predictor of cause-specific work disability and delayed return to work. *Sleep, 33,* 1323-1331. doi: -

Schneider, T. R. (2004). The role of neuroticism on psychological and physiological stress responses. *Journal of Experimental Social Psychology, 40,* 795-804. doi: 10.1016/j.jesp.2004.04.005

Schneider, T. R., Rench, T. A., Lyons, J. B., & Riffle, R. R. (2012). The influence of neuroticism, extraversion and openness on stress responses. *Stress and Health: Journal of the International Society for the Investigation of Stress, 28,* 102-110. doi: -

Sivertsen, B., Øverland, S., Pallesen, S., Bjorvatn, B., Nordhus, I. H., Maeland, J. G., & Mykletun, A. (2009). Insomnia and long sleep duration are risk factors for later work disability. The Hordaland Health Study. *Journal of Sleep Research, 18,* 122-128. doi: 10.1111/j.1365-2869.2008.00697.x

Smith, K. J., McNaughton, S. A., Gall, S. L., Blizzard, L., Dwyer, T., & Venn, A. J. (2009). Takeaway food consumption and its associations with diet quality and abdominal obesity: A cross-sectional study of young adults. *International Journal of Behavioral Nutrition and Physical Activity, 6,* 29. doi: 10.1186/1479-5868-6-29

Tamakoshi, A., & Ohno, Y. (2004). Self-Reported Sleep Duration as a Predictor of All-Cause Mortality: Results from the JACC Study, Japan. *Sleep, 27,* 51-54. doi: -

Telama, R., Yang, X., Laakso, L., & Viikari, J. (1997). Physical activity in childhood and adolescence as predictor of physical activity in young adulthood. *American Journal of Preventive Medicine, 13,* 317-323.

Törnroos, M., Hintsanen, M., Hintsa, T., Jokela, M., Pulkki-Råback, L., Kivimäki, M., . . . Keltikangas-Järvinen, L. (2012). Personality traits of the five-factor model are associated with effort–reward imbalance at work. *Journal of Occupational and Environmental Medicine, 54*. doi: 10.1097/JOM.0b013e31824fe0e4

van de Laar, M., Verbeek, I., Pevernagie, D., Aldenkamp, A., & Overeem, S. (2010). The role of personality traits in insomnia. *Sleep Medicine Reviews, 14*, 61-68. doi: 10.1016/j.smrv.2009.07.007

Van Dongen, H. P. A., Vitellaro, K. M., & Dinges, D. F. (2005). Individual differences in adult human sleep and wakefulness: Leitmotif for a research agenda. *Sleep, 28*, 479-496. doi: -

Venn, A. J., Thompson, R. J., Schmidt, M. D., Cleland, V. J., Curry, B. A., Gennat, H. C., & Dwyer, T. (2007). Overweight and obesity from childhood to adulthood: A follow-up of participants in the 1985 Australian Schools Health and Fitness Survey. *Medical Journal of Australia, 186*, 458-460. doi: -

Williams, P. G., & Moroz, T. L. (2009). Personality vulnerability to stress-related sleep disruption: Pathways to adverse mental and physical health outcomes. *Personality and Individual Differences, 46*, 598-603. doi: 10.1016/j.paid.2008.12.017

Vincent, N., Cox, B., & Clara, I. (2009). Are personality dimensions associated with sleep length in a large nationally representative sample? *Comprehensive Psychiatry, 50*, 158-163. doi: 10.1016/j.comppsych.2008.07.007

Wittchen, H.-U. (1994). Reliability and validity studies of the WHO - Composite International Diagnostic Interview (CIDI): A critical review. *Journal of Psychiatric Research, 28*, 57-84.

Table 1. Descriptive Statistics of the Study Samples.

	Australian sample (N =1104)				Finnish sample (N = 1623)			
Variable	Mean	SD	Number	%	Mean	SD	Number	%
Age at baseline	36.5	2.6			37.7	5.0		
Sex								
Women			687	62.2			942	58.0
Men			417	37.7			681	42.0
Neuroticism (1-5)[1]	2.49	0.67			2.37	0.67		
Extraversion (1-5)[1]	3.48	0.49			3.40	0.54		
Openness (1-5)[1]	3.33	0.51			3.18	0.53		
Agreeableness (1-5)[1]	3.77	0.44			3.69	0.49		
Conscientiousness (1-5)[1]	3.87	0.52			3.70	0.55		
Sleep Duration	7.41	0.98			7.40	0.83		
Sleep deficiency	0.59	1.03			0.48	0.86		
Sleep problems					3.23	1.51		

[1] Theoretical range. Non-standardized values are shown for personality traits.

Table 2. Linear Regressions on associations for personality traits with sleep duration.

	AUSTRALIAN DATA (n=1104)					FINNISH DATA (n= 1623)				
	B	SE	R^2 *change*	Adjusted *R^2*	*p*	B	SE	R^2 *change*	Adjusted *R^2*	*p*
Neuroticism										
Model 1	-0.034	.029	.001	.029	.242	-0.035	.021	.002	.027	.085
Model 5	-0.032	.036	.001	.044	.375	0.001	.028	.000	.051	.974
Extraversion										
Model 1	-0.020	.029	.000	.028	.496	-0.006	.020	.000	.025	.751
Model 5	-0.070	.035	.003	.044	.047	-0.043	.026	.002	.051	.095
Openness										
Model 1	-0.022	.029	.001	.028	.447	0.031	.021	.001	.027	.131
Model 5	-0.017	.031	.000	.044	.577	0.011	.022	.000	.051	.624
Agreeableness										
Model 1	0.081	.030	.006	.034	**.007**	0.091	.021	.012	.037	**<.001**
Model 5	0.075	.031	.005	.044	.017	0.083	.022	.008	.051	**<.001**

Conscientiousness										
Model 1	0.045	.029	.002	.030	.128	-0.006	.020	.000	.025	.758
Model 5	0.041	.033	.001	.044	.215	-0.008	.022	.000	.051	.719

Model 1 - adjusted for age and gender. Models 2 - 4 are presented in a Supplementary table on the web site.

Model 5 - adjusted for age, gender, education, working full time, Irregular working times / shift work, BMI, alcohol consumption, smoking, physical activity, depression, and other five factor personality traits.

Note: All traits are analyzed with separate analyses. The traits are standardized (mean=0, standard deviation=1) and therefore B represents change in outcome variable per 1 SD change in the given personality trait.

Table 3. Linear Regressions on associations for personality traits with sleep deficiency.

	AUSTRALIAN DATA (n=1104)					FINNISH DATA (n=1623)				
	B	SE	R^2 *change*	Adjusted *R^2*	*p*	B	SE	R^2 *change*	Adjusted *R^2*	*p*
Neuroticism										
Model 1	0.162	.031	.024	.022	**<.001**	0.150	.021	.030	.032	**<.001**
Model 5	0.138	.038	.011	.035	**<.001**	0.090	.029	.006	.043	**.002**
Extraversion										
Model 1	-0.092	.031	.008	.006	**.003**	-0.095	.021	.012	.015	**<.001**
Model 5	0.020	.037	.000	.035	.587	-0.016	.027	.000	.043	.560
Openness										
Model 1	-0.007	.031	.000	-.002	.830	-0.011	.022	.000	.003	.601
Model 5	-0.023	.033	.000	.035	.489	0.011	.023	.000	.043	.635
Agreeableness										
Model 1	-0.055	.032	.003	.001	.082	-0.093	.022	.011	.014	**<.001**
Model 5	-0.024	.033	.001	.035	.464	-0.056	.023	.004	.043	.016

Conscientiousness										
Model 1	-0.097	.031	.009	.007	**.002**	-0.052	.021	.004	.006	.015
Model 5	-0.044	.035	.001	.035	.214	0.003	.023	.000	.043	.884

Model 1 - adjusted for age and gender. Models 2 - 4 are presented in a Supplementary table on the web site.

Model 5 - adjusted for age, gender, education, working full time, Irregular working times / shift work, BMI, alcohol consumption, smoking, physical activity, depression, and other five factor personality traits.

Note: All traits are analyzed with separate analyses. The traits are standardized (mean=0, standard deviation=1) and therefore B represents change in outcome variable per 1 SD change in the given personality trait.

Table 4. Ordinal Regressions on associations for personality traits with sleep problems (n = 1623).

	Sleep problems			
	LnOR	SE	OR	*p*
Neuroticism				
Model 1	0.498	0.046	1.645	**<.001**
Model 5	0.260	0.062	1.297	**<.001**
Extraversion				
Model 1	-0.362	0.045	0.696	**<.001**
Model 5	-0.175	0.058	0.839	**.002**
Openness				
Model 1	0.037	0.045	1.038	.403
Model 5	0.108	0.049	1.114	.029
Agreeableness				
Model 1	-0.243	0.045	0.784	**<.001**
Model 5	-0.100	0.049	0.905	.044
Conscientiousness				
Model 1	-0.196	0.045	0.822	**<.001**
Model 5	0.000	0.050	1.000	1.000

Model 1 - adjusted for age and gender.

Models 2 - 4 are presented in a Supplementary table on the web site.

Model 5 - adjusted for age, gender, education, working full time, Irregular working times / shift work, BMI, alcohol consumption, smoking, physical activity, depression, and other five factor personality traits.

LnOR = Logarithmic Odds Ratios

OR = Odds Ratios calculated as exp(LnOR)

Note: All traits are analyzed with separate analyses.