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Structural equation modelling for the effect of physical exercise on excessive daytime sleepiness

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ABSTRACT

Objectives: The present study aimed to examine the effect of physical exercise on excessive daytime sleepiness (EDS) which is a significant public health problem.

Study design: This is a population-based cohort study.

Methods: We hypothesized that those who engage in regular exercise would have lower chances of dozing in the daytime and examined causal relationships between EDS and known risk factors for EDS using structural equation model (SEM).

Results: We found that causal relationships from both depression and sleep quality to EDS were relatively weaker in those who regularly engage in physical exercise, which resulted in lower chances of having EDS.

Conclusion: Regular exercise may play a protective role in EDS prevention.

Introduction

Sleepiness is a physiological state that promotes the onset of sleep. Excessive daytime sleepiness (EDS) is a persistent sleepiness during the daytime, and it can induce an impaired daytime functioning with tiredness or fatigue together. Specifically, EDS has known to greatly increase the risk of involvement in automobile accidents,[1] which draws people's attention, and it is now a significant public health problem.

The prevalence rates of EDS in the general population were estimated as high as 18% in the USA[2] and 15.3% in Australia.[3] Common causes of EDS are insufficient sleep and poor sleep quality.[1] Although EDS is associated with a wide range of neurological, pulmonary and psychological disorders,[4] both sleep quantity and sleep quality of healthy controls are easily influenced by various external factors in their daily lives. However, their impacts on EDS are under-recognized among the general population; so, appropriate remedy or prevention for EDS is often ignored.

Recently, physical exercise has known to have anti-inflammatory effect by altering cytokine responses and that can reduce the chance of EDS.[5] Inflammatory responses are associated with obesity, type II diabetes, heart failure and obstructive sleep apnoea syndrome (OSAS)[6–9] and those diseases are inter-related with poor sleep quality or insufficient sleep both directly or indirectly. Also, poor sleep quality and

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insufficient sleep are known to associated with the depression status of people,[10–12] and exercise has a potential to treat depression.[13] Thus, various factors are inter-correlated with EDS, and it is not easy to single one out for prevention or remedy for EDS.

The purpose of the present study is to examine the effect of physical exercise on EDS regarding the inter-correlation among risk factors based on causal inference. We hypothesized that those who regularly engage in physical exercise would have lower chances of EDS in comparison with those who did not.

Methods

Study design

Study subjects were recruited from March, 2007 to March, 2009 at the Korea University Ansan Medical Center (KUAMC) as a subset of the Korean Genome and Epidemiology Study (KoGES), an ongoing population-based cohort study since 2001. Subjects were permanent residents of Ansan city, Korea, and aged over 45 years. Individuals who might have abnormal sleep patterns during the study period were excluded from the data analysis: (1) shift workers (194); and (2) anyone who is diagnosed with chronic illness (409) such as diabetes, myocardial infarction, thyroid, asthma, chronic obstructive pulmonary disease, and psychological symptoms. A total of 2168 subjects were included in the data analysis, and written informed consent was obtained from each subject after the study protocol was approved by the institutional review board of KUAMC.

Measures

Epworth sleepiness scale

Epworth sleepiness scale (ESS) is a self-administered questionnaire regarding general level of daytime sleepiness with eight questions.[14] Each item is rated on a 4-point Likert-type scale, and the questions ask individuals to rate the usual chances of dozing off or falling asleep in their daily lives. Total score, the sum of all items, ranges from 0 to 24, and the higher scores indicate a higher chance of daytime sleepiness. The ESS does not usually show any difference between healthy men and healthy women nor do they significantly vary with age.[15]

Pittsburgh sleep quality index

The Pittsburgh sleep quality index (PSQI) consists of 19 items with seven component scores: subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbance, use of sleeping pill, and daytime dysfunction.[16] As a standardized measure for the subjective sleep quality, lower global PSQI scores indicate better sleep quality, and some clinical studies have assessed sleep problems based on PSQI.[17,18]

Beck depression inventory

Beck's depression inventory (BDI) is one of the most widely used questionnaires to measure the severity of depression. It consists of 21 multiple-choice questions, and total BDI score ranges from 0 to 63. Higher total BDI score indicates more severe depressive symptoms. Its internal consistency has been reported from 0.73 to 0.92.[19] Severe depression can cause inability to stay asleep or a loss of sleep; so, BDI was used to measure the depression level of each participant. There was no specific screening procedure for clinical depression.

Demographic and socio-behavioural information

Each participant self-reported his or her demographic information such as gender and age. Height and weight were measured by licensed clinicians at KUAMC on his or her visit, and body mass index (BMI) was calculated with those measures. The participants also self-reported their marriage status, religion, smoking status, alcohol intake, physical exercise engagement, and average sleep duration.

Determinant of engagement in physical exercise

Individuals were asked whether they were regularly engaged in physical exercise or not for 6 months at least, and they were classified into two groups according to their responses. Group 1 is 'healthy controls with no engagement in physical exercise' and Group 2 is 'healthy controls with engagement in physical exercise'. A total of 1338 participants (61.72%) belonged to Group 2 in the present study.

Statistical analyses

We conducted structural equation modelling to examine causal relationships among variables and compare the difference of the estimates between Group 1 (healthy controls with no engagement in physical exercise) and Group 2 (healthy controls with engagement in physical exercise), which were derived from the final model. Structural equation model has been substantively used to assess or modify theoretical models,[20,21] and it offers great potential to test relationships as a comprehensive means although its relative sophistication is often criticized. We hypothesized that 'physical exercise' has a protective role in EDS under the assumption that other covariates are the same between two groups. Firstly, we derived global scores for depression, sleep quality and EDS from BDI, PSQI and ESS according to the protocols. Then, all possible paths were considered among them with manifest variables (age, sleep duration, weight, height, and BMI) in path diagram with Group 1 (healthy controls who were not engaged in physical exercise), and statistically insignificant paths were removed based on their P-values under $\alpha = 0.05$. The goodness of fitness for the final model was evaluated with fit indices such as standardized root-mean-square residual (RMR), goodness-of-fit index (GFI), adjusted GFI, Bentler's comparative fit index (CFI).[19] Typically, if GFI, adjusted GFI, Bentler's CFI are greater than 0.9, the model is regarded as having a good fit. According to the path diagram of Group 1, we fitted the same model to Group 2, and examined the difference in estimates between Group 1 and Group 2.

Besides, general characteristics of participants were summarized using descriptive statistics (mean ± standard deviation for continuous variables, the number of observations [%] for discrete variables). All statistical analyses were performed with SAS version 9.4 (SAS Institute Inc, Cary, NC).