Effects of Sleep on Health-Related Quality of Life in Patients

With Coronary Heart Disease
Abstract

Sleep problems have been associated with a wide range of adverse health outcomes and are common in patients with coronary heart disease (CHD). Even though research working with these patients has frequently used the Pittsburgh Sleep Quality Index (PSQI) as a self-report measure to assess sleep quality, its factor structure has yet to be validated in this population. Therefore, the first aim of this study is to examine the factor structure of the PSQI in CHD patients. Additionally, this study also investigated both the cross-sectional and longitudinal relationships between sleep and health-related quality of life. Participants in the study included 167 patients with CHD enrolled in a cardiac rehabilitation program, and 109 of them also completed follow-up assessments three months later. Results from the confirmatory factor analysis revealed that the proposed two-factor structure with sleep efficiency and perceived sleep quality best fitted the data. Subsequent analyses using structural equation modelling found that sleep quality, but not sleep efficiency, significantly predicted emotional, physical, and social quality of life. Sleep quality was also found to predict physical and social quality of life, but not emotional quality of life, three months later. These findings demonstrated the usefulness of assessing sleep in terms of its dimensions, and that improving sleep quality is key to enhancing quality of life in cardiac patients.

Keywords: heart disease, sleep quality, sleep efficiency, quality of life.
Effects of Sleep on Health-Related Quality of Life in Patients With Coronary Heart Disease

Sleep complaints appear to be rather common in the modern society (Nowicki et al., 2016; Ohayon, 2002), with an estimated one-third of the adult population experiencing problems with their sleep (Doi, Minowa, Uchiyama, & Okawa, 2001; Kuppermann et al., 1995). Those with sleep problems often reported issues such as not getting enough sleep, suffering from poor quality sleep, and difficulties initiating or maintaining their sleep (Ohayon, 2002). Although the effects of poor sleep are not immediately apparent, it can nonetheless lead to a wide range of adverse outcomes. For example, sleep problems were found to affect both academic (Curcio, Ferrara, & De Gennaro, 2006) and work performance (Manocchia, Keller, & Ware, 2001).

Alterations to sleep can also lead to subsequent biological changes in the body, and this can have important health consequences. Knutson et al. (2009) showed that both poor sleep maintenance and short sleep duration were linked to higher blood pressure in young and middle aged adults. Other studies have found sleep impairments to be associated with severe mental and physical health issues, including depression and anxiety (Morphy, Dunn, Lewis, Boardman, & Croft, 2007), chronic diseases such as cardiovascular disease (Sands-Lincoln et al., 2013), and even deaths (Cappuccio, D'Elia, Strazzullo, & Miller, 2010).

Sleep and Cardiovascular Disease

According to the World Health Organization (WHO, 2015), cardiovascular diseases (CVD), including coronary heart disease (CHD), are the leading cause of mortality in the world. Although interventions such as diet control, increased physical activity, and decreased alcohol use have been proposed for CVD control and prevention (WHO, 2015), previous works have also observed strong links between sleep and CVD. For example, Sands-Lincoln et al. (2013) found that women with exceptionally long or short sleep duration were more
likely to develop CHD and CVD after controlling for age and race. However, this relationship lost significance when other demographic characteristics and comorbidities were included. High insomnia scores, on the other hand, remained significantly associated with increased risk of CHD and CVD even after adding these covariates.

Sleep complaints are also common in patients already diagnosed with CHD (Denollet, 1994). Norra et al. (2012) found that more than two-third of their 94 heart disease patients had sleep difficulties, and those reporting problems with sleep quality and daytime dysfunction were more likely to exhibit depressive symptoms. In addition, Leineweber, Kecklund, Janszky, Åkerstedt, and Orth-Gomér (2003) found that poor sleep quality was linked to higher risk of severe or acute events, such as surgeries and deaths related to the cardiovascular systems, as well as heart attack in CHD patients. These findings indicate the need for more extensive studies on sleep in the heart disease population in order to have a clearer understanding of the benefits of adequate, good quality sleep.

Sleep and Health-Related Quality of Life

Sleep can also affect quality of life. The health-related quality of life (HRQoL), which focuses on the health aspects of a patient’s wellbeing, is often used as an indicator of health status (Kyle, Morgan, & Espie, 2010). Particularly, HRQoL represents the patient’s perception of the treatment and effects of a disease on his emotional, physical, and social aspects of functioning (Sevinç & Akyol, 2010; Stafford, Berk, Reddy, & Jackson, 2007). Poor HRQoL has also been associated with other adverse health outcomes. For example, through a five-year follow-up study, Hansen et al. (2015) found HRQoL to be predictive of subsequent hospitalizations and mortality in patients with ischaemic heart disease.

Previous studies have investigated the relationship between sleep and HRQoL. Manocchia et al. (2001) showed that the severity of sleep problems reported by patients with chronic diseases was associated with lower physical and mental HRQoL. Similar results
showing the relationship between sleep problems and HRQoL have been observed in patients with type 2 diabetes (Luyster & Dunbar-Jacob, 2011) and heart failure (Broström, Strömberg, Dahlström, & Fridlund, 2004). However, these results were based on cross-sectional data, and longitudinal studies examining sleep and HRQoL are lacking. A study by Faubel et al. (2009) did include longitudinal assessments, but reported that sleep duration did not predict changes in HRQoL two years later.

**Dimensions of Sleep**

The Pittsburgh Sleep Quality Index (PSQI; Buysse, Reynolds, Monk, Berman, & Kupfer, 1989) is a widely used measure to assess sleep quality. It consists of seven sleep components, such as subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, sleep medication use, and daytime dysfunction. Although the component scores have often been summed to obtain a global sleep quality score, studies have provided compelling evidence that the PSQI is not unidimensional, and that the seven components reflected either two (sleep efficiency and perceived sleep quality) or three (sleep efficiency, perceived sleep quality, and daily disturbances) sleep factors. Magee, Caputi, Iverson, and Huang (2008) showed that the two-factor solution with the sleep efficiency factor, consisting of the sleep duration and habitual sleep efficiency components, and the perceived sleep quality factor, consisting of the subjective sleep quality, sleep latency, sleep medication use, sleep disturbances, and daytime dysfunction components, better represented the PSQI. In contrast, Cole et al. (2006) found that the PSQI was best represented by three latent factors, involving the same two factors of sleep efficiency and perceived sleep quality, but with the sleep disturbances and daytime dysfunction components in the additional daily disturbances factor. These findings suggest that utilising the factor scores may be more valid than the global score in assessing sleep.
However, few studies have investigated how these factors were associated with other health-related constructs. Nicassio et al. (2014) tested the factor structure of the PSQI using confirmatory factor analysis and found that the two-factor solution with sleep efficiency and perceived sleep quality best fitted the data. The researchers proceeded to correlate the factor scores with other measures and found that sleep quality had significant correlations with measures of illness beliefs, fatigue, depression, vitality, and both physical and mental functioning, whereas sleep efficiency was only correlated with fatigue, vitality, and mental functioning. On the other hand, Chasens, Korytkowski, Sereika, and Burke (2013) directly scored the PSQI by the three factors of sleep efficiency, perceived sleep quality, and daily disturbances in their study of diabetes patients, and found that both perceived sleep quality and daily disturbances, but not sleep efficiency, had significant relationships with many of the diabetes self-management subscales.

The Current Study

Although past studies have examined the effects of sleep on HRQoL, there appears to be a lack of research studying this association in heart patients. Additionally, most of these studies have only focused on one specific aspect of sleep, such as sleep duration (Faubel et al., 2009), subjective sleep quality (Nunes et al., 2009), or sleep disturbances (Baldwin et al., 2010). Thus, it remains unclear which aspect of sleep is most related to HRQoL. This suggests a need to include multiple sleep dimensions in a single study when assessing sleep and HRQoL. The PSQI is a suitable measure to achieve this objective, as various studies have provided evidence supporting its multidimensionality (Cole et al., 2006; Magee et al., 2008). However, in order to use the sleep dimension scores, the factor structure of the PSQI must first be determined. This is in contrast to the study by Chasens et al. (2013) which directly used the factor scores without first ascertaining its factor structure, raising potential questions about the validity of their factors. To date, the factor structure of the PSQI has yet to be
validated in patients with cardiovascular or heart disease, even though the measure has been frequently used in research with heart disease patients (Freitas et al., 2011; Norra et al., 2012; Skobel et al., 2005). Therefore, this study is the first to examine the factor structure of the PSQI in CHD patients via confirmatory factor analysis.

Moreover, previous studies mainly used cross-sectional data, while the current study also included longitudinal assessment to probe the temporal relationship between sleep and HRQoL. Furthermore, most studies used regression analyses (Faubel et al., 2009; Luyster & Dunbar-Jacob, 2011; Nunes et al., 2009), whereby only one dependent variable could be examined at any one time. In contrast, structural equation modelling (SEM) can be used to simultaneously study the effects of several independent variables on several dependent variables. As such, SEM is used to examine the effects of the different sleep dimensions on the emotional, physical, and social HRQoL domains.

Therefore, the current study aims to address several research questions, including 1) examining the factor structure of the PSQI, 2) investigating which dimension of sleep is associated with emotional, physical, and social HRQoL, and 3) whether the sleep dimensions at baseline are predictive of subsequent HRQoL domains three months later in CHD patients.

Methods

Participants

A total of 167 participants enrolled in a cardiac rehabilitation program were recruited in the study. The age of the participants ranged from 36 to 85 (\(M = 63.28, SD = 8.88\)). There were 137 (82.0%) men and 30 (18.0%) women. Majority were Chinese (83.2%), followed by Indian (10.2%), Malay (1.2%), and other Asians or Eurasians (5.4%). Participants were eligible for the study if they were at least 21 years of age and diagnosed with CHD. Those with severe life-threatening or psychiatric illnesses were excluded. A subset of 109 participants also completed follow-up assessment three months later.
Procedures

Participants were approached and introduced to the study during their cardiac rehabilitation session. After obtaining their informed consent, a demographic and medical interview was conducted before they were asked to complete a set of questionnaires. Three months after the baseline assessment, participants were asked to complete the same set of questionnaires again. They were paid and compensated for their effort. Their medical records were also reviewed to retrieve their medical history and comorbidities.

Measures

**Demographic and medical information.** Demographics, such as age, gender, ethnicity, education level, and type of residence were collected in the study. The participants’ medical records were also examined for a list of health and medical history information.

**Sleep quality.** The Pittsburgh Sleep Quality Index (PSQI; Buysse et al., 1989) is a 19-item scale to measure sleep quality. It includes seven components, with each component score ranging from ‘0’ to ‘3’. The sum of the seven sleep components forms a global score, with higher scores indicating poorer sleep quality. A global score of more than ‘5’ is associated with poor sleep quality. The PSQI has displayed high internal consistency with a Cronbach’s alpha of .83 and high temporal stability with a test-retest reliability index of .85.

**Health-related quality of life.** The MacNew Heart Disease Health-related Quality of Life questionnaire (MacNew HRQoL; Höfer, Lim, Guyatt, & Oldridge, 2004) is a disease-specific instrument used specifically to measure the quality of life in heart disease patients. It consists of three domains - emotional, physical, and social HRQoL, with response ranging from ‘1’ *(all of the time)* to ‘7’ *(none of the time)*. Higher scores indicated better HRQoL. The three domains of the MacNew HRQoL have shown high internal consistency with Cronbach’s alphas ranging from .93 to .95 (Valenti, Lim, Heller, & Knapp, 1996).
**Control variables.** Demographics, such as age, gender, ethnicity, education level, and type of residence were included as covariates in the models examining sleep and HRQoL. As most respondents were Chinese, ethnicity was coded to ‘1’ for Chinese, and ‘0’ for others. In consideration of the large number of medical variables from the participants’ medical records, a bivariate correlation was conducted and only medical variables that had $p$ values of .1 and below with at least one of the three HRQoL domain scores were kept as covariates.

**Statistical Analysis**

**PSQI factor structure.** Confirmatory factor analysis (CFA) was conducted using Mplus 6 (Muthén & Muthén, 1998-2010) to examine the factor structure of the PSQI. In view of the ordinal scoring of the PSQI components, the mean and variance-adjusted weighted least squares (WLSMV) estimator was used as it is suitable for handling non-normal data. Other than fitting the original one-factor model by Buysse et al. (1989), the two-factor model by Magee et al. (2008) and three-factor model by Cole et al. (2006) were also tested. Model fit was assessed by multiple fit indices, including the chi-square ($\chi^2$) test, comparative fit index (CFI; Bentler, 1990), Tucker-Lewis index (TLI; Tucker & Lewis, 1973), and root mean square error of approximation (RMSEA; Steiger, 1990). A non-significant $\chi^2$ test indicates that the model fits the data well. Additionally, a CFI and TLI of .95 and above have been suggested to indicate good model fit (Hu & Bentler, 1999). Lastly, RMSEA values of above .10 indicate poor fit, while values of .08 and below indicate fair fit, and values of .05 and below indicate close model fit (Browne & Cudeck, 1992).

**Sleep and HRQoL.** SEM was used to investigate the cross-sectional relationship between the sleep dimensions and HRQoL domains. Following the CFA results, composite sleep dimension scores were computed according to the model with best overall fit. These scores were used as the exogenous variables. The endogenous variables were the time 1 (baseline) emotional, physical, and social HRQoL scores, and the residuals were allowed to
covary in the model. Demographic and medical covariates were also included. The Maximum-Likelihood estimator was used for this analysis as the HRQoL domains were measured on a continuous scale. The same fit indices were used to assess model fit before the standardized path estimates were examined. Certain paths in the model could subsequently be constrained, and the $\chi^2$ difference test was used to compare between the constrained and unconstrained model due to their nested relationship. A non-significant $\chi^2$ difference test indicates that the constrained (more parsimonious) model did not fit significantly worse and is thus favoured over the unconstrained model.

To assess the longitudinal relationship, three separate models were fitted. The first model included the sleep dimensions as the exogenous variables, and both time 1 and time 2 emotional HRQoL (assessed three months after baseline) as the endogenous variables. The time 1 and time 2 emotional HRQoL were also regressed on the same demographic and medical covariates. Furthermore, time 2 emotional HRQoL was also controlled for time 1 emotional HRQoL. The second model was similar to the first, except that the time 1 and time 2 emotional HRQoL were replaced with time 1 and time 2 physical HRQoL respectively. Likewise, the last model was fitted with time 1 and time 2 social HRQoL.

**Results**

**Descriptive Statistics**

Out of the 167 participants, 76 (45.5%) had poor sleep quality as indicated by their global PSQI score of more than ‘5’. It was particularly noted that only eight participants (4.8%) had used sleep medication in the past two weeks. The 109 participants who completed the follow-up assessments three months later did not differ significantly with those who did not in terms of age, gender, ethnicity, education level, or type of residence ($p > .05$). The two groups also did not differ significantly in the proportion of sample experiencing poor sleep quality based on the global PSQI cut-off score ($p > .05$).
PSQI Factor Structure

The one-, two-, and three-factor models were fitted and the factor loadings of the sleep medication item in all three models were very low and not significant. Thus, each model was fitted again without this item. The fit indices for the six CFA models are shown in Table 1. Both the two- and three-factor models without the sleep medication item appear to have a better fit over the other models. A graphical representation of these two models with the factor loadings and correlations is shown in Figure 1, while illustrations of other models can be found in Appendix A. Based on the fit indices, the two-factor model has the best overall fit. Furthermore, the very high factor correlation of .861 between perceived sleep quality and daily disturbances in the three-factor model suggests a need to merge the two factors, and this is essentially the two-factor solution. Therefore, the two-factor model without the sleep medication item was ultimately chosen as the most optimal model.

Table 1

Model Fit Indices for the Six Models Fitted

<table>
<thead>
<tr>
<th>Model</th>
<th>χ²(df)</th>
<th>p</th>
<th>CFI</th>
<th>TLI</th>
<th>RMSEA</th>
</tr>
</thead>
<tbody>
<tr>
<td>One-factor model with sleep medication item</td>
<td>65.65 (14)</td>
<td>.000</td>
<td>.844</td>
<td>.766</td>
<td>.149</td>
</tr>
<tr>
<td>One-factor model without sleep medication item</td>
<td>53.48 (9)</td>
<td>.000</td>
<td>.875</td>
<td>.792</td>
<td>.172</td>
</tr>
<tr>
<td>Two-factor model with sleep medication item</td>
<td>31.40 (13)</td>
<td>.004</td>
<td>.944</td>
<td>.910</td>
<td>.092</td>
</tr>
<tr>
<td>Two-factor model without sleep medication item</td>
<td>14.01 (8)</td>
<td>.082</td>
<td>.983</td>
<td>.968</td>
<td>.067</td>
</tr>
<tr>
<td>Three-factor model with sleep medication item</td>
<td>29.75 (11)</td>
<td>.002</td>
<td>.943</td>
<td>.892</td>
<td>.101</td>
</tr>
<tr>
<td>Three-factor model without sleep medication item</td>
<td>12.72 (6)</td>
<td>.048</td>
<td>.981</td>
<td>.953</td>
<td>.082</td>
</tr>
</tbody>
</table>

Note. CFI = comparative fit index; TLI = Tucker-Lewis index; RMSEA = root mean square error of approximation.
Figure 1. Confirmatory factor analysis models showing the factor loadings and factor correlations of the two- and three-factor structure without the sleep medication indicator.

***p < .001.

Cross-Sectional Analysis of Sleep and HRQoL

Based on the CFA results, a sleep efficiency and perceived sleep quality composite score were obtained by summing the scores of their respective sleep components for use in the analysis. Results from the bivariate correlation between the medical variables and HRQoL domains revealed that history of angina pectoris, coronary artery bypass graft, valve
replacement or repair surgery, diabetes, and cancer had $p$ values of .1 and below. These variables were thus included as controls alongside the demographic variables.

The cross-sectional analysis examining sleep efficiency, perceived sleep quality, and the three HRQoL domains was conducted. The model fit was good, $\chi^2(20) = 18.79, p = .535$; $\text{CFI} = 1.00; \text{TLI} = 1.00; \text{RMSEA} = .000$, but the effects of sleep efficiency on emotional ($\beta = -.013, p = .856$), physical ($\beta = -.062, p = .385$), and social ($\beta = -.076, p = .334$) HRQoL were very weak and not significant. Consequently, the model was constrained by fixing these three paths to ‘0’. Thus, this model assumes that sleep efficiency has no impact on emotional, physical, and social HRQoL (see Figure 2). The fit of the constrained model remained acceptable, $\chi^2(23) = 20.16, p = .632$; $\text{CFI} = 1.00; \text{TLI} = 1.00; \text{RMSEA} = .000$. The $\chi^2$ difference test was not significant, $\chi^2(3) = 1.37, p = .714$, and therefore, the constrained model was chosen over the unconstrained model.

* * * $p < .001$.

Poor sleep quality was significantly related to lower emotional ($\beta = -.469, p < .001$), physical ($\beta = -.441, p < .001$), and social ($\beta = -.343, p < .001$) HRQoL after adjusting for

![Figure 2. Constrained model illustrating the effects of sleep efficiency and sleep quality on emotional, physical, and social HRQoL. Values shown are the standardized path estimates.](image-url)
demographic and medical covariates. The negative path estimates were not surprising as higher sleep scores represented poorer sleep, whereas higher HRQoL scores represented better quality of life. The $R^2$ of the emotional HRQoL was .304, indicating that 30.4% of the variance in the emotional HRQoL was explained in this model. The $R^2$’s of the physical and social HRQoL were .300 and .162 respectively.

**Longitudinal Analysis of Sleep and HRQoL**

The longitudinal analysis was conducted by first fitting the model with both time 1 and time 2 emotional HRQoL and the covariates. However, the model had inadequate fit due to the inclusion of covariates that did little to explain the endogenous variables. Thus, the model was modified by removing the covariates if their effects on the endogenous variables were not significant ($p > .05$), while basic demographic variables such as age, gender, and education remained regardless of their significance. The same procedure was carried out for the physical and social HRQoL models.

In the analysis of sleep and emotional HRQoL, the covariates type of residence and cancer significantly affected time 1 and time 2 emotional HRQoL respectively. Thus, these paths were kept in the model. Particularly, other than controlling for age, gender, and education on both time 1 and time 2 emotional HRQoL, time 1 emotional HRQoL was also controlled for type of residence, while time 2 emotional HRQoL was also controlled for cancer. The model had a good fit, $\chi^2(12) = 14.78, p = .254; \text{CFI} = .982; \text{TLI} = .977; \text{RMSEA} = .046$. Refer to Figure 3 for an illustration of the model.

Results showed that time 1 emotional HRQoL strongly predicted time 2 emotional HRQoL. The effects of sleep efficiency on both time 1 ($\beta = .000, p = .995$) and time 2 emotional HRQoL ($\beta = .051, p = .435$) were not significant. In contrast, sleep quality predicted time 1 ($\beta = -.533, p < .001$) but not time 2 emotional HRQoL ($\beta = -.071, p = .349$) after controlling for time 1 levels. Overall, neither sleep quality nor sleep efficiency predicted
time 2 emotional HRQoL over and beyond the contribution of time 1 emotional HRQoL. The $R^2$ of the time 2 emotional HRQoL was .619.

Figure 3. Model illustrating the effects of sleep efficiency and sleep quality on time 2 emotional HRQoL after controlling for time 1 emotional HRQoL. Values shown are the standardized path estimates.

***$p < .001$. 

In the analysis of sleep and physical HRQoL, only the covariates cancer and ethnicity had a significant impact on time 1 and time 2 physical HRQoL respectively and thus, these paths were kept in the model. The fit indices indicated good model fit, $\chi^2(12) = 13.22, p = .353; CFI = .990; TLI = .987; RMSEA = .031$, but the effects of sleep efficiency on both time 1 ($\beta = .001, p = .995$) and time 2 physical HRQoL ($\beta = .022, p = .762$) were very weak and not significant. Consequently, the model was constrained by fixing these two paths to ‘0’. This model assumed that sleep efficiency did not have an effect on either time 1 or time 2 physical HRQoL (see Figure 4). The constrained model had a good fit, $\chi^2(14) = 13.31, p = .502; CFI = 1.00; TLI = 1.00; RMSEA = .000$. The $\chi^2$ difference test was not significant, $\chi^2(2) = 0.09, p = .956$, and therefore, the constrained model was chosen over the unconstrained model.
Results showed that time 1 physical HRQoL significantly predicted time 2 physical HRQoL. More importantly, sleep quality predicted not only time 1 ($\beta = -.466, p < .001$) but also time 2 physical HRQoL ($\beta = -.151, p = .048$) after controlling for time 1 levels. The $R^2$ of the time 2 physical HRQoL was .533.

Figure 4. Constrained model illustrating the effects of sleep efficiency and sleep quality on time 2 physical HRQoL, after controlling for time 1 physical HRQoL. Values shown are the standardized path estimates.

*p < .05. **p < .01. ***p < .001.

In the analysis of sleep and social HRQoL, only the covariate ethnicity had a significant impact on time 1 social HRQoL, and thus this path was kept in the model. The fit indices indicated good model fit, $\chi^2(9) = 8.88, p = .449$; CFI = 1.00; TLI = 1.00; RMSEA = .000, but the effects of sleep efficiency on both time 1 ($\beta = -.003, p = .970$) and time 2 social HRQoL ($\beta = -.011, p = .884$) were very weak and not significant. Consequently, the model was constrained by fixing these two paths to ‘0’. This model assumed that sleep efficiency did not have an effect on either time 1 or time 2 social HRQoL (see Figure 5). The constrained model had a good fit, $\chi^2(11) = 8.90, p = .631$; CFI = 1.00; TLI = 1.00; RMSEA = .000. The $\chi^2$ difference test was not significant, $\chi^2(2) = 0.22, p = .989$, and therefore, the constrained model was chosen over the unconstrained model.
Results showed that time 1 social HRQoL significantly predicted time 2 social HRQoL. More importantly, sleep quality predicted not only time 1 ($\beta = -0.458, p < .001$) but also time 2 social HRQoL ($\beta = -0.166, p = .034$) after controlling for time 1 levels. The $R^2$ of the time 2 social HRQoL was .474.

![Figure 5](image)

*Figure 5.* Constrained model illustrating the effects of sleep efficiency and sleep quality on time 2 social HRQoL after controlling for time 1 social HRQoL. Values shown are the standardized path estimates.

*p < .05. ***p < .001.

**Discussion**

**PSQI Factor Structure**

Results from the CFA revealed that the two-factor model with sleep efficiency and perceived sleep quality best represented the PSQI in patients with CHD. The sleep medication indicator was removed based on several considerations. Firstly, its factor loading was very low and did not reach significance, suggesting that sleep medication was a poor indicator of perceived sleep quality in this sample. Secondly, less than five percent of the participants in the study have reported using sleep medication in the past two weeks. The low usage could be due to the possible side effects associated with the medication.
Cross-Sectional Analysis of Sleep and HRQoL

Results from the SEM revealed that poorer perceived sleep quality, but not sleep efficiency, was associated with worse emotional, physical, and social HRQoL. The finding that sleep efficiency did not affect HRQoL is inconsistent with previous studies (Lima, Barros, & Alves, 2012; Stranges et al., 2008). Several reasons may be plausible for this observation. For example, sleep efficiency dimension in the current study included both sleep duration and habitual sleep efficiency, whereas existing studies focused solely on sleep duration (Lima et al., 2012; Stranges et al., 2008). Additionally, these studies did not simultaneously examine both the effects of sleep efficiency (or duration) and sleep quality on HRQoL (Faubel et al., 2009; Lima et al., 2012, Stranges et al., 2008). There is a possibility that the effect of sleep duration on HRQoL will diminish after sleep quality is accounted for in these studies.

The finding that poor sleep quality could lead to reduced HRQoL is in line with past studies (Luyster & Dunbar-Jacob, 2011; Nunes et al., 2009). Sleep quality can affect emotional HRQoL in several ways. For example, the presence of negative moods and the reduced ability to regulate them can contribute to a worse emotional HRQoL. Sonnentag, Binnewies, and Mojza (2008) found that poor sleep quality was a significant predictor of negative affect in the morning, even after accounting for sleep duration. Furthermore, poor sleep quality was also linked to impaired emotional regulation ability after controlling for sleep duration (Mauss, Troy, & LeBourgeois, 2013).

Fatigue due to poor quality sleep (Sonnentag et al., 2008) can also lead to worse physical HRQoL, as it was found to have limited the ability of CHD patients to carry out physical activities (Johansson et al., 2007). Additionally, poor sleep quality associated with reduced levels of slow-wave sleep was found to cause metabolic and hormonal dysfunctions
even when the total sleep time remained unchanged (Tasali, Leproult, Ehrmann, & Van Cauter, 2008).

The mechanism in which how poor sleep quality can lead to a lower social HRQoL is less clear. It was suggested that fatigue caused by poor sleep could lead to reduced interest and ability to participate in social activities (Cricco, Simonsick, & Foley, 2001; Small & Lamb, 1999). Those with poor sleep quality may also have trouble with emotion recognition, considering that poor sleep may impair emotional face processing (Soffer-Dudek, Sadeh, Dahl, & Rosenblat-Stein, 2011), which may hinder patients’ ability to maintain a positive social relationship.

**Longitudinal Analysis of Sleep and HRQoL**

Results from the longitudinal assessment provided some evidence suggesting a causal relationship between sleep quality and HRQoL. After adjusting for baseline physical HRQoL, sleep quality at baseline prospectively predicted further declines in physical HRQoL three months later. Similar pattern of results was found for social HRQoL.

In contrast, although sleep quality was concurrently associated with emotional HRQoL, such simultaneous relationship did not translate to further declines in emotional HRQoL three months later. One possible reason is that sleep quality affects emotional HRQoL on a more day-to-day basis, suggesting that any changes in sleep quality will result in an immediate change in emotional HRQoL accordingly. For instance, Sonnentag et al. (2008) have found that the quality of sleep at night was predictive of emotional states the next morning. Another possibility is that sleep quality did affect emotional HRQoL, but the MacNew HRQoL may not be sensitive enough to capture the changes in emotional HRQoL.

**Implications**

Findings from the current study have several important implications. Firstly, results from the CFA add on to the current literature, supporting the multidimensionality of the
PSQI. It is recommended that revisions to the PSQI scoring be made so that clinicians can easily pinpoint if a patient is suffering from poor sleep efficiency or sleep quality. Secondly, this study has found that poor sleep quality was associated with lower HRQoL in CHD patients. This suggests the need for clinicians to offer recommendations to improve sleep quality in heart patients, rather than merely focusing on increasing their sleep duration.

**Limitations and Future Directions**

Several limitations are noted. Firstly, the issue of reverse causation between sleep and HRQoL could not be eliminated. Although randomized controlled trials may help to address this, it is not ethically acceptable to manipulate sleep in patients with heart disease. Nevertheless, the longitudinal analysis provided further support for the causal relationship of sleep on HRQoL. Secondly, the current study only relied on subjective measures of sleep. Using objective assessments such as polysomnography can help to verify the results.

Future studies can look into establishing the clinical significance of scoring the PSQI by its sleep efficiency and perceived sleep quality dimensions. Other studies can assess sleep using a combination of subjective and objective sleep measures.

**Conclusion**

The current study has shown that the two-factor structure with the sleep efficiency and perceived sleep quality factors best represented the PSQI in patients with CHD. Furthermore, the sleep quality dimension predicted not only concurrent emotional, physical, and social HRQoL, but also physical and social HRQoL three months later. In contrast, the sleep efficiency dimension failed to predict any of these domains. This suggests that improving sleep quality is vital to enhancing quality of life in cardiac patients.
References


SLEEP AND QUALITY OF LIFE


Appendix A

Confirmatory Factor Analysis Models Fitted in the Study

Figure A1. Confirmatory factor analysis models showing the factor loadings and factor correlations of the one-factor structure with and without the sleep medication indicator.

***$p < .001$. 
Figure A2. Confirmatory factor analysis models showing the factor loadings and factor correlations of the two-factor and three-factor structure with the sleep medication indicator.

***p < .001.
Appendix B

Models Fitted for the Analysis of Sleep and Health-Related Quality of Life.

Figure B1. Unconstrained model illustrating the effects of sleep efficiency and sleep quality on emotional, physical, and social HRQoL based on cross-sectional data. Values shown are the standardized path estimates. For presentation clarity, covariates are not displayed.

***p < .001.

Figure B2. Unconstrained model illustrating the effects of sleep efficiency and sleep quality on time 2 physical HRQoL, after controlling for time 1 physical HRQoL. Values shown are the standardized path estimates.

*p < .05. ***p < .001.
Figure B3. Unconstrained model illustrating the effects of sleep efficiency and sleep quality on time 2 social HRQoL, after controlling for time 1 social HRQoL. Values shown are the standardized path estimates.

*p < .05. ***p < .001.
Appendix C

Measures Used in the Study.

Due to copyright regulations, only a number of sample items are shown for the MacNew Heath-Related Quality of Life questionnaire.

**PSQI (Pittsburgh Sleep Quality Index)**

The following questions are about your usual sleep habits during the past two weeks. Your answers should indicate the most accurate reply for the majority of days and nights in the past two weeks.

**During the past two weeks...**

1. What time have you usually gone to bed? ______________ am/pm
2. How long (in minutes) has it taken you to fall asleep each night? ______________ minutes
3. When have you usually gotten up in the morning or the next day? ______________ am/pm
4. How many hours of actual sleep do you get at night? (This may be different than the number of hours you spend in bed) ______________

<table>
<thead>
<tr>
<th>During the past two weeks, how often have you had trouble sleeping because you...</th>
<th>Not during the past two weeks (0)</th>
<th>Less than once a week (1)</th>
<th>Once or twice a week (2)</th>
<th>Three or more times a week (3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Cannot get to sleep within 30 minutes</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>b. Wake up in the middle of the night or early morning</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>c. Have to get up to use the bathroom</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>d. Cannot breathe comfortably</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>e. Cough or snore loudly</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>f. Feel too cold</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>g. Feel too hot</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>h. Have bad dreams</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>i. Have pain</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>
j. Other reason(s), please describe, including how often you have had trouble sleeping because of this reason(s):

<table>
<thead>
<tr>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
</table>

6. In the past two weeks, how often have you taken medicine (prescribed or “over-the-counter”) to help you sleep?

<table>
<thead>
<tr>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
</table>

7. During the past two weeks, how often have you had trouble staying awake while driving, eating meals, or engaging in social activity?

<table>
<thead>
<tr>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
</table>

8. During the past two weeks, how much of a problem has it been for you to keep up enthusiasm to get things done?

<table>
<thead>
<tr>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
</table>

9. During the past two weeks, how would you rate your sleep quality overall?

<table>
<thead>
<tr>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
</table>
This questionnaire is designed to find out how you have been feeling during the last two weeks. The questions that you will be asked are all related to the problems or feelings that heart patients often experience. You will be asked about some of the symptoms you may have experienced. For the following questions, please rate how often you exhibit this behavior and circle the number that best describes how you feel or experience.

<table>
<thead>
<tr>
<th>Question</th>
<th>Rating Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. How much time during the last two weeks have you felt frustrated, impatient or angry?</td>
<td>1 = All of the time, 2 = Most of the time, 3 = A good bit of the time, 4 = Some of the time, 5 = Little of the time, 6 = Hardly any of the time, 7 = None of the time</td>
</tr>
<tr>
<td>2. How often during the last two weeks have you felt worthless or inadequate?</td>
<td>1 = All of the time, 2 = Most of the time, 3 = A good bit of the time, 4 = Some of the time, 5 = Little of the time, 6 = Hardly any of the time, 7 = None of the time</td>
</tr>
<tr>
<td>3. In the last two weeks, how much time did you feel very confident and sure that you could deal with your heart problem?</td>
<td>1 = All of the time, 2 = Most of the time, 3 = A good bit of the time, 4 = Some of the time, 5 = Little of the time, 6 = Hardly any of the time, 7 = None of the time</td>
</tr>
</tbody>
</table>