OBSTRUCTIVE SLEEP APNEA:
CONSIDERATIONS FOR THE PRIMARY CARE PRACTITIONER

By

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A clinical project submitted in partial fulfillment of
the requirements for the degree of

MASTER OF NURSING

WASHINGTON STATE UNIVERSITY
Intercollegiate Center for Nursing Education

May 1998
To the Faculty of Washington State University:

The members of the Committee appointed to examine the clinical project of MARILYN J. HEDGES find it satisfactory and recommend that it be accepted.

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Obstructive sleep apnea (OSA) affects millions of Americans each year and is the most serious of the sleep disorders in terms of morbidity and mortality. Numerous studies have linked OSA to increased risk of hypertension, stroke, myocardial infarction, motor vehicle accidents, and cognitive and social impairment. OSA is caused by collapse or obstruction of the upper airway during sleep, which leads to frequent nocturnal arousals and sleep fragmentation. Patients usually present with a history of chronic snoring and daytime hypersomnolence. Children with OSA commonly snore but may not have daytime sleepiness. OSA can lead to poor growth and behavioral problems in children. Previous studies on adults have shown that daytime hypersomnolence, obesity, increased neck circumference, male gender, and hypertension are strongly associated with obstructive sleep apnea. In the present study, 20 clinical indicators taken from a questionnaire completed by 131 patients referred for OSA, were analyzed and correlated to the apnea-hypopnea index, or degree of OSA. Neck circumference, male gender, hypertension, and daytime hypersomnolence were found to have statistically significant correlations to OSA, thus substantiating prior research.

Diagnosis of obstructive sleep apnea is based on overnight polysomnography, which measures sleep staging, the number of obstructive respiratory events per hour, and other physiological parameters. The treatment of choice for adults is nasal continuous positive airway pressure (CPAP), a mask and blower device that is worn during sleep and acts as a pneumatic splint. Though research has shown CPAP to be effective and safe, patient compliance remains an issue. Behavioral changes, particularly lateral positioning during sleep, weight loss, and avoidance of alcohol and sedatives are beneficial. Limited success has been achieved with pharyngeal surgery, medications, and dental appliances. In children, adenotonsillectomy is usually effective.

Recommendations for the practitioner include particular awareness of these clinical indicators when making patient assessments, as well as patient education and supportive follow up in order to successfully treat patients suffering from this serious sleep disorder.
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Chapter One: Obstructive Sleep Apnea

Introduction

According to the National Commission on Sleep Disorders Research (1993), millions of Americans each year are adversely affected by the consequences of sleep disorders. Insomnia, obstructive sleep apnea, restless leg syndrome, and sleep pattern disruption related to shift work are common sleep disorders that disturb and destroy normal sleep patterns. Of these, obstructive sleep apnea is second only to insomnia in prevalence and the most serious in terms of morbidity and mortality. Obstructive sleep apnea (OAS) affects approximately 2-4% of middle-aged adults (Young, et al., 1993) and an estimated 1-3% of children (Rosen, 1996). The National Commission on Sleep Disorders Research reports that as many as 95% of patients with OSA may be undiagnosed. Primary care practitioners play an important role in the diagnosis, treatment, and follow up of patients suffering from this disorder.

Physiology of sleep apnea

There are two types of sleep apnea: central and obstructive. Central apnea, characterized by a lack of ventilatory effort, is uncommon and rarely occurs in isolation (American Sleep Disorders Association and Sleep Research Society, 1997). Patients often have both central and obstructive apneas. Obstructive sleep apnea is much more common and occurs during sleep when a narrowing or closure in the upper airway impedes airflow and increases ventilatory effort, leading to frequent arousals from sleep. This sleep fragmentation, combined with the effects of increased ventilatory effort, oxygen desaturation, and hypercarbia during airway obstruction, are thought to be responsible for the increased daytime sleepiness, fatigue, cognitive changes, and other comorbid factors associated with OSA.
Factors predisposing individuals to OSA include craniofacial skeletal abnormalities, genetic characteristics, hypertrophy of the soft palate, and increased adiposity of the neck and pharyngeal tissue. In children, tonsillar hypertrophy is the most common cause of OSA (National Heart, Lung, and Blood Institute Working Group on Sleep Apnea, 1996). During sleep, airway patency may be further compromised by underlying neuromuscular tone, upper-airway muscle synchrony, and stage of sleep affecting relaxation of the musculature of the upper airway.

The Extent of the Problem

Many studies have demonstrated significant relationships between OSA and other adverse health conditions. In several studies, OSA has been associated with increased morbidity and mortality from acute cardiovascular and cerebrovascular conditions (Baumel, Maislin, & Pack, 1997; Lavie et al., 1995). An estimated 38,000 cardiovascular deaths per year may be attributable to obstructive sleep apnea (National Commission on Sleep Disorders Research, 1993). Sudden death, myocardial infarction, nocturnal dysrhythmias, pulmonary hypertension, and right and left ventricular failure have all been associated with OSA. Lavie et al. (1995) found a significantly higher mortality rate from myocardial infarction in individuals with OSA than in the general population. In another study, OSA was implicated as an independent contributor to diurnal hypertension (Aboussouan, Golish, Dinner, Strome, & Mendelson, 1997). When hypertensive patients with OSA were treated for their sleep apnea, their hypertension improved significantly (Suzuki, Otsuka, & Guilleminault, 1993).

OSA can seriously impair neuropsychological function. Individuals with OSA and their families commonly report cognitive changes, memory loss, employment difficulties, and emotional disturbances. Sleep related factors and impaired alertness are implicated in a variety of home-based and public disasters, from automobile accidents to nuclear plant catastrophes. Individuals
with severe sleep apnea are 2-3 times more likely to fall asleep while driving and become involved in motor vehicle accidents than those in the general population (Phillipson, 1993). However, one study found that sleep apnea may be as prevalent as 46% in commercial truck drivers (Stoohs, Bingham, Itoli, Guilleminault, & Dement, 1995). Treatment of severe OSA has been shown to decrease a person’s risk for motor vehicle accident by more than 80% (Cassel et al., 1996).

Sleep apnea has been linked to a variety of other complaints. Nath and Chervin (1997) found an association between cluster headaches and sleep apnea and suggested the mechanism for the headaches was related to oxygen desaturation. Treating the sleep apnea reduced the frequency and severity of the headaches.

In growing children, obstructive sleep apnea may be responsible for serious consequences, such as poor growth, school failure, neurobehavior problems, cardiorespiratory failure, and even death (Rosen, 1996). Chervin, Ganoczy, Pituch, and Dillion (1997) found an association between OSA and hyperactivity in children. Children with OSA had improved growth rates and attentiveness when they received treatment for their apnea (Chervin, Hopwood, Clark, Malow, & Tolooi, 1997). Though few cases of OSA in pregnancy have been described in the literature, an association between severe OSA and impaired fetal growth has been reported (Lefcourt & Rodis, 1996).

Ronald, Delaire, Roos, Manfreda, and Kryger (1997) compared the utilization of health care resources by 530 patients with OSA to a randomized matched control group from the general population. They found that in the five years prior to diagnosis, patients with OSA spent almost twice as many days in the hospital and used approximately twice as many health care resources as the control group. The authors concluded that OSA is associated with many other disorders and
suggested that considerable health benefits and cost savings could be realized by earlier diagnosis and therapy.

**Diagnosis**

Diagnosis of obstructive sleep apnea can rarely, if ever, be made on the basis of the history and physical alone. According to the American Sleep Disorders Association (1997), the “gold standard” for diagnosis of sleep-related breathing disorders is an over-night sleep study, or polysomnography. Polysomnography (PSG) involves monitoring multiple channels of physiologic parameters, including, but not limited to, electroencephalography (EEG), electro-oculography (EOG), electromyography (EMG), electrocardiography (ECG), heart rate, respiratory effort, airflow, and oxygen saturation. This study requires expensive, labor intensive and highly specialized sleep centers available in only a few areas. The cost of the PSG plus associated hospital and professional fees is often greater than $2,000.

The apnea index (AI), or number of obstructive apneas per hour of sleep, is obtained from the sleep study. An obstructive apnea is defined as cessation of airflow for 10 seconds or more despite continuing ventilatory effort. This airway obstruction is usually associated with a desaturation in oxyhemoglobin of 4% or more. The International Classification of Sleep Disorders diagnostic criteria require an AI of 5 or greater and either excessive daytime sleepiness or nocturnal insomnia to make the diagnosis of OSA.

Many clinicians make the diagnosis of obstructive sleep apnea using the apnea-hypopnea index (AHI), also known as the respiratory disturbance index (RDI). This is obtained by combining the number of obstructive apneas with the number of obstructive hypopneas per hour of sleep. An obstructive hypopnea is defined as a decrease of 30%-50% of airflow for 10 seconds or more, with a desaturation in oxyhemoglobin of 4% or greater (Strollo & Rogers, 1996).
An apnea index of 5 (Kryger, 1994) or an apnea-hypopnea index of 10 (Deegan & McNicholas, 1996) are appropriate and commonly used diagnostic criteria for OSA. Therapy may not be beneficial for patients with lower indices. A variant of OSA, called upper airway resistance syndrome, occurs in some symptomatic patients who do not meet diagnostic criteria on PSG. These patients have a degree of upper airway obstruction or resistance but arouse from sleep before developing overt apnea. Treatment may benefit these patients, and a trial of therapy is recommended (Kryger, 1994).

Clinical Predictors

A large number of studies have been conducted in an attempt to develop clinical prediction rules to screen and reduce the number of patients referred for PSG. Neither the physical exam nor patient history alone can accurately predict a patient’s likelihood of having OSA. Hoffstein and Szalai (1993) found that clinical features, including history, physical exam, and subjective impression, could predict sleep apnea in only about 50% of patients. They concluded that the clinical features obtained during the history and physical exam alone are not sensitive enough to identify patients with sleep apnea. Deegan and McNicholas (1996) studied a number of indicators of OSA and found that no one sign or symptom is 100% predictive. Kramer and Bailey (1997) found the diagnostic accuracy of the medical history for OSA to be 68%. A combination of factors must be considered in making a referral for further evaluation.

The history. If the patient does not snore, then obstructive sleep apnea is unlikely. The prevalence of habitual snoring is nearly 100% in individuals with OSA but only about 40% in the general population (Hoffstein & Szalai, 1993; National Heart, Lung, and Blood Institute Working Group on Sleep Apnea, 1996). In a study by Young et al. (1993), habitual snoring was strongly associated with an apnea-hypopnea index greater than 15. When snoring loudness was tested as a
predictor of apnea, researchers found that patients who were mild snorers were twice as likely to have OSA as nonsnorers, and that extremely loud snorers, whose snoring was “loud enough to be heard through a closed door”, were 21 times more likely to have OSA (Kump et al., 1994). However, nearly 60% of the patients with OSA were not extremely loud snorers. Although snoring is a strongly associated characteristic, Phillipson, (1993) notes that habitual or severe snoring cannot reliably predict apnea in all cases.

The most common presenting complaint for patients diagnosed with OSA is excessive daytime sleepiness (Kryger, 1994). Though most patients with sleep apnea are sleepy, subjective reports do not always match objective measurements. Patients with OSA and their families may have gradually adapted to this hypsomnolence and believe that falling asleep while driving or after dinner is not particularly unusual. The Epworth Sleepiness Scale (see Appendix A), an assessment tool that has been shown to correlate to apnea-hypopnea index, is useful for measuring daytime sleep propensity (Johns, 1991).

The quality of the patient’s sleep is another indicator of OSA. Patients with OSA often complain of unrefreshing sleep, recurrent awakenings, nocturnal gastroesophageal reflux, hypnagogic hallucinations, morning “hang-overs” or headaches, and cognitive impairment. Though these reports are common and important in sleep apnea patients, they have not been found to be specific independent predictors (Flemons, Whitelaw, Brant, & Remmers, 1994).

Other nocturnal complaints, such as angina, should raise suspicions that sleep apnea may be a factor. Pressman, Figuerca, Kendrick-Mohamed, Greenspon, & Peterson (1996) found that many awakenings from sleep attributed by patients as the pressure to urinate were instead a result of sleep apnea. The authors concluded that patients are often poor judges of the reason for
awakening from sleep, and that the diagnosis of OSA should be entertained whenever a patient reports awakening frequently to urinate.

Abnormal nocturnal respirations, such as snoring, gasping or choking, are frequently reported by the patient or a partner. Kump et al. (1994) found that subjects who have been observed to choke while asleep have odds of OSA 50 times greater than subjects without these symptoms. These authors also identified 5 factors from the patient history making the greatest contributions to prediction. These factors were: 1) the functional impact of daytime sleepiness, 2) self-reported nocturnal breathing disturbances, 3) roommate-observed breathing disturbances, 4) driving impairment, and 5) insomnia. The American Sleep Disorders Association (1997) encourages the use of a sleep diary, combined with the clinical history, to evaluate the likelihood of OSA. A history of smoking and alcohol intake must be considered when evaluating a patient, as both increase the risk of obstructive sleep apnea.

Physical characteristics. A normal physical exam cannot exclude sleep apnea, though some physical findings have been identified as predictive variables. These including obesity, neck circumference, systemic hypertension, male gender, and age.

Obesity, as indicated by body-mass index (BMI), was the most important demographic predictor of OSA in one study, followed by age, male gender, and ethnicity (Kripke et al., 1997). These authors found that 16.3% of U.S. Hispanics and racial minorities had significant sleep apnea compared to 4.9% of non-Hispanic. Age, gender, and BMI are particularly important when used in combination (Deegan & McNicholas, 1996; Hoffstein & Szalai, 1993). A mathematical model using these variables with subjective measurements of loud snoring, breathing cessation, and snorting or gasping, successfully predicted the probability of having sleep apnea in a study by Maislin et al., (1995).
Neck circumference was a more significant clinical predictor than obesity in a study by Flemons et al. (1994). A neck circumference greater than 17 inches in men or 16 inches in women was particularly significant. The authors combined neck circumference with the subject’s degree of hypertension to design a mathematical model for generating sleep apnea likelihood ratios. Other authors have combined neck circumference, the presence of hypertension, habitual snoring and partner report of nocturnal gasping or choking to predict the likelihood of the diagnosis of sleep apnea (Aboussouan et al., 1997). These authors found that the use of these clinical indicators for evaluating patients suspected of having sleep apnea could significantly reduce the number of unnecessary sleep studies.

Men are more likely to have obstructive sleep apnea than women. The male:female ratio of subjects with OSA was approximately 3:1 in one survey (Young et al., 1993). In adults, the incidence of OSA is highest between the ages of 40 and 65 (Norman et al., 1997).

Enlarged soft palate, thickened or redundant soft tissue in the pharynx, or tonsillar hypertrophy observed on physical exam may be clues to OSA. One study found that an abnormal pharyngeal exam, which includes a bulky or long uvula that fails to elevate from the base of the tongue during phonation, large tonsils compromising the orifice, or general appearance of the pharynx as being small or narrow could assist in predicting OSA (Hoffstein & Szalai, 1993). Others have found examination of the upper airway of no value (Deegan & McNicholas, 1996).

**Obstructive Sleep Apnea in Children**

The clinical presentation of obstructive sleep apnea in children may differ markedly from that in adults (see Table 1). Snoring remains the most common symptom, occurring in 10-12% of school age children with OSA (Rosen, 1996). Unlike adults, however, most children with OSA do not have daytime hypersomnolence (Carroll & Loughlin, 1994). Male:female ratio is equal in
school age children, and the majority of children with OSA are of normal weight. Current International Classification of Sleep Disorder diagnostic criteria for OSA do not apply to children. The polysomnogram often shows a lower apnea index than that for adults, but more frequent hypopneas. Children may have significant airway obstruction without significant apnea. Hypoxemia is usually present, but sleep fragmentation may not be experienced. (Rosen, 1996).

The degree of airway obstruction in children may be more significant than suggested by the history and physical exam. Clinical presentations compatible with OSA include weight loss, poor growth rate, poor school performance, secondary enuresis, and behavioral problems, including hyperactivity (National Heart, Lung, and Blood Institute Working Group on Sleep Apnea, 1996). Children with trisomy 21, obesity, sickle cell disease, neuromuscular disorder, and craniofacial and genetic disorders are at increased risk. The peak incidence for OSA in children is between the ages of 2-6 years, corresponding to normal lymphoid hyperplasia and adenotonsillar hypertrophy, the most common cause of childhood OSA. Surgical intervention, or adenotonsillectomy, is the most common treatment for obstructive sleep apnea in children.

Screening/Practice Parameters

Despite attempts by researchers to design clinical prediction rules, the primary care practitioner still faces a challenge in deciding when to refer a patient for the expense and inconvenience of overnight polysomnography (PSG). A variety of in-home monitoring devices are available that can record pulse oximetry alone or in addition to a number of other parameters, including heart rate, breathing sounds, body position, nasal/oral airflow, respiratory movements, and electrophysiological changes. These differ from the PSG in that they exclude the electroencephalogram (EEG), or ability to stage sleep.
The use of in-home cardiorespiratory monitoring systems is controversial, as they may not always provide accurate, specific, or sensitive data. A number of studies have evaluated the efficacy of these devices as a more cost-effective alternative to the PSG. Some studies found significant correlation between the data from home studies and the apnea-hypopnea index (Deegan & McNicholas, 1996; Redline, Tosteson, Boucher, & Millman, 1991; Schafer, Ewig, Hasper, & Luderitz, 1997) However, a negative nocturnal pulse oximetry study does not rule out OSA (Williams, Yu, Santiago, & Stein, 1991). Nocturnal pulse oximetry has more diagnostic value as the severity of OSA increases, but is inaccurate in patients with chronic obstructive pulmonary disease. Combining the information from home studies with the clinical presentation increases predictive value significantly. Flemons and Remmers (1996) proposed an algorithm for clinical decision making incorporating clinical prediction models and home sleep study data. The authors recommended portable monitoring only for those patients in whom the estimated probability of OSA is high. If the home study supports the diagnosis of OSA in a symptomatic patient, they recommend initiating treatment without further study. If a symptomatic patient’s home study is negative, they recommend attended polysomnography for further evaluation.

The American Sleep Disorders Association (ASDA) (1997) has developed practice parameters based on review of research findings to guide clinicians in decision making. Routine use of unattended cardiorespiratory sleep studies, which do not incorporate electro-encephalography for sleep staging, is not supported by the ASDA. The ASDA guidelines specify PSG as the standard test for diagnosis, evaluation of therapy, and follow-up when indicated. Unattended, portable monitoring systems are an acceptable alternative only in the following situations:

1. For patients with severe clinical symptoms indicative of OSA, for whom initiation of treatment is urgent and PSG is not readily available.
2. For patients unable to be studied in the sleep laboratory, such as those patients who are medically unstable or unable to be transported to a sleep center.

3. For follow-up studies when a diagnosis of OSA has already been established by PSG, with the intent of evaluating the response to therapy.

**Treatment of Obstructive Sleep Apnea**

In deciding when to treat sleep apnea, the severity of the disease, the patient’s occupation, the degree of clinical complaint, and the patient’s functional impairment should be considered. Patients with AHIs greater than 20 have a higher mortality rate and should be treated. Even with a positive diagnosis of obstructive sleep apnea, many patients fail to follow up on treatment or recognize the seriousness of their condition. In one study, 63% of the patients surveyed did not plan to treat their OSA, frequently citing dissatisfaction with treatment options as the reason (Hsieh, Kushida, Guilleminault, Clerk, & Dement, 1997). The authors emphasized the importance of patient education regarding the seriousness of untreated sleep-related breathing disorders. All patients should be counseled on the benefits of therapy and the risks of going without treatment.

**Behavioral interventions.** All overweight patients with OSA should be encouraged to lose weight. A 10% weight loss has been shown to decrease the number of apneas by approximately 50% (Hudgel, 1996). Exercise and diet used in the management of OSA has been shown to lead to a significant improvement in mood and affective states, though not physical function nor daytime somnolence (Norman et al., 1997). Many patients are resistant or noncompliant with weight loss programs. Weight loss should be considered an important adjunct to therapy but not efficacious as first line treatment.

Use of alcohol, sedatives, and hypnotic agents reduce upper-airway tone, alter respiratory patterns, and suppress arousal. These should be avoided, particularly if taken in the evening
before sleep. In patients with compromised airways, even as few as 2 drinks per day can increase sleep-related motor vehicle accidents 5-fold (Aldrich & Chervin, 1997). Sleeping in an exclusively lateral recumbent position may be helpful for some patients who only have upper-airway dysfunction during sleep in the supine position. The practitioner should also remind the patient that obstructive sleep apnea greatly increases the risks of driving. The individual should be reminded of his or her responsibility for safe driving habits.

**Nasal CPAP.** Nasal continuous positive airway pressure (CPAP) is generally considered the first-line treatment of choice for most adults with obstructive sleep apnea (Kryger, 1994). The CPAP device includes a mask which the patient wears while sleeping. The mask is sealed over the nose and connected to a blower that forces air through the nasal passages. The positive pressure of the forced air acts as a pneumatic splint, countering the collapsing forces in the upper airway. The minimal amount of positive pressure to achieve therapeutic result is often determined by titration in the sleep laboratory. This is usually the amount that eliminates snoring.

Nasal CPAP is noninvasive and lacking in serious side effects. Claustrophobia is a common complaint, though many patients adjust readily to the mask. Minor complications include local skin irritation, drying of airway mucosa, nasal congestion, and eye irritations. Humidifiers, nasal steroids, saline sprays, decongestants, and fit adjustments are often effective in reducing these problems. Major complications, such as infection, massive epistaxis, or pneumocephalus are rare (Kryger, 1994; Man, 1996).

The clinical effectiveness of CPAP has been well documented by many studies in the literature. Suzuki et al. (1995) found a significant improvement in the average daytime systolic and diastolic blood pressures and heart rate in hypertensive patients on CPAP. CPAP therapy has been shown to improve the energy levels and emotional reactions of patients with OSA by 60%, with an
associated improvement in the quality of life, daytime somnolence and fatigue (Meslier et al., 1997). CPAP is an effective and well-tolerated treatment for children with severe OSA, with a compliance rate between 69% and 76%, similar to that found in studies with adults (Downey, Perkin, McQuarrie, & Gold, 1997). CPAP has been demonstrated to have a very favorable cost-utility ratio when the benefits of improvement were compared to the cost of treatment (Tousignant, Cosio, Levy, & Groome, 1994).

Despite the proven effectiveness of CPAP therapy, patient acceptance remains a significant problem. In an 11 year study of 8500 patients with OSA, Kramer & Bailey (1997) found the known compliance rate was at least 29%, but no higher than 79%. Patients sometimes find the CPAP device inconvenient or uncomfortable. Engleman, Martin, & Douglas (1994) found that patients who experience disagreeable side effects were less likely to continue treatment. Other studies have found that CPAP use correlates more closely to the severity of sleep apnea and the degree of subjective improvement (Kreiger, Kurtz, Petiau, Siörrza, & Trautmann, 1996; Meurice et al., 1994; Rauscher, Popp, Wanke, & Zwick, 1991). Patients are more willing to use the CPAP consistently when they experience a subjective benefit. Krieger et al. (1996) found that the most important incentive to continue therapy was the medical staff’s conviction that treatment was a necessity.

The practitioner plays an important role in improving the patient’s acceptance of CPAP therapy. Nearly half of the patients discontinuing treatment do so in the initial two weeks (Nino-Murcia et al., 1989). This initial period is critical for adjusting to CPAP and requires maximum support. Likar, Panciera, Erickson, & Rounds (1997) found that group sessions offering encouragement, personal support, education, and interaction with other OSA patients resulted in sustained improvement in regular CPAP use. Group sessions in their study were managed by a
pulmonary nurse practitioner. If a support group is not available in the community, individuals can find similar support groups and a wealth of information and networking opportunities pertaining to sleep apnea on the Internet.

Educational pamphlets on OSA, snoring, and the importance of continuing therapy can significantly improve CPAP compliance (Chervin, Theut, Bassetti, & Aldrich, 1997). Both group support and educational material are more effective than telephone reinforcement. Self-reports of CPAP use are unreliable in distinguishing between compliant and noncompliant patients, as patients have been found to overestimate the duration of actual CPAP use (Kribbs et al, 1993; Rauscher et al., 1991).

**Medications.** Currently no medications have proven safe and effective for routine treatment of obstructive sleep apnea. (National Heart, Lung, and Blood Institute Working Group on Sleep Apnea, 1996). A few medications have been shown to have limited efficacy in mild cases. Antidepressants, such as protriptyline and fluoxetine, have been used with varying success. These medications, which further alter sleep stage distribution, may reduce daytime symptoms without significant improvement in the degree of apnea by polysomnography (Kryger, 1994).

Endocrine imbalances should be treated when appropriate. Hypothyroidism and acromegaly predispose to OSA. Thyroid replacement may improve periodic breathing, suppressed respiratory drive, and upper-airway function in the thyroid deficient patient (Hudgel, 1996). Progesterone may be used to stimulate ventilatory function (Man, 1996).

Acetazolamide is effective in preventing clinically significant alkalosis with respiratory depression in patients on diuretics. Avoiding potassium depletion is important in these cases. Beta antagonists for hypertension may exacerbate OSA in some patients (Kryger, 1994). Oxygen does
not reduce sleep disruption or daytime sleepiness and should be used with extreme caution, especially in patients with hypercapnia (Man, 1996).

**Surgery.** Adenotonsillectomy is the most common treatment for obstructive sleep apnea in children and adolescents. In adults, surgery may be indicated for select patients with anatomic defects who do not respond to more conservative treatment. Uvulopalatopharyngoplasty, removal of part of the soft palate, the uvula, tonsils and redundant posterior pharyngeal soft tissue, usually reduces snoring but may not always relieve the apnea. Specific patients may improve after nasal or maxillofacial surgery. In severe cases tracheostomy may be used as the last resort. Complications, as for any surgical procedure, include pain, swelling, infection, and bleeding.

**Dental Appliances.** Dental appliances are sometimes used to increase the diameter of the upper airway by repositioning the mandible. These devices are considered second-line therapy, as they may eliminate snoring without improving the apnea (Man, 1996). There is a lack of standardization in the use of oral appliances and wide variation in individual efficacies. Complications include temporomandibular joint discomfort and occlusive malalignment.

**Follow Up**

The practitioner should be alert for potential recurrence of symptoms in all patients receiving treatment. Symptomatic improvement is experienced over the first 3-12 months after initiation of CPAP therapy, with eventual stabilization (Sullivan & Grunstein, 1994). If the patient was suffering from right-sided heart failure, initiation of CPAP may lead to rapid improvement in cardiac function, diuresis and resolution of peripheral edema. The practitioner may need to make adjustments in the patient’s antihypertensive medication after reversal of OSA related hypertension. The practitioner should also inform patients that REM rebound (long periods of
both REM and stage 4 NREM sleep) with vivid dreams may be experienced within the first week or two on CPAP (Sullivan & Grunstein, 1994).

The American Sleep Disorders Association (1997) recommends a follow-up PSG or cardiorespiratory sleep study to ensure therapeutic benefit after surgical intervention, treatment with an oral appliance, or return of symptoms. For patients on CPAP therapy, the ASDA recommends follow-up PSG if there has been insufficient clinical response, return of symptoms, or significant weight loss or gain. Follow up is not necessary as long as the patient remains asymptomatic. If sleepiness persists with therapy, the patient should be evaluated for other problems. Patients on CPAP should have their machines periodically evaluated. With even one night discontinuance of CPAP, daytime sleepiness begins to return, and within a few days, the sleep apnea progresses to the previous level of severity (Sullivan & Grunstein, 1994).

The Role of the Primary Care Practitioner

Evidence suggests that sleep apnea is significantly underrecognized by primary care practitioners (Cook, Kramer, Carlisle, Corwin, & Millman, 1997). Researchers examining health care utilization records found that patients with OSA were 23 times more likely to have been diagnosed with mental, cardiovascular, neurologic, respiratory, and “ill-defined” signs and symptoms in the five years before the apnea diagnosis than controls, suggesting that these patients made frequent visits to providers in which the diagnosis of OSA was missed (Ronald et al., 1997). Despite its high prevalence and the serious risk it poses to public health, most primary care practitioners lack training in how to diagnose and treat OSA.

A recent project to educate primary care physicians and the public on the detection and treatment of patients previously undiagnosed with OSA resulted in an 8-fold increase in referrals for sleep testing (Ball et al., 1997). Of those referred, 81% were diagnosed with OSA. The
authors concluded that proper education and awareness of this disorder among community health
care providers could significantly increase successful identification and treatment of affected
individuals. By increasing awareness of obstructive sleep apnea as a potential diagnosis and
providing appropriate referral and follow-up, primary care practitioners can help reduce the
enormous impact of this sleep disorder on public health and welfare.
Chapter Two: Data Analysis

Introduction

When evaluating patients for the likelihood of obstructive sleep apnea (OSA), primary care practitioners are faced with the challenge of determining which clinical indicators are most useful for estimating the patients at greatest risk. Understanding the clinical predictors of OSA helps the primary care practitioner better identify patients who may suffer from OSA while reducing the number of low risk patients referred for unnecessary, expensive and inconvenient sleep studies.

Purpose of the Study

The purpose of this study is to determine if there is a relationship between clinical characteristics of a population of patients evaluated for obstructive sleep and their diagnosis or severity of OSA. The findings could be used to improve the ability of practitioners to assess patients for this disorder.

Method

The Population. The study population was selected from several hundred patients evaluated for OSA between January 1996 and December 1997 by the pulmonary department of Wenatchee Valley Clinic, Wenatchee, Washington, a community of approximately 50,000. The pulmonary department includes three pulmonologists, one of whom received special training at Stanford University in evaluation of sleep disorders. Most of the patients were referred to the pulmonologists by their primary care providers. These patients were asked to fill out a questionnaire (see Appendix B) describing their clinical signs and symptoms. Other physical parameters were also measured and recorded on the questionnaire. The questionnaire was designed by the pulmonologist with sleep training and based on commonly reported clinical indicators for OSA.
Several hundred patient records were reviewed, and 131 were purposefully selected for the study population based on the following criteria:

1. The patient had been referred for suspected OSA
2. The patient had filled out the questionnaire
3. The patient had completed overnight 6-channel polysomnography (PSG) in which the apnea-hypopnea index (AHI) had been measured.

**Population Bias.** In order for patients in this study to be referred for diagnostic PSG, they had to have strong clinical indicators of sleep apnea. Primary care providers who suspect OSA in their patients and refer them for further study are aware that certain clinical parameters are often associated with OSA. For example, studies have shown that most patients with OSA are habitual snorers. This association is known to many individuals in the general population, who sometimes seek evaluation because they have a history of loud, habitual snoring. Therefore, the study population had a much higher percentage of snorers than the general population. In addition, many of the patients were initially screened by the pulmonary department using unattended cardiorespiratory home sleep studies, including nocturnal pulse oximetry. If the home study was not strongly suggestive of OSA, no further testing was recommended. Only those patients with suggestive home studies or severe symptoms were referred for diagnostic overnight attended polysomnography. Thus the study population had already met certain criteria and was not representative of the general population.

**Data Collection and Analysis.** The independent variables taken from the questionnaire included the patient’s subjective reports of symptoms, behaviors, and sleep habits as well as demographics: date of birth, date of sleep study, sex, height, weight, neck circumference, blood pressure, and usual number of hours slept each night. The dependent variable, or the apnea-
hypopnea index (AHI) quantifying the subject’s degree of OSA, was taken from the patient’s polysomnography report. These variables were given numerical value and entered into a Microsoft Excel spreadsheet format. Spreadsheet functions were used to calculate age at the time of study, mean arterial blood pressure (diastolic + 1/3 pulse pressure), and body mass index (weight in kilograms divided by height in meters squared).

The following 20 independent variables were selected for analysis: (a) daytime sleep propensity (excessive daytime sleepiness or the tendency to fall asleep at inappropriate times during the day), (b) daytime grogginess, (c) nocturnal gasping/choking, (d) confusion upon awakening, (e) morning headaches, (f) nasal congestion, (g) alcohol consumption, (h) habitual snoring, (i) snoring loudness, (j) ankle swelling, (k) nightmares, (l) arousals from sleep, (m) accident propensity, (n) whether or not the patient felt rested upon awakening, (o) time slept each night, (p) body mass index, (q) neck circumference, (r) mean arterial blood pressure, (s) age, and (t) sex.

An apnea-hypopnea index (AHI) of 10 or above was used as the diagnostic criteria for OSA. This was the criteria used by Flemons, Whitelaw, et al. (1994) in their study to identify clinical predictors. Patients with AHIs less than 10 were considered nonapneic, while those with AHIs greater than 10 were considered apneic. Statistical analysis was performed using the statistical software SPSS for Windows, version 5.

Results

Descriptive Statistics. The majority of the sample population was male (71%), had a history of habitual snoring (96%), and did not feel rested upon awakening in the morning (66%) (see Table 2). More than half (56%) of the 129 snorers in the population responded that their snoring was extremely loud and “could be heard through a closed door”. The only two patients, both male,
who described themselves as nonsnorers, were diagnosed with OSA (AHI scores of 53 and 15.9).

Age of the patients in the study population ranged from 18 to 80, with a mean age of 52. Body mass index ranged from 18.7 to 64.7, with a mean of 34.1. Neck circumference in centimeters ranged from 32.5 to 60.5, with a mean of 44.5. The apnea-hypopnea index ranged from 0.9 to 108, with a mean of 20.68.

Of the total study population, 63% were diagnosed with obstructive sleep apnea. The mean AHI was 29.5 for the apneic population and 5.5 for the nonapneic population. Means for the other variables are summarized in Table 3. A comparison of the frequency distribution curves for age, body mass index (BMI), and neck circumference in the apneic and nonapneic populations is illustrated in Figure 1. There was no difference in the means between the apneic and nonapneic populations in mean arterial blood pressure (98.6) and hours slept each night (7.5). Mean arterial pressure (MAP) ranged from 64 to 128, and the number of hours slept each night, from 4 to 11 hours.

Differences between males and females were apparent when the population was divided according to gender. There were more than twice as many males as females with OSA. The majority of the females (87%) had an AHI less than 20, compared to only 46% of the males (see Figure 2). 18% of the males, but none of the females, had an AHI greater than 40. Males had mean scores notably greater than females for the variables AHI, MAP, BMI, neck circumference, and daytime sleep propensity (see Table 4). Mean score for morning headaches was greater for females than males. The means for snoring loudness were comparable for males and females.

Relationships Between Apnea-Hypopnea Index and the Dependent Variables. Variables were analyzed using Pearson's correlation and t-test for significance. Only 4 of the 20 independent
variables were found to correlate to the apnea-hypopnea index with statistical significance. These were, in order of significance:

1. neck circumference
2. male sex
3. daytime sleep propensity
4. mean arterial pressure

BMI and age did not correlate with statistical significance, but were next in correlation value (see Table 5). These variables; neck circumference, male sex, daytime sleep propensity, hypertension, BMI, and age, have been shown to be significant clinical indicators in other studies as well (Deegan & McNicholas, 1996; Flemons, Whitelaw, et al., 1994; Hoffstein & Szalai, 1993; Kripke et al., 1997, Norman et al., 1997).

Neck Circumference, Male Gender, and Obesity. The significant correlation between neck circumference and OSA is consistent with findings in other studies in which neck circumference was often the strongest correlate (Flemons, Whitelaw, et al., 1994). Previous studies also identified male gender as a significant independent clinical predictor. Young, et al. (1993) found that the male:female ratio of subjects with OSA was approximately 3:1. In the study by Deegan and McNicholas (1996), the odds ratio that an apneic patient would be male was 2.7:1, and in the present study, these odds were 2.3:1.

The interrelationships between sex and anthropomorphic measurements like neck circumference and obesity (increased BMI) are obviously important factors in predicting sleep apnea. When the population was divided according to sex, a significant correlation was found between AHI and neck circumference in males but not in females (see Figure 3). The opposite was found by Deegan and McNicholas (1996). In their study, neck circumference was an
independent correlate in females but not in males. They also found that BMI was a stronger predictor than neck circumference, though this was not the finding in the present study. Though the correlation between BMI and AHI did not reach statistical significance in the present study (using Pearson’s correlation), BMI had a strong correlation (Pearson’s $r = 0.592$) to neck circumference (see Figure 4). The neck circumference:BMI ratio was also significantly greater in males than in females. A better understanding of how gender based body morphology affects the pathogenesis of OSA could help practitioners screen for this disorder.

In most populations, BMI increases with age, but in this population, there was an inverse relationship between these variables. Hoffstein and Szalai (1993) used the product of BMI and age and found it had greater predictive value for OSA than either variable alone. When this was done in the present study, the age x BMI product was found to correlate to AHI significantly at the $p=0.05$ level (Pearson’s $r = 0.231$).

**Daytime Sleep Propensity and Other Symptoms.** The finding that daytime sleep propensity is correlated with OSA is not surprising considering that excessive daytime sleepiness is the most common presenting complaint for patients diagnosed with OSA (Kryger, 1994). Excessive daytime sleepiness and a tendency to doze while driving has been shown to correlate to OSA in other studies (Deegan & McNicholas, 1996; Hoffstein & Szalai, 1993). However, Flemons, Whitelaw, et al. (1994) were unable to find a relationship between sleep apnea and any commonly reported daytime symptoms, including hypersomnolence, unrefreshing sleep, morning headaches, and cognitive impairment.

In the present study, the number of hours of sleep each night did not affect daytime sleepiness. A gender difference was noted, though, in how patients rated their daytime sleep propensity (see Figure 5). Excessive daytime sleepiness correlated to AHI for men, but not for women. This was
probably because OSA was more severe in the men than in the women and had a greater influence on their subjective reports of daytime sleepiness. Other daytime symptoms, including any measurement of fatigue, tiredness, groginess, or cognitive impairment, did not correlate with AHI in this study or those sited previously. These symptoms must be distinguished from sleep propensity, the tendency to fall asleep readily and at inappropriate times during the day. Sleep propensity was a stronger correlate.

Morning headache, another symptom sometimes associated with sleep apnea, did not correlate to AHI, and in fact, was slightly more prevalent in the nonapneic population. Another interesting finding was a weak but statistically significant relationship between female gender and morning headaches (see Figure 6). Whether or not the patient felt rested upon awaking in the morning had no correlation to AHI, but also no meaningful correlation to the other independent variables, including daytime sleepiness or the number of hours slept each night. During data collection, it was noted that some patients had apparent difficulty answering the question, “Do you feel rested upon awaking in the morning?”, with a “yes” or “no” answer, sometimes leaving it blank or writing in “?” or “sometimes”. This question appears to have little value in assessing the risk for OSA. Alcohol intake was also not a significant correlate to AHI in the present study, although it was in previous studies (Deegan & McNicholas, 1996).

**Hypertension.** Although hypertension has been shown to correlate to AHI in other studies, the correlation in the present study (see Figure 7) is notable because it was based upon one blood pressure reading alone. In some studies, patients were considered hypertensive even if blood pressure was well controlled on antihypertensive medication (Flemons, Whitelaw, et al., 1994). In the present study, a few patients who were normotensive at the time of the questionnaire were noted to be on antihypertensive medication. This was particularly remarkable for the individual
with the lowest mean arterial pressure (MAP=67.3) whose AHI was 64.4. When the chart was reviewed at the time of data collection to determine why this individual’s blood pressure was so low, it was discovered that he was taking antihypertensive medication. This “outlier” was eliminated from the population used for the graphic representation in Figure 7, but not from the population used for calculating the Pearson correlation coefficient, which still met significance.

**Snoring, Gasping, and Choking at Night.** A significant relationship between habitual snoring and OSA is well recognized (National Heart, Lung, and Blood Institute Working Group on Sleep Apnea, 1996; Young et al., 1993; Kump et al., 1994). Kump et al. found that the best clinical predictors of OSA, besides falling asleep while driving, were snoring intensity and roommate observed nocturnal choking. Despite the high percentage of loud snorers in the study population, habitual and loud snoring did not correlate significantly to AHI in the present study. Phillipson (1993) noted that the presence of habitual and loud snoring were of low predictive value if not combined with other characteristics. Because snoring is often one of the main reasons individuals are evaluated for OSA, snoring is often as common in those with a negative diagnosis as those with apnea in the population of individuals referred for sleep studies.

Though no correlation was found between nocturnal gasping or choking and AHI, this characteristic was strongly related to sleep apnea in other studies (Aboussouan et al., 1997; Flemons, Whitelaw, et al., 1994, Hoffstein and Szalai, 1993; Maislin et al., 1995). Because of this, bed partner reports of nocturnal choking or gasping were often considered in the design of clinical prediction models by these authors. This characteristic may have proven significant in the present study if bed partner reports had been included in the questionnaire, as many individuals cannot reliably assess their own nocturnal sleep behavior.
Evaluation of the Questionnaire

Since only four of the twenty variables measured on the questionnaire proved to be statistically significant in relationship to obstructive sleep apnea, the questionnaire, as a whole, was not a strong tool for clinical use. Suggestions include simplifying the questionnaire to measure only the variables neck circumference, BMI, sex, age, daytime sleep propensity, blood pressure, snoring and snoring loudness, and bed partner reports of nocturnal gasping or choking. Information regarding the patient’s use of antihypertensive medication or a previous diagnosis of hypertension should be included in the patient assessment along with the measured blood pressure.

Recommendations for the Primary Care Practitioner

It is no surprise that research has not come up with consistent rules for making clinical decisions. Clinical decision making is a complex art that relies upon scientific knowledge. Many of the findings in this study corroborate those of previous researchers. These findings are the basis for the following recommendations for practitioners when evaluating patients for obstructive sleep apnea.

1. Give male gender and anthropomorphic measurements, such as body mass index and neck circumference, more weight in comparison to subjective reports of symptoms. In all previous studies, these variables were consistently stronger correlates than the patient’s subjective descriptions of daytime sleepiness, nocturnal behaviors, or associated complaints.

2. Recognize that the tendency to fall asleep often or at inappropriate times during the day is more significant than general tiredness, fatigue, grogginess, or awakening unrefreshed. The Epworth Sleepiness Scale (see Appendix B) has been shown to be a reliable and valid measurement of daytime sleep propensity (Johns, 1991). Use of this assessment tool enables the practitioner to better evaluate this important predictive characteristic.
3. Consider gender differences in subjective responses. The degree of reported daytime sleep propensity may have more significance for males than females. Morning headaches are more common in females, and may be unrelated to OSA.

4. Do not dismiss the diagnosis of OSA simply because the patient denies habitual or loud snoring. The consideration of snoring should be made in combination with all other variables demonstrated to correlate to OSA. As in this study, occasionally a patient with sleep apnea may deny being a habitual snorer. Snorers cannot evaluate their own snoring. The diagnosis of sleep apnea could be missed if snoring is considered a necessary characteristic.

5. Entertain the potential of OSA in any hypertensive patient. If a patient has severe or refractory hypertension and sleep apnea is suspected, the cost of an overnight sleep study might be justified in cost:benefit ratio (Maislin et al., 1995). Treatment for OSA may improve the individual’s hypertension (Suzuki et al., 1993).

In conclusion, clinical decision making still depends upon the practitioner’s ability to combine characteristics into a subjective impression. It is the hope that this study contributes to a better understanding of those characteristics associated with obstructive sleep apnea, provides recommendations for evaluating patients, and improves the practitioner’s ability to recognize those patients at risk.
References


### Table 1.

**Comparison of Obstructive Sleep Apnea in Adults and Children**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Adults</th>
<th>Children</th>
</tr>
</thead>
<tbody>
<tr>
<td>Snoring</td>
<td>Most common sign</td>
<td>Most common sign</td>
</tr>
<tr>
<td>Daytime sleepiness</td>
<td>Main presenting symptom</td>
<td>Uncommon</td>
</tr>
<tr>
<td>Male:female</td>
<td>3:1</td>
<td>1:1</td>
</tr>
<tr>
<td>Common age</td>
<td>40-65</td>
<td>2-6</td>
</tr>
<tr>
<td>Obesity</td>
<td>Majority</td>
<td>Minority</td>
</tr>
<tr>
<td>Obstructive pattern</td>
<td>Mainly apnea</td>
<td>Mainly hypopnea</td>
</tr>
<tr>
<td>Mouth breathing</td>
<td>No</td>
<td>Common</td>
</tr>
<tr>
<td>Most common treatment</td>
<td>Nasal CPAP</td>
<td>Adenotonsillectomy</td>
</tr>
</tbody>
</table>
Table 2.

Numbers of Patients According to Characteristics

<table>
<thead>
<tr>
<th>Population</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>131</td>
<td>100</td>
</tr>
<tr>
<td>Male</td>
<td>93</td>
<td>71</td>
</tr>
<tr>
<td>Female</td>
<td>38</td>
<td>29</td>
</tr>
<tr>
<td>Snorers</td>
<td>129</td>
<td>99</td>
</tr>
<tr>
<td>Unrested in the morning</td>
<td>97</td>
<td>74</td>
</tr>
<tr>
<td><strong>Apneic</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>83</td>
<td>63</td>
</tr>
<tr>
<td>Male</td>
<td>58</td>
<td>70</td>
</tr>
<tr>
<td>Female</td>
<td>25</td>
<td>30</td>
</tr>
<tr>
<td>Snorers</td>
<td>81</td>
<td>98</td>
</tr>
<tr>
<td>Unrested in the morning</td>
<td>54</td>
<td>65</td>
</tr>
<tr>
<td><strong>Nonapneic</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>48</td>
<td>37</td>
</tr>
<tr>
<td>Male</td>
<td>35</td>
<td>73</td>
</tr>
<tr>
<td>Female</td>
<td>13</td>
<td>27</td>
</tr>
<tr>
<td>Snorers</td>
<td>48</td>
<td>100</td>
</tr>
<tr>
<td>Unrested in the morning</td>
<td>43</td>
<td>90</td>
</tr>
</tbody>
</table>
Table 3.

Means for Population Characteristics

<table>
<thead>
<tr>
<th>Variable</th>
<th>Total (n=131)</th>
<th>Apneic (n=83)</th>
<th>Nonapneic (n=48)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>52.1</td>
<td>52.6</td>
<td>51.1</td>
</tr>
<tr>
<td>BMI</td>
<td>34.1</td>
<td>34.7</td>
<td>33</td>
</tr>
<tr>
<td>Neck circumference</td>
<td>44.3</td>
<td>44.8</td>
<td>43.9</td>
</tr>
<tr>
<td>MAP</td>
<td>98.3</td>
<td>98.3</td>
<td>98.3</td>
</tr>
<tr>
<td>Hours slept each night</td>
<td>7.5</td>
<td>7.5</td>
<td>7.5</td>
</tr>
<tr>
<td>Daytime sleep propensity</td>
<td>1.87 (0-4)</td>
<td>1.71</td>
<td>2.15</td>
</tr>
<tr>
<td>Daytime groginess</td>
<td>2.38 (0-4)</td>
<td>2.32</td>
<td>2.49</td>
</tr>
<tr>
<td>Nocturnal gasping/choking</td>
<td>1.87 (0-4)</td>
<td>1.84</td>
<td>1.93</td>
</tr>
<tr>
<td>Awakening confused</td>
<td>0.97 (0-4)</td>
<td>0.96</td>
<td>0.98</td>
</tr>
<tr>
<td>Morning headache</td>
<td>1.17 (0-4)</td>
<td>1.28</td>
<td>0.98</td>
</tr>
<tr>
<td>Nasal congestion</td>
<td>2.35 (0-4)</td>
<td>2.38</td>
<td>2.31</td>
</tr>
<tr>
<td>Alcohol consumption</td>
<td>0.95 (0-4)</td>
<td>0.96</td>
<td>0.87</td>
</tr>
<tr>
<td>Snoring loudness</td>
<td>3.325 (0-4)</td>
<td>3.3</td>
<td>3.35</td>
</tr>
<tr>
<td>Ankle swelling</td>
<td>0.38 (0-1)</td>
<td>0.38</td>
<td>0.38</td>
</tr>
<tr>
<td>Nightmares</td>
<td>0.35 (0-1)</td>
<td>0.32</td>
<td>0.41</td>
</tr>
<tr>
<td>Nocturnal arousals</td>
<td>0.73 (0-1)</td>
<td>0.73</td>
<td>0.73</td>
</tr>
<tr>
<td>Accident propensity</td>
<td>0.21 (0-1)</td>
<td>0.19</td>
<td>0.23</td>
</tr>
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</table>
Table 4.

Means of Variables According to Gender

<table>
<thead>
<tr>
<th>Variable</th>
<th>Female (n=38)</th>
<th>Male (n=93)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AHI</td>
<td>11.6</td>
<td>24.4</td>
</tr>
<tr>
<td>BMI</td>
<td>35.8</td>
<td>52.3</td>
</tr>
<tr>
<td>Neck circumference</td>
<td>41.2</td>
<td>45.6</td>
</tr>
<tr>
<td>MAP</td>
<td>94.8</td>
<td>99.8</td>
</tr>
<tr>
<td>Daytime sleep propensity</td>
<td>1.42</td>
<td>2.05</td>
</tr>
<tr>
<td>Morning headaches</td>
<td>1.53</td>
<td>1.02</td>
</tr>
<tr>
<td>Snoring loudness</td>
<td>3.27</td>
<td>3.35</td>
</tr>
</tbody>
</table>
Table 5.

**Correlation Between the Apnea-Hypopnea Index and Independent Variables in Order of Significance**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Pearson's correlation coefficient, r</th>
<th>Significance (1 tailed), p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neck circumference</td>
<td>0.436</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Male sex</td>
<td>0.306</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Daytime sleep propensity</td>
<td>0.191</td>
<td>.014</td>
</tr>
<tr>
<td>Mean arterial pressure</td>
<td>0.170</td>
<td>.030</td>
</tr>
<tr>
<td>Age</td>
<td>0.139</td>
<td>.057</td>
</tr>
<tr>
<td>Body mass index</td>
<td>0.105</td>
<td>.117</td>
</tr>
</tbody>
</table>
Figure 1. Frequency distribution curves for the variables age, body mass index, and neck circumference in the apneic and nonapneic populations.
Figure 2. Distribution of apnea-hypopnea (AHI) scores in the male and female populations.
Figure 3. Relationship between apnea-hypopnea index (AHI) and neck circumference for males and females.
Figure 4. Scatter graph with trendline illustrating relationship between body mass index and neck circumference in the total population.
Figure 5. Relationship between apnea-hypopnea index and daytime sleep propensity scores for males and females.
Figure 6. Relationship between morning headaches, gender, and obstructive sleep apnea. (Headache score range is 0-4). A statistically significant relationship was found between female sex and reports of morning headache, but not between morning headache and obstructive sleep apnea.
Figure 7. Relationship between apnea-hypopnea index and mean arterial pressure (MAP).
Appendix A

Epworth Sleepiness Scale

Rate your chance of dozing in the following situations and total your score:

0 = no chance of dozing
1 = slight chance of dozing
2 = moderate chance of dozing
3 = high chance of dozing

<table>
<thead>
<tr>
<th>SITUATION</th>
<th>CHANCE OF DOZING</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sitting and reading</td>
<td></td>
</tr>
<tr>
<td>Watching TV</td>
<td></td>
</tr>
<tr>
<td>Sitting inactive in a public place (e.g. a theater or a meeting)</td>
<td></td>
</tr>
<tr>
<td>As a passenger in a car for an hour without a break</td>
<td></td>
</tr>
<tr>
<td>Lying down to rest in the afternoon when circumstances permit</td>
<td></td>
</tr>
<tr>
<td>Sitting and talking to someone</td>
<td></td>
</tr>
<tr>
<td>Sitting quietly after a lunch without alcohol</td>
<td></td>
</tr>
<tr>
<td>In a car, while stopped for a few minutes in traffic</td>
<td></td>
</tr>
</tbody>
</table>

TOTAL SCORE

Total score:

1 - 6 Congratulations, you are getting enough sleep!
7 - 8 Your score is average
9 & up Seek the advice of a sleep specialist without delay
Appendix B

Wenatchee Valley Clinic Pulmonary Physiology Laboratory: Breathing Related Sleep Disorder

Questionnaire

Identification number: __________

Date of birth: __________

Date of study: __________

Male/female: __________

5 point scale for questions 1-7:

0 = Never

1 = Rarely (less than once per week)

2 = Sometimes (1-2 per week)

3 = Frequently (3-4 per week)

4 = Almost always

Do you ever, or have you been told that you:

1. ___ Fall asleep at inappropriate times (while driving, sitting quietly, during conversations)?

2. ___ Feel sleepy, groggy, or in a fog during the daytime?

3. ___ Stop breathing or wake up gasping for breath?

4. ___ Feel confused when awakened from sleep?

5. ___ Wake up in the morning with headaches?

6. ___ Have nasal congestion?

7. ___ Drink alcoholic beverages (beer, wine, mixed drinks, etc)?

8. Do you snore? Yes  No
9. How would you or another person rate your snoring?
   
   ___ Slightly louder than heavy breathing
   ___ As loud as mumbling or talking
   ___ Louder than talking
   ___ Extremely loud, can be heard through a closed door
   ___ Do not know

10. Do your ankles swell?  Yes  No

11. Do you have nightmares?  Yes  No

12. Do you wake up frequently?  Yes  No

13. Do you feel accident prone?  Yes  No

14. What time do you go to bed?  _____

15. What time do you usually wake up?  _____

16. Do you feel rested when you wake up?  Yes  No

17. Height  _____

18. Weight  _____

19. Neck size  _____

20. Blood pressure  _____