Physical activity and symptoms of depression and anxiety in sleep apnea patients.

MSc THESIS

Roumeliotou Artemis

Supervisor: Dr. Hatzigeorgiadis Antonios

Trikala, 2019

ABSTRACT

Obstructive Sleep Apnea (OSA) is a sleeping disorder, which is characterized by daytime sleepiness and it has been linked to various physical and mental problems, like depression and anxiety. Although there is a range of possible treatments for OSA, research on the association of physical activity (PA) based on Self-determination Theory (SDT) with sleepiness, depression and anxiety is scarce. This study aimed to explore the interactions of SDT tenets and specifically the basic psychological needs of competence, autonomy and relatedness for exercise with depression, anxiety and daytime sleepiness. Additionally, whether PA, as measured in Metabolic Equivalents (METs), contributes to the improvement of daytime sleepiness among OSA patients and whether SDT contributes to the adoption of PA were examined. A total of 51 adult patients diagnosed with OSA (males = 38 females = 13) and a mean age of approximately 51 years participated in the study. During a private meeting, participants filled questionnaires that measured PA, depression, anxiety and the psychological needs for exercise of competence, autonomy and relatedness. Results revealed several significant relationships between the variables. Also, exercisers showed lower depression and more competence satisfaction. Stepwise regression analyses yield a significant prediction of daytime sleepiness from moderate METs and a significant prediction of METs total from competence satisfaction. Present findings suggest that PA may have a beneficial effect on lowering depression and that especially PA of moderate intensity may reduce daytime sleepiness in OSA patients. Likewise, satisfaction of basic need of competence may lead to higher physical activity participation among OSA patients. However, more research is needed.

Keywords: Obstructive Sleep Apnea (OSA); daytime sleepiness; physical activity; depression; Metabolic Equivalents (METS); need satisfaction.

CONTENTS

1. INTRODUCTION

1.1 Obstructive Sleep Apnea

Sleep disordered breathing (SDB) is a chronic condition which encloses two significant disorders related to problematic sleeping: Obstructive Sleep Apnea (OSA) and Central Sleep Apnea (CSA). The word “apnea” stems from the Greek language and it means “breathless” or “absence of breath”. What distinguishes OSA from CSA is the actual cause of disorder, but in both cases, the inflow of the air is being temporarily blocked. Thus, the people who are suffering from untreated sleep apnea are not able to breathe and sleep properly and continuously during the night (Ho & Brass, 2011). This can mean breathing interruptions and awakenings during nighttime because of hard breathing or choking sensation (Epstein, et. al., 2009). Among OSA and CSA, the most common type has been found to be OSA, with the percentage of prevalence being more than 85% when it comes to SDB cases (Ho & Brass, 2011). Nonetheless, in 1966 Gaustaut et al. included a third type of apnea: the “mixed” one, in which an obstructive event follows right after a central one (Gibson, 2004).

Obstructive Sleep Apnea is characterized by upper airway collapse and it can be experienced in two forms: complete inability (airflow cessation - apnea) and partial inability (airflow reduction - hypopnea) to breathe properly during night (Al Lawati, Patel & Ayas, 2008; Jordan, McSharry & Malhotra, 2014). An obstructive apnea episode can be defined as the absence of airflow for at least 10 seconds (Punjabi, 2008) and it is assessed by polysomnography; an equipment-based medical examination which monitors the sleep for an entire night (Haensel et al., 2007). At first, for OSA’s identification the apnea index (AI) was used, which was an indicator of the appropriate frequency of apneas (>5 events per hour/sleep). However, given that: a) healthy individuals could have an AI > 5, b) the OSA symptoms could be seen in patients with hypoapnea and c) the severity spectrum ranges from mild to severe, the AI was rejected and ultimately replaced by the apnea - hypopnea index (AHI) (Gibson, 2004). AHI assesses the quantity of apneas and hypopneas that someone can experience per hour of sleep (Guilleminault & Abad, 2004; Punjabi, 2008; Young, Peppard & Gottlieb, 2002). According to AHI, apnea's severity is categorized to: a) mild apnea (5 – 15events per hour/sleep), which is characterized by passive or sedentary sleepiness, b) moderate apnea (15 – 30 events per hour/sleep), in which sleepiness can be identified in inappropriate times, but without interfering with daily function and c) severe apnea (≥ 30 events per hour/sleep), in which sleepiness is really interfering with everyday life and it can be very harmful (Al Lawati, Patel & Ayas, 2008; Rossini, 2009).

The reference to the disorder has been made in a range of terms such as: Obstructive Sleep Apnea (OSA), obstructive sleep apnea-hypopnea syndrome (OSAHS), sleep apnea-hypopnea syndrome (SAHS), sleep apnea syndrome (SAS) and obstructive sleep disordered breathing (OSDB). For the present study the term "Obstructive Sleep Apnea" (OSA) will be used, as it is the most common term and there is no particular difference in the hardcore symptomatology among all the above.

1.2 Obstructive Sleep Apnea Symptoms and Affect

Even though OSA is sometimes asymptomatic and thus difficult to be diagnosed, the most common and disabling symptom is daytime sleepiness (Franklin & Lindberg, 2015). Sleepiness is measured by the Epworth Sleepiness Scale (ESS) (Ho & Brass, 2011) and it is the main reason why people refer to a polysomnographic study (Macey, Woo, Kumar, Cross & Harper, 2010). Other clinical symptoms are: a) loud snoring, b) morning headache with a sensation of fatigue and c) dry throat (Ho & Brass, 2011; Jordan et al., 2014).

Obstructive Sleep Apnea can lead to cognitive and sexual dysfunction, reduced work performance, decreased quality of life (Punjabi, 2008) and poor sleep quality (Macey et al., 2010). Additionally, OSA can lead to personality and mood changes, insomnia (39%-58%) and to an increased risk for cardiovascular morbidity and mortality (Epstein, et al., 2009; Guilleminault & Abad, 2004; Luyster, Buysse & Strollo, 2010). For example, high risk of systemic hypertension (~ 30%) (Punjabi, 2008; Al Lawati, Patel & Ayas, 2009), myocardial infarction, heart failure (12-53%) and stroke (43%-91%) (Fogel et al., 2001; Bradley & Floras, 2009) have been reported. Also, it has been found that OSA can coexist with epilepsy in 10.2% of epileptic patients (Manni et al., 2003). Finally, OSA not only acts as a risk factor for car accidents due to sleepiness (0.4% - 30%) (Horstmann et al., 2000) but it is also linked to depression and anxiety even though their relationship remains unclear (Ejaz, Khawaja, Bhatia, & Hurwitz, 2011; Heinzer et al., 2015).

1.3 Obstructive Sleep Apnea and Risk Factors

A screening tool called STOP BANG questionnaire, has identified 8 risk factors in OSA: Snoring, Tiredness, Observed apneas, elevated blood Pressure, Body mass index (BMI; greater than 35 kg/m2), Age (greater than 50), Neck circumference (greater than 40 cm), and Gender (male) (Ho & Brass, 2011). BMI is closely related to another major risk factor for OSA, obesity and it has been found that patients with OSA are mostly overweight (Franklin & Lindberg, 2015; Palmer et al., 2003). For example, 58% of people with high BMI have been diagnosed with moderate or severe OSA, while excess body weight increases by 4-fold the prevalence of the disease

(Young et al, 1993). However, even though it has been proved that a 10% of weight change can be associated with a 30% change in the AHI, there is a limitation· the actual causal relationship between obesity and OSA remains uncertain (Palmer et al., 2003; Schwartz, et al. 2008). According to studies (Barvaux, Aubert & Rodenstein, 2000; Grunstein et al., 2007) weight decrease (either surgical or dietary) can affect the severity of OSA, even though weight loss maintenance doesn't prevent the re-occurrence of OSA symptoms (Sampol et al., 1998).

Additional risk factors, yet not established for OSA, are considered to be smoking and alcohol consumption. Smoking (either passive or heavy) is linked to increased risk of snoring and/or sleep apnea and alcohol, mainly before sleeping, increases the number of sleep apneas and enhances their duration (Franklin & Lindberg, 2015; Punjabi, 2008).

1.4 Obstructive Sleep Apnea and Age

Obstructive Sleep Apnea is a global health problem as it dominates in general population. It affects more than 12 million adult Americans as well as Europeans, Brazilians and people from several Asian countries (Jordan et al., 2014). Even though children may suffer from OSA (Guilleminault, Korobkin & Winkle, 1981 for a review), it seems that when the age increases so does the frequency of the disorder, regardless of gender. For example, despite *Bixler's et al.* (*1998*) support that OSA increases until the age of 55 and then it whether stops increasing or decreases, several studies have shown that even after the age of 60, OSA's prevalence still augments (Durán, Esnaola, Rubio & Iztueta 2001; Ho & Brass, 2011; Franklin & Lindberg, 2015). For instance, it has been proved that OSA can affect people over 65 years old up to 42% (Hoth et al., 2013). Similarly, *Sforza et al., (2016)* reported studies which evidence that 24-62% of elderly people suffer from mild OSA and 19-44% of them suffer from moderate to severe OSA. So, Bixler's et al. finding could be attributed to the fact that elderly people living alone show limited awareness of their OSA (Engleman & Douglas, 2004).

1.5 Obstructive Sleep Apnea and Gender

Findings regarding the prevalence rate of gender in OSA are controversial. *Young et al*. (*1993)* were the first to assess OSA's prevalence in Wisconsin and they drew the conclusion that for people aged between 30 and 60 years old, the prevalence rate is 9-24% for men and 4-9% for women. According to a review, subsequent studies from 1993 to 2013 in this field identified a mean score of 22% for men, which ranges from 9-37% and a mean score of 17% for women, which ranges from 4-50%. However, according to the same review, more recent studies from 2008 to 2013 have reported 37% of prevalence in men and 50% in women (Franklin & Lindberg, 2015). Most likely, these differences over time could be attributed to technical factors and differences in the equipment, the design, the population and the interpretation of index scoring (Franklin & Lindberg, 2015).

According to *Senaratna et al.,* (*2017*), another range of studies has identified that men are more prone to the disorder than women, with a ratio of 10:1 for sleep clinic populations and approximately 3:1 in community-based population with a percentage of 4% for middle-aged men and 2% for middle-aged women (Fogel et al. 2001; Campos-Rodriguez et. al., 2012; Hoth & al., 2013). This difference is supposed to be minimized after the age of 60, probably because of women's menopause (Heinzer et al., 2015), as postmenauposal women's likelihood of being affected by OSA is increased between 2- and 3-fold compared to premenopausal women. That means that hormonal status can affect a woman's median score of apnea-hypopnea and protect her from this sleeping disorder (Al Lawati, Patel & Ayas, 2009; Heinzer et al., 2015). Other factors that could possibly affect the gender differences is the more central distribution of body fat in men (Mortimore, Marshall, Wraith, Sellar & Douglas, 1998) and the lower neck circumference in favor of women (Heinzer et al., 2015).

1.6 Obstructive Sleep Apnea and Treatment

Obstructive Sleep Apnea is a chronic disorder which needs to be addressed in a multidisciplinary way, even though a large proportion of people with moderate or severe OSA remain undiagnosed and thus untreated (Young, Evans, Finn & Palta, 1997; Gibson, 2004). There are clinical (Continuous Positive Airway Pressure; CPAP and oral appliances; OA), behavioral (exercise, weight loss/diet, positional therapy and minimization of alcohol or sedatives consumption) and surgical OSA treatments.

1.6.1 Continuous Positive Airway Pressure

According to the American Academy of Sleep Medicine, continuous positive airway pressure (CPAP) or other oral appliances (OA) could be used for OSA treatment (Schmidt-Nowara et al., 1995). Continuous Positive Airway Pressure (CPAP) is a nose mask introduced by Sullivan et al. in 1981. Specifically, it's the application of a positive pressure via the nose and sometimes the mouth, which helps in stabilizing the breathing, suppressing the snoring, normalizing the quality of sleep and minimizing the daytime symptoms (Gibson, 2004).

When it comes to severe OSA, CPAP is recommended as a primary treatment (Iftikhar, Kline & Youngstedt, 2014). It is considered to be the most common and highly cost-effective treatment as it can improve: a) oxygen saturation during sleep

(Ferguson et al., 1996) b) subjective daytime sleepiness and c) the quality of life (Epstein, et. al., 2009; McEvoy et al., 2016; Ferguson et al., 1996) and it can reduce the risk of cardiovascular disease both in middle-aged and elderly patients (Martínez-García et al., 2012). In order for the treatment to be effective, the mask must be used at least 2 hours per night and those who use it 6 to 7 hours benefit the most (Scottish Intercollegiate Guideline Network, 2003). Thus, education about the proper utilization of the equipment, and information about the benefits and the minor but potential risks of this treatment are recommended prior to the application (Epstein et al., 2009).

Despite CPAP's effectiveness, the equipment' acquisition is not affordable to all patients. Additionally, many of those who can afford it, they are intolerant and unwilling to comply with this therapy, probably due to claustrophobia, the noise of the machine or the side effects. Thus, they don't use it in long-term (Gibson, 2004). Actually, it has been monitored that the average CPAP's usage is less that 50% during the whole night, while the ones who discontinue the treatment the most are those who are less symptomatic. (Kribbs et al., 1993).

1.6.2 Oral Appliances

Oral appliances (OA) consist of devices that are inserted into the mouth in order to modify several structures of the upper airway, in an attempt to reduce the level of snoring and sleep apnea. OA have been used as a treatment to upper airway obstruction since early 1902 as an alternative treatment to dissatisfying or complex therapies (Schmidt-Nowara et al., 1995) According to a review conducted by *Ferguson et al.*, in *2006*, OA's efficiency relies on: a) OSA severity (mild to moderate), b) BMI, c) level of AHI depending on sleep position (higher in supine rather than lateral) and d) amount of mandibular protrusion. In severe OSA, oral appliances are recommended as a second-line treatment (Iftikhar, Kline &

Youngstedt, 2014) and it can be used as an adjunct treatment to CPAP, as it leads to fewer side effects and greater satisfaction. (Ferguson, Ono, Lowe, Keenan & Fleetham, 1996; Iftikhar, Kline & Youngstedt, 2014).

1.6.3 Behavioral Strategies

Behavioral strategies for addressing OSA include lifestyle interventions like weight loss, exercise, minimization of alcohol or sedatives consumption before bedtime and positional therapy (Epstein et al., 2009).

Weight loss should be definitely recommended for obese OSA patients, especially for those with mild and perhaps moderate OSA (Rossini, 2009) as it has been found to be preferable to surgical interventions or other medical therapies due to risks, side effects and effects on the sleeping pattern (Smith et al., 1985). Another behavioral therapy that could be used is positional therapy (Rossini, 2009). Its importance lies on the effect that sleeping position has on the upper airway system and the oxygen saturation. For this reason, with the use of a positioning device like a pillow, the patient is kept in a non-supine position leading to a normalized AHI (Epstein et al., 2009). However, not all patients experience such normalization in non-supine (Morgenthaler et al., 2006). Finally, exercise has also been found to be a viable alternative treatment to OSA, as it improves a range of OSA related problems: AHI (Kline et al., 2011; Desplan et al., 2014), daytime sleepiness (Ackel-D’Elia et al., 2012; Desplan et al., 2014), quality of life (Ackel-D’Elia et al., 2012), quality of sleep (Kline et al., 2011; Desplan et al., 2014) and oxygen desaturation index (ODI; Kline et al., 2011).

Behavioral treatment is suggested to be used as an adjunct to basic treatment and not as treatment alone. That's because even though it can improve OSA and the cardiovascular disease risk, its effects on the disorder may be delayed or unsustainable without surgery (Rossini, 2009; Chirinos et al., 2014). Thus, behavioral strategies should be combined with a primary therapy, like CPAP (Rossini, 2009).

1.6.4 Surgery

The surgical treatment for OSA is the modification of the upper airway and it, actually, is the first treatment used for this disorder. Yet, there are several limitations. Particularly, the severity of OSA should be diagnosed in accordance with the eligibility evaluation, before subjecting a patient to an upper airway surgery. That means that experts of the field should assess the existence of any co-morbidities, (either medical or psychological), in order to avoid possible side effects after the surgery. Also, the patients must be informed about the benefits and the potential risks of this treatment. Surgery can be used as a primary treatment in cases of mild OSA, as a secondary when CPAP or OA are inadequate or ineffective or as an adjunctive therapy (Epstein, et al., 2009). In any case, OSA treatment should be individualized and continued long-term (Rossini, 2009).

1.7 Obstructive Sleep Apnea and Depression - Anxiety

According to World Health Organization (WHO; 2001), "depression is the leading cause of disability globally and ranks fourth in the ten leading causes of global burden of disease". Likewise, anxiety is considered to be "the fundamental phenomenon and the central problem of neurosis, and it is one of the most pervasive psychological phenomena of our time" (Speilberger et al., 1971).

In Obstructive Sleep Apnea, both depression and anxiety have been found to be high and the most prevalent psychological disturbances in OSA patients (Macey et al., 2010; Rezaeitalab et al., 2014; Saunamaki & Jehkonen, 2007 for a review) even though anxiety has, generally, received less attention than depression (Andrews & Oei, 2014). More specifically, for diagnosed adult OSA patients, it has been found that 7-63% of them are experiencing depression and 11-70% are experiencing anxiety (Saunamaki & Jehkonen, 2007). Additionally, for people over the age of 65, it was found that anxiety was present in 38% of the sample and depression in 8% (Sforza et al., 2016). Those rates were evidenced regardless of OSA severity (AHI) (Macey et al., 2010). This could imply that factors other than AHI, could contribute to this phenomenon and mediate the OSA – depression/anxiety relationship. For example, it has been found that when health related problems like hypertension and obesity are controlled, the relationship between OSA and depression weakens (Bardwell, Berry, Ancoli-israel & Dimsdale, 1999).

Studies investigating the prevalence of depression and anxiety in OSA patients have reported high rates of coexistence in both primary care (undiagnosed OSA) and clinical populations (entered the sleep clinics and diagnosed with OSA) ranging from 5 to 63% according to a review conducted by *Ejaz et al.* (*2011*). Especially for depression, OSA patients seem to report higher rates compared to community settings (3-5%) and primary care (5-10%) (Harris, Glozier, Ratnavadivel & Grunstein, 2009 for a review). Furthermore, a review by the Veterans Health Administration, reported higher rates of depression in OSA rather than general population (21.8% in contrast to 9.43%) (Ejaz et al., 2011).

Surprisingly, not all reviews support the aforementioned findings. For example, in a review made in 2005 several studies came up with no correlation between depression and OSA, but this might be attributed to different sample size, study population, age, gender and different questionnaires used (Schröder & O'Hara, 2005). Likewise, *Andrews and Oei, (2014*), reported in their review that not all researchers found a relationship between anxiety and OSA and that other factors like quality of life (QoL) could mediate this relationship. Thus, it could be supposed that once QoL is improved after OSA treatment, anxiety levels would be improved too.

The causal relationship between OSA and the psychological disorders remains unclear. Actually, their relationship is rather complex, as many OSA symptoms, including sleep disturbances, are similar to those of the psychiatric disease of depression (Kjelsberg, Ruud & Stavem, 2005) and clinicians face a difficulty in identifying if: a) there is a mental disorder independent of OSA, b) the depressive mood occurs as a secondary disorder to the physical medical one, c) depression promotes OSA and d) depression doesn't really exist (Sharafkhaneh et al., 2005; Macey et al., 2010; Andrews & Oei, 2004 for a review). One reason for that could be the inappropriate use of measures like Minnesota Multiphasic Personality Inventory (MMPI), and Profile of Mood States (POMS) which consist of items that are OSA core symptoms (Andrews & Oei, 2004). However, it is commonly recommended that depression acts as a secondary disorder to OSA and that when an individual experiences symptoms like mood disturbances, fatigue or issues on sleep patterns, they should be tested for OSA (Saunamaki & Jehkonen, 2007).

When it comes to gender differences, women with OSA report more depressive and anxious symptoms even though men are more prone to OSA (Broström et al., 2007). This could be attributed to variations in neural injuries between men and women that are caused by the disorder (Lee, Han, & Ryu, 2015). For example, a study found that female OSA patients show several neural structures with reduced integrity (e.g., white matter injury), which could be associated with the higher prevalence of psychological symptoms of depression and anxiety in women (Macey, Kumar, Yan-Go, Woo & Harper, 2012).

1.8 Depression-Anxiety Treatment in Obstructive Sleep Apnea

In cases that OSA is supposed to cause depression, then OSA therapies are expected to improve the mental disorder too (Harris et al., 2009). However, while in some studies with controlled trials CPAP was found to improve mood disturbances (Giles et al., 2006; Means et al., 2003), in other cases such an improvement was not evidenced. For example, *Haensel et al.*, (*2007*), showed no significant differences in mood amelioration between intervention (therapeutic CPAP) and control (placebo-CPAP) groups after two weeks of treatment. Similarly, *Henke et al*., (*2001*) using a randomized placebo-controlled (effective vs ineffective CPAP) study, drew the conclusion that there is no significant improvement in depression after a 2 to 3-week treatment with effective CPAP.

Likewise, there is no consistency in literature when it comes to anxiety's treatment. Specifically, it has been found that compliance with CPAP therapy leads to lower levels of anxiety (Kjelsberg et al., 2005; Fidan et al., 2007). For example, in a longitudinal study it was found that there was a significant decline in both trait and state anxiety after 1 and 3 months of treatment with CPAP (Sánchez, Buela-casa, Bermudez & Casas-Maldonado, 2001). However, on the other part, in prospective controlled studies no improvement was indicated after 3 and 12 months of CPAP's use (Muñoz et al. 2000; Borak et al., 1996).

Even though OA are an alternative treatment to OSA, only a limited number of studies have examined its effectiveness on depression, while for anxiety none study was found. According to a review conducted by *Harris et al.,* (*2009*), a randomized controlled crossover trial reported an improvement on the somatic but not on the cognitive components of depression, after two 4-week treatment phases in favor to OA treatment, while another didn't find a significant impact of OA in mood compared to placebo treatment after 3 months. Varying findings may be due to differences on study designs or due to different diagnostic tools (Harris et al., 2009).

Other treatment suggested for depression and anxiety is a medical one, with the use of antidepressants and anxiolytic drugs like benzodiazepine and hypnotic. Still, in this way OSA may worsen, leading to an increased number and duration of apneas (Ejaz et al., 2011). In any case, OSA and depression and/or anxiety are comorbid disorders and even though results are not conclusive, patients with OSA display higher rates of depression compared to general population (Lee, Han, & Ryu, 2015).

1.9 Physical Activity

Physical activity is defined as "any bodily movement produced by skeletal muscles that result in energy expenditure" (Caspersen & Christenson, 1985) and it is generally accepted that it plays a crucial role in healthy living (WHO, 1995). Physical activity can be expressed in different forms (endurance training, resistance training and combined training) (Silva et al., 2017) and it is difficult to be measured as not only everyday life includes many activities of different intensities and durations, but also because self-report questionnaires are prone to bias. Those questionnaires depend on a person's memory skills by asking them to recall the duration and/or the frequency of an activity during a specific period of time, which is not always reliable (Igelstrom, Emtner, Lindberg & Åsenlof, 2013). Especially in OSA patients, who show impaired memory (Naëgelé et al., 2006) and decreased concentration due to sleep impairment and daytime sleepiness (Igelstrom et al., 2013).

A way of measuring physical activity is via the use of Metabolic Equivalents. Metabolic Equivalents (METs) are a process of quantifying the energy cost of activities and they provide a range of activities in which one can safely participate. Most physical activities range in an intensity scale from low to high: a) "low" when the activity produces only a slight increase in breathing above normal and a minimal perspiration (4 METs), b) "moderate" when the activity leads to an increased breathing above normal and a definite perspiration (6 METs) and c) "high" when a heavy breathing and perspiration is produced (10 METs) (Jette, Sidney & Blumchen, 1990; Ainsworth et al., 2011).

Based on the World Health Organization (WHO, 2010), and the physical activity guidelines, in order for an individual to have a healthy life and avoid chronic disease, at least 150min of moderate intensity per week or 75min of vigorous intensity per week are recommended. According to *Silva et al*. (*2017*), those who report moderate or vigorous activity for at least 10 minutes once a week are considered to be regularly active. Additionally, according to the aforementioned researchers occupational activity is another way of being physically active. It includes standing, walking, sitting, lifting, carrying, pushing and pulling. Workers with sedentary or light work are classified as non-active, while those with medium, heavy or very heavy work are classified as active.

For patients and elderly people, it is proposed that moderate intensity activities (5-8 METs) could act as a sufficient training stimulus. However, in any case, any activity should be proposed after taking into account the fitness level of each participant (Jette, et al., 1990). Information about specific physical activities and their associated MET values can be obtained from the Compendium of Physical Activities, which is regularly updated, whenever new activities are identified (Ainsworth et al., 2011).

1.10 Exercise

Even though exercise is used interchangeably with physical activity, they are not synonymous. Actually, even though they share several elements (involvement of any bodily movement, range from low to high, positive correlation with fitness), exercise is a subcategory of physical activity. Particularly, "exercise is a planned behavior, which is also structured and systematic, in an attempt to achieve something, like improving or maintaining one's physical fitness or state". Physical activities of moderate or high intensity could be considered as physical exercise, when the criteria mentioned above are met. Even activities such as occupational or household can be considered exercise, when they are performed in an attempt to improve or maintain one's physical fitness (Caspersen & Christenson, 1985).

1.11 Physical Inactivity - Sedentary Lifestyle

Physical inactivity and sedentary lifestyle is responsible for 9% of premature mortality or >5.3 of the 57 million deaths in 2008 (WHO, 2011). Even though it is not known how much sedentary behavior is acceptable for maintaining a healthy life, it is well established that 1hour increase in sedentary time per day has a negative impact on health (Igelstrom et al., 2013) and it can contribute to type 2 diabetes and cardiovascular disease (Mendelson et al., 2014; Simpson et al., 2015). It has been evidenced that the percentage of adults not meeting the physical activity guidelines is high, even though the rates vary. For example more than 70% of adults were found to be physically inactive according to WHO (Department of Health, 2004). In *2009*, *WHO* reported that 17% of people were not meeting the guidelines, while in another study, it was found that 31% of world's population was classified as inactive (Hallal et al., 2012). In any case, given the high prevalence of physical inactivity and its consequent harmful health, social and environmental consequences, this issue must be addressed as a global problem and must be seen as a health priority.

1.12 Physical (in)Activity in Obstructive Sleep Apnea

Physical inactivity acts as a risk factor for OSA (Mendelson et al., 2014; Simpson et al., 2015), even though the relationship between sedentary lifestyle and OSA is rather complicated and not fully examined. Nevertheless, the daily average sedentary time in OSA patients has been found to range from 8h to 9h and 55 min (Igelström et al., 2013) to 11 h and 45 min (Igelström, Emtner, Lindberg & Åsenlöf, 2014). Additionally, even though sedentary lifestyle in work and leisure-time has been associated with higher obesity rates (King et al., 2001), studies have shown that time spent sitting during the day is positively related to increased AHI level (Redolfi et al., 2009), even regardless of obesity levels (Simpson et al., 2015). In addition, sedentary behaviors objectively measured by actigraphy (Mendelson et al., 2014) and self-reported lack of exercise (Peppard & Young, 1992) are associated with OSA severity. However, the differences between males and females concerning physical inactivity are yet to be examined (Cintra et al., 2009).

On the other part, physical activity and especially the number of steps walked during the day have been reversely correlated not only with comorbidities like hypertension, diabetes and obesity, but also with AHI during REM sleep in patients with moderate to severe OSA (Verwimp, Ameye & Bruyneel 2013). Regarding occupational activity, even though *Simpson et al*. (*2015*) revealed that work activity is associated with a decreased risk of moderate-severe OSA, *Silva et al*. (*2017*) reported no association between work activity and OSA severity, probably due to age, BMI and low rate of active exercisers in the working group.

As a result, lifestyle interventions like physical activity could be a possible alternative treatment for OSA, because of the minimal cost and side effects and its evidenced effectiveness. However, more research is needed for confirmation of the promising findings (Araghi et al., 2013).

1.13 Physical Activity - Exercise in Obstructive Sleep Apnea (RCTs)

Physical Activity and exercise have been linked to OSA in a range of Randomized Controlled Trials (RCTs). In the RCT by *Sengul et al.*, (*2011),* the effects of breathing and aerobic exercise were compared to a routine clinical treatment. A statistically significant effect in favor of the supervised exercise was found when it comes to AHI, quality of sleep (measured by Functional Outcomes of Sleep Questionnaire - FOSQ) and health-related quality of life (measured by Short-Form 36 – SF-36) in patients with mild to moderate OSA. Nevertheless, after the 12-

week intervention and during the follow-up, there were no statistically significant differences between the two groups. Another RCT (Ackel-D'Elia et al., 2012) compared the use of CPAP to CPAP + exercise for patients with moderate to severe OSA for two months. The results showed that both types of treatment were significantly effective in improving subjective excessive sleepiness (measured by ESS) and health-related QoL (measured by SF-36). Their difference lies in that CPAP + exercise treatment was more effective in maintaining the improvement during the 1-week washout (no treatment week).

In *2011, Kline et al.* examined the effects of exercise on sleep in OSA patients. Exercise training was favorably compared to stretching training, as after a two-week treatment it brought a statistically important effect on AHI, on subjective sleep quality (measured by Pittsburgh Sleep Quality Index - PSQI) and on oxygen desaturation index (ODI). However, objective sleep quality (measured by a monitor home sleep/wake status) was not significantly affected. Another RCT by *Desplan et al.* (*2014*) examined the effects of an inpatient rehabilitation program on sedentary patients with moderate to severe OSA, which included, among other, an individualized exercise training program (IET). It was compared to education activity sessions applied for one month. A statistically significant decrease of AHI and of daytime sleepiness (measured by ESS) and a significant improvement of sleep quality (measured by PSQI) in favor of IET program were depicted.

Exercise effectiveness was also supported by *Servantes et al. in 2012.* The study examined the effects of a home-based exercise training divided into two groups: a) aerobic training b) aerobic training + strength training, compared to an untrained group. In the first two groups the sleep quality of OSA patients (measured by polysomnography) was improved with a statistically significance. Specifically, the first group showed a statistically significant decrease in hypoapnea events, while the second showed a statistically significant decrease in both apneas and hypoapneas during the night. In addition the number of nocturnal arousals was also significantly decreased, associated with a significant increase in sleep efficiency, in contrast to the untrained group. Finally in the RCt of *Schutz et al., (2013),* aerobic / resistance exercise was favorably compared to CPAP and OA treatment on the symptom of subjective daytime sleepiness.

1.14 Physical Activity - Exercise in Obstructive Sleep Apnea (meta-analyses)

Several meta-analyses examined also the effects of exercise and physical activity on OSA symptoms. For example, *Ifthikar et al*. (*2017*), who recruited RCTs, found that CPAP was the most effective treatment in reducing OSA symptoms. Nevertheless, when exercise was compared to control condition of CPAP, Mandibular Advancement Device (MAD) or dietary weight loss, even though CPAP was the most effective in improving all the parameters of OSA severity, exercise training improved significantly apnea/hypoapnea levels and sleepiness scores. Similarly, *Ifthikar et al.* (*2014)*, allocated three RCTs and two single group intervention studies for pre and post-intervention examination. A statistically significant effect for exercise in reducing apnea/hypoapnea and improving sleep efficiency (measured by overnight polysomnography and expressed as a percentage of time spent asleep in bed) was found. Also, exercise improved sleepiness, showing its potential in OSA management.

In the meta-analysis of *Thomasouli et al.* (*2016*), twelve RCTs were included but only six of them compared an experimental group (lifestyle program which included dietary plus/or exercise) to a control group (dietary advice) for at least two months. Lifestyle interventions led to a statistically significant reduction in the apnea/hypoapnea levels and a non-significant reduction in sleepiness scores. *Aiello et al. (2016*), recruited six RCTs and two single group intervention studies where supervised and unsupervised exercise programs were used as interventions. Results showed a statistically significant effect for exercise in decreasing apnea/hypoapnea levels and reducing sleepiness scores but a statistically non-significant effect in reducing BMI.

In the meta-analysis of *Mendelson et al.,* (*2018*) physical activity was favorably compared to control conditions (CPAP or dietary modification), showing a significant effect on apnea/hypoapnea and sleepiness improvement. Finally, given that OSA is related to obesity, a meta-analysis by *Araghi et al*. (*2013*), examined the impact of weight loss through diet and physical activity on apnea/hypoapnea level, daytime sleepiness measured by ESS and on ODI. The study recruited seven RCTs which showed that weight reduction programs (exercise or exercise + diet) can lead to a statistically significant decrease in apnea/hypoapnea level but not in daytime sleepiness. Additionally, the study recruited fourteen single-group before-after intervention studies. Those single intervention studies (exercise or exercise + diet) supported the significant decrease in apnea/hypoapnea. Regarding ODI, only the diet-intervention studies reported a significant decrease.

1.15 Exercise and Depression - Anxiety

The primary treatment for depression is medication, which, even though it has been proved beneficial for severe depression (Fournier et al., 2010), it hasn't been effective for mild to moderate depression (Kirsch et al., 2008; Prior, Wood, Lewis, &

Pill, 2003). Another type of treatment is counseling and psychotherapy, to which people turn, in an attempt to avoid the side effects of medication (e.g., nausea, vomiting, weight gain, sleepiness, and sexual problems). However, it can be expensive or unavailable (e.g., Demyttenaere, 2003).

Hence, research has turned the attention to alternative treatments like physical activity and exercise. Although the American Psychiatric Association (APA; 2000), suggests that exercise may be of value, but only as an adjunctive therapy to antidepressants or psychotherapy, it has been proved that exercise is beneficial for both prevention (e.g: Ball, Burton, & Brown, 2009) and treatment for depression· specifically, it has been reported that physical activity can improve depression just like cognitive behavioral therapy (Mead et al., 2009) or medication (Blumenthal et al., 1999; 2007).

A meta-analysis of RCTs in which exercise was compared to placebo or control groups, a significant improvement in depressive symptoms was evidenced in favor of exercise (Mead et al., 2009). What is more, a significant improvement in depression was found, when exercise was used as an adjunct therapy to antidepressants (Mather et al., 2002), but not as an adjunct to cognitive behavioral therapy (Fremont & Craighead, 1987). Notably, the intensity of physical activity seems to play an important role, as low intensity exercise was found to have the same effect as a placebo in depression treatment (Dunn, Trivedi & O'Neal, 2001)· instead, higher intensity, meeting the guidelines proposed by WHO, was more effective (Singh, et al., 2005). Interestingly, even though exercise has been found to be more effective than no treatment and as effective as traditional interventions (medication and/or psychotherapy) (Daley, 2008 for a review) it seems that physical activity engagement is affected by several factors like low self-esteem or confidence, social anxiety, weight problems or poor fitness levels (Donaghy & Taylor, 2010; Fava et al., 2006; Taylor, 2010).

Treatment of anxiety has received less attention, even though it is associated with inability to concentrate, to sleep and thus to carry out daily tasks (Hamilton, 1983). Nevertheless, research focused on anxiety has shown that medication, relaxation and biofeedback are the strategies used in clinical practice, as they contribute to the improvement of both physiological and psychological components of anxiety (Shapiro, 1982). Additionally, it has been found that Cognitive Behavioral Therapy (CBT) can also reduce anxiety sensitivity, through feared somatic sensations, arousal reduction and cognitive-restructuring techniques (Telch et al., 1993). However, studies have evidenced that exercise and physical activity can play a crucial role in decreasing anxiety levels, too. For example, it was found that exercise reduced state anxiety for individuals who showed either normal or elevated levels of anxiety (Raglin, 1997). On the other part, a recent meta-analysis showed that physical activity was more effective in reducing anxiety levels in people with clinical rather than non-clinical levels of anxiety (Wegner et al., 2014).

When it comes to the type of physical activity, aerobic exercise was found to reduce state anxiety (Cox et al., 2004) or generalized anxiety, just like CBT (McEntee & Haglin, 1999). The same result was evidenced when aerobic exercise was compared to placebo (Books et al., 1998). In addition to that, not only aerobic but also non-aerobic exercise forms (muscular strength, flexibility, relaxation) were found to improve anxiety levels (Martinsen, Hoffart & Solberg, 1989). However, once again, even though people are aware of the exercise effectiveness, it doesn’t mean their willingness to stick with an exercise program (Buckworth & Dishman, 2002).

1.16 Self-determination Theory

Self-Determination Theory (SDT) is a macrotheory of human motivation and personality and it is developed through five mini-theories which altogether constitute its theoretical framework. The Cognitive Evaluation Theory (CET) examines the social environment's effect on the autonomous motivation's enhancement or undermining and how factors like rewards, feedback and deadlines can have an impact on the important needs of competence and autonomy. Organismic Integration Theory (OIT) refers to the internalization of extrinsic motives, as the more autonomous motivation will lead to enhanced persistence on an activity and to greater performance. Internalization can be facilitated mostly by the satisfaction of autonomy, competence and relatedness. Causality Orientations Theory (COT) describes three types of causality orientation that affect the subsequent motivation: autonomy orientation which orients to what is interesting, control orientation which orients to control and rewards and imersonal orientation. Basic Psychological Need Theory (BPNT) connects well-being with the satisfaction of the psychological needs and examines differences between and within individuals across time. Finally, Goal Contents Theory (GCT) examines how goals are framed and the difference between extrinsic and intrinsic goals when it comes to their impact on need satisfaction and ultimately well-being (Ryan, 2009).

Self-Determination Theory emphasizes in the relationship between a person and its environment. It focuses on the support and satisfaction of the three innate psychological needs of competence, relatedness and autonomy and on how their enhancement or diminishment affects the individual's psychological adjustment, self-motivation and personality integration (Ryan & Deci, 2000). "Autonomy" is defined as the support of the person's capacity to be self-initiating and autonomous, thus being responsible for their own actions (Ryan & Deci, 2000). It has been differentiated from individualism and independence, while autonomy's opposite is "heteronomy" which can be described as being forced to do something that doesn't reflect someone's authentic interests and integrated desires (Chirkov, Ryan, & Kim, 2003). "Relatedness" points out the dynamic and important nature of our relationship with the significant others and the need to provide and be provided of love and care, meaning a sense of belonging and connected to others (Ryan & Deci, 2000; Vallerand, Koestner & Pelletier, 2008). "Competence", on the other hand, is defined as the perceived effectiveness and a need to succeed at optimally challenging tasks, while extending one's skills and attaining desirable outcomes (Ryan & Deci, 2000; Luyckx & Vansteenkiste, 2014).

When all the needs are equally satisfied, an optimal motivation toward a task will be achieved and a sense of personal growth, constructive social functioning and well-being will be experienced. The connection between the psychological needs and well-being has been reported in diverse domains like sport, education, work, parenting, health care and psychotherapy, as mentioned by *Ryan, (2009)* or *Bartholomew et al.,* (*2011*). This connection is universal and it refers to people from all cultures who share those basic and essential psychological needs (Ryan & Deci, 2000). Actually, it has been found that giving choice and acknowledging someone's feelings can increase the autonomous motivation toward an activity. In addition, when the needs are satisfied over time and in different contexts, while an individual is growing, then the creation of a strong autonomous motivation is facilitated (Ryan, 2009).

The thwarting of the basic needs can lead to cognitive, affective and behavioral patterns that represent a non-optimal adjustment. For example, controlling motivational style can display a negative consequence on health and well-being and even lead to psychopathology. However, the difference between need dissatisfaction and need thwarting has not been explicitly identified. Nevertheless, the latter seems to be more related to negative outcomes and ill-being, independently of need satisfaction. As a result, an autonomy-supportive behavior fosters the positive psychological experience while a controlling one undermines it (Bartholomew et al., 2011). What is more, when relatedness and competence are satisfied but autonomy is thwarted, then people tend to develop a more controlled orientation that can lead to controlled motivation (Ryan, 2009).

Attention has been paid not only to the quantity of motivation but also the quality of it, as although it is important to know the amount of motivation toward behaviors, it is also crucial to be aware of the motivation's type in order to be able to predict the behaviors' maintenance (Deci & Ryan, 2015). According to SDT, motivation varies in a continuum ranging from amotivation to controlled motivation and ultimately to autonomous motivation.

Most positive outcomes seem to derive from self-determined types of motivation like identified, integrated, and internal, which constitute the autonomous motivation (Vallerand et al., 2008). Some examples could be the enhanced performance, the heightened self-esteem and the persistence on the task. "Identified" motivation refers to the acceptance of the value of the activity and thus one is identifying with the importance of the behavior. "Intergrated" motivation refers to the assimilation of the identification, making the behavior part of "who" one is. Finally, "internal" motivation refers to the engagement in an activity as it produces enthusiasm, spontaneity, excitement and joy. On the other part, controlled motivation consists of external motivation, which is the participation in an activity because of external rewards or punishment avoidance and the introjected motivation, which is the participation in an activity to avoid feelings of guilt (Ryan & Deci, 2000).

Even though all people, from their time of birth share an inherent and deep inclination toward spontaneous interest, their maintenance and enhancement depend on the conditions which may sustain or undermine the innate propensity. As a result, the less self-determined types like introjected and external lead to negative outcomes. However, there is also the amotivation which is defined as the absence of motivation which leads to maladaptive outcomes (Vallerand et al., 2008).

1.17 Self-Determination Theory and Obstructive Sleep Apnea

Several facilitators and barriers for adherence to CPAP have been identified, while some of them are related to SDT. For example, it has been identified that insufficient support from healthcare personnel, feelings of uncertainty toward OSA diagnosis and difficulty in understanding the need of CPAP treatment can act as risk factors. On the other part, a good relationship with the medical staff, one's own belief in a positive CPAP effect, and a belief in one's own capacity to manage the treatment, can act as protective factors and they seem to be important both before and during the treatment (Broström et al., 2010).

Self-Determination theory has been applied in OSA patients, even though the studies are limited. It has been found that the application of a group-based program in recently diagnosed OSA patients, which uses the components of SDT as a facilitator, resulted in facilitative, adaptive and acceptable CPAP adherence levels (Broström et al., 2011). Additionally, a prospective, multi-site, RCT called "GotoSleep" by *Matthias et al.* (*2014*), used conversations with OSA patients based on SDT at baseline and intervention interviews (CPAP vs usual care). At 1-month follow-up most of the patients were still motivated and trying to use the mask, in an attempt to overcome the physical discomfort and develop new bedtime routines. Some of them had given up and few reported that they were adhering to CPAP, recognizing its benefits, even though those benefits were not immediately apparent. However, none of them identified the use of CPAP as part of who they were, maybe due to insufficient time to integrate CPAP into their personal identity. *Igelström et al.* (*2014*) compared CPAP treatment + behavioral medicine intervention (based on SDT) to CPAP + advice, examining the association between weight and OSA. The intervention led to changes in eating behavior by OSA patients, which resulted in weight loss and reduction in waist circumference and ultimately in the facilitation of CPAP adherence.

However, in the RCT by *Bravata et al.* (*2018*), it was found that an enhanced adherence intervention based on SDT didn't differ from the standard protocol (focused on technical issues related to the CPAP equipment) in CPAP adherence in OSA patients with ischemic stroke/transient ischemic attack after one-year treatment.

Brostrom et al. (*2011*) identified several perceived barriers related to the disorder and its treatment, affecting OSA patients' motivation: uncertainty of the CPAP or the OSA symptoms, and anxiety regarding the exposure to other participants of the program. Hence, by using small groups to increase patients' opportunity to discuss their thoughts and concerns, their program led to an enhanced sense of satisfied need of competence (perceiving the program as a challenge which will lead to personal development), relatedness (interacting with others and receiving support) and autonomy (influencing the topics and the degree of difficulty of the information). As a result, higher CPAP adherence was observed.

1.18 Self-Determination Theory and sleep

Poor sleep is related to perceived stress, loneliness and financial strain and it leads to impaired cognitive functioning, diabetes, obesity and cardiovascular diseases. On the contrary, better sleep is related to mindfulness and gratitude. However, no psychological framework has been developed to explain how the identified sleep predictors are associated with sleep outcomes (Campbell et al., 2015). Given that SDT has been associated positively with general well-being and negatively with ill-being (Ryan, 2009), Campbell et al., (2015) wanted to explore the relationship between psychological need satisfaction and subjective measures to the physiological need of sleep. They found that need satisfaction was positively associated with good sleep quality, probably due to the creation of positive thoughts when falling asleep as a result of the positive daily experiences. Additionally, they found a decrease in the experienced daytime dysfunction and a positive but less pronounced relation between need satisfaction and sleep quantity. Finally, they found that mindfulness facilitates need satisfaction which leads to the acceptance of sleep-interfering thoughts, while financial strain thwarts need satisfaction as it undermines the feeling of competence and increases interpersonal conflicts, leading to an impaired sleep.

1.19 Self-Determination Theory and Depression - Anxiety

To date, depression has received great attention in clinical psychology, as it is one of the mental disorders linked to hopelessness and suicidal ideas (Beck et al., 1993; Cavanagh et al., 2003 for a review). Boredom at work leads to feelings of being unchallenged, feelings of a meaningless work experience, to a loss of intrinsic motivation towards desired goals and ultimately to a depressive mood (Wiesner, Windle & Freeman, 2005; van Hooff & van Hooft, 2006). Those feelings can be transferred to a home environment via the creation of work-related unpleasant feelings and thoughts which affect employees' other life domains (Judge and Ilies, 2004). According to SDT, the fulfillment of the three innate psychological needs can minimize the work-related negative effect and lead to positive emotions of happiness and enjoyment (Reis et al., 2000). Specifically, managers' and subordinates' provision of an autonomy-supportive climate (Baard, Deci and Ryan, 2004) and daily satisfaction of autonomy, competence and relatedness after work (van Hooff and van Hooft, 2006) can actually combat its negative effects and contribute to well-being.

Except work-related negative feelings, SDT and need satisfaction have been related to depression and anxiety in a variety of other studies. For example, environments that tend to thwart the psychological needs via pressuring or intrusive strategies can cause depressive symptoms (Soenes et al., 2008). In the study of *Dwyer et al*. (*2011*), high autonomy need satisfaction in both depressed and anxious patients resulted in reduction of negative thinking and in more positive outcomes during a cognitive-behavioral therapy. Additionally, individuals high in autonomy seem to react differently under stressful conditions. For example, relative to controlled motivation, autonomously motivated individuals reported a reduced threat response, less anxiety and an enhanced performance during a stressing interview (Hodgins et al., 2010). Similarly, *Munster Halvari et al.* (*2010*) found that patients' perceptions of autonomy satisfaction were related to decreased anxiety for dental treatment, leading to enhanced dental clinic attendance and to minimized postponement of making an appointment. On the other part, *Eberhart* and *Hammen* (*2006*) found that unsatisfied relatedness on the part of family and peers can result in depressive symptoms during a 2-year period.

Research focused on elderly people living in nursing homes, has shown that greater self-determination is linked to better psychological adjustment (O'Connor & Vallerand, 1994) and that perceived autonomy satisfaction provided by family, friends and the institutional staff was associated with lower depression and higher well-being (Kasser, 1999). However, a more recent study in elderly people (80 years and over) living in residential homes, found that while individuals with high need satisfaction reported more personal growth and purpose in life than those with low satisfaction, no difference was reported in the depressive feelings between the two profiles (Ferrand, Martinent, & Durmaz, 2014).

Depression and anxiety affect also university students as university life is associated with three main concerns: a) academic performance, b) pressure to succeed, c) post-graduation plans (Beiter et al., 2015). However, SDT and the psychological needs seem to be negatively related to depressive symptoms (Wei et al., 2005), as greater need satisfaction (including provision of choices and meaningful rationales) in a supportive environment led to better outcomes and lower anxiety levels compared to low need satisfaction in a controlling environment (Sheldon and Krieger, 2007; Black and Deci, 2000).

Depression is closely related to suicidal thoughts and behaviors. In 2010 suicide was ranked as the tenth cause of American deaths (38,000), while those who attempted suicide that year were approaching the 1 million (Mcintosh & Drapeau, 2012). Thwarted belongingness and feelings of burdensomeness in combination to one's capability to cause lethal self-harm can lead to suicidal desire or behavior (Joiner, 2005). However, studies have shown that psychological intervention can act as a buffering and protective factor (e.g., Brown et al., 2005).

As depression has been associated with the basic psychological needs (Wei et al., 2005) SDT components might provide a solid ground for understanding the desire to die and creating a therapeutic relationship in an attempt to enhance individuals' motivation for treatment. *Tucker* and *Wingate* (*2014*) found that satisfied needs lead to lower levels of suicidal ideation, thwarted belongingness and perceived burdensomeness and that the needs work through these two interpersonal risk factors. Additionally, they found that relatedness had a more direct effect on those factors even when the depressive symptoms were controlled, probably because it is linked to feelings of loneliness and lack of mutuality in close relationships.

Given that applying the humanistic tenets of SDT could help therapists in motivating their clients/patients and thus leading to the enhancement of their therapeutic program's efficacy (Sheldon et al., 2003), those tenets could also be beneficial to the treatment of suicidal ideation. Actually, *Britton*, *Williams* and *Conner*, (*2008*) proposed that: a) a client's autonomy satisfaction (taking into account their perspective, giving them options and providing them with meaningful rationales for every recommendation) b) perceived competence satisfaction (positive feedback regarding their ability to start a treatment and engage in that) and c) relatedness satisfaction (encouragement, and emphasis on the therapeutic relationship's quality), will ultimately lead to treatment engagement and treatment outcome.

1.20 Self-Determination Theory and Physical Activity - Exercise

Physical activity and exercise have been linked to physical and psychological well-being (e.g., Department of Health, 2004), even though population surveys show that only a minority of people engage in sufficient physical activity (e.g., Colley et al., 2011; Sisson & Katzmarzik, 2008). Thus, attention has been turned to exercise motivation. People seem to be amotivated due to low interest in exercise (Ryan, Williams & Deci, 2009), or they are insufficiently motivated because of several limitations: a) lack of sense of competence, b) other daily interests/demands or c) health issues (Korkiakangas, Alahuhta & Laitinen, 2009). Additionally, not all of the people who start exercising persist in exercise behaviors, probably because they are driven by external motivation (Ryan, Williams & Deci, 2009). Hence, researchers have tried to examine the factors that contribute to the uptake and maintenance of regular exercise or physical activity.

Self-Determination Theory (SDT) is one theoretical perspective that helps in understanding the social and psychological processes that influence physical activity or exercise adherence (Ryan & Deci, 2000). According to Deci and Ryan (1985, 2000) when the basic psychological needs are satisfied, more self-determined types of motivation will guide people's behaviors (internal, integrated and identified motivation). As a result, more adaptive behavioral and cognitive outcomes will be achieved, like exercise engagement and commitment. What is more, the people will experience more vitality and well-being. Maladaptive outcomes, on the other part, are the result of the thwarting need satisfaction and the consequent less self-determined types of motivation (introjected and external motivation, amotivation).

Previous research in exercise setting has shown that basic need satisfaction is associated with more self-determined than controlled exercise motives (Wilson, Rodgers & Fraser, 2002), which in turn lead to global and contextual well-being (Wilson et al., 2006). Higher perceived competence and autonomy are related to positive effects and autonomous motivation towards exercise participation (Markland, 1999), while self-determined and autonomous motivation seem to mediate the relationship between psychological needs and exercise motivation (McDonough &

Crocker, 2007; Weman-Josefsson, Lindwall, & Ivarsson, 2015) or the relationship between need for competence and intensive exercise (Edmunds, Ntoumanis & Duda, 2006). Intervention in exercise domain has shown that people who participated in exercise programs based on SDT, reported greater increase in competence satisfaction and positive affect (Edmunds, Ntoumanis & Duda, 2008). Even RCTs conducted in three different countries showed that the psychological needs are, indeed, universal and that when they are satisfied, autonomous motivation is prompted, which can ultimately predict physical activity (Fortier, Duda, Guerin, & Teixeira, 2012). For sustaining a physical activity and exercising behavior*, Edmunds et al.,* (*2006*) suggested that it probably requires a lot of effort and an identification with the exercising outcomes, as having just fun or feeling challenged is not sufficient. This finding is in line with *Koestner and Losier* (*2002*), who proposed that in behavioral domains, engagement and persistence is not only based on internal motivation, but it requires also internalization of the outcomes.

1.21 Self-Determination Theory and exercise/Physical Activity in Depression/Anxiety

Despite people's awareness of exercise and physical activity effectiveness, their engagement is rather limited (Donaghy & Taylor, 2010; Fava et al., 2006; Taylor, 2010; Buckworth & Dishman, 2002). For this reason, research focused on how to increase motivation for physical activity among individuals with psychiatric problems, like depression and anxiety.

Self-Determination Theory (SDT) proposed by Deci and Ryan (2000) could be used as a theoretical framework in understanding how to increase motivation in this population. For example, *Sorensen* (*2006*) found that population of psychiatric patients who had experienced self-determined physical activity during their treatment, were more motivated in continuing physical activity. Most of them showed introjected ("ought to for my health") and internal motives (pleasure), which were linked to higher activity level. Given that autonomous motivation is associated with increased physical self-esteem (Wilson & Rodgers, 2003), positive attitudes towards exercise (Wilson et al., 2004), and greater participation and exercise adherence (Chatzisarantis & Hagger, 2009), Haase et al., (2010) conducted a study. They found that a complex exercise intervention based on motivational interviewing (Miller & Rollnick, 2002) and on psychological need satisfaction, was effective in reducing depression and cost-effective compared to usual care. Additionally, Duda et al., (2014) found that an exercise intervention based on SDT, led to great reduction in reported anxiety, pointing out the importance of need supportive consultations, which will enhance participants' basic need satisfaction and motivation for engagement.

1.22 Aim of Study

To our knowledge, no research examined before the levels of depression, anxiety, daytime sleepiness and physical activity in relation to Self-Determination Theory (SDT) in Obstructive Sleep Apnea (OSA). The present study was an attempt to extend the current literature in the physical activity-OSA area with a threefold aim: a) to explore the interactions of SDT tenets and physical activity with depression, anxiety and OSA symptom of daytime sleepiness, b) to examine whether physical activity can contribute to the minimization of daytime sleepiness among OSA patients and c) to examine whether SDT can contribute to the adoption of physical activity in OSA patients.

2. METHODS

2.1 Subjects

Participants of the present study were 51 (males = 38, females = 13) adult patients ($mean_{age}$ =~ 51 y.o) diagnosed with Obstructive Sleep Apnea. They were recruited from a pneumonological clinic of a university hospital, in which they were evaluated for suspected OSA via a full night sleep study using polysomnography. Basic demographic information was obtained from a self-reported checklist. Inclusion criteria were: a) aging above 18 years but no older than 65 y.o. and b) having an AHI ≥ 5/h, regardless OSA severity and CPAP use. Participants provided written informed consent prior to the fulfillment of the questionnaires (demographics presented in Table 1).

2.2 Measures

Daytime Sleepiness was evaluated using the *Epworth Sleepiness Scale (ESS)*, a self-report scale regarding how likely participants would be to fall asleep in eight everyday situations. Scores range from 0 to 24 with 10 and above considered as excessive sleepiness (Johns, 1991).

Beck Depression Inventory-II (BDI-II) is a 21-item self-report scale that evaluates symptoms of depression over the past 1 week. Each item is rated on four-point scale (0-3), while scores range from 0 to 63. Higher scores reflect greater depression (Beck, Steer & Brown, 1996).

State Trait Anxiety Inventory is a 40-item self-report scale, which includes two subscales: state and trait anxiety. It assesses the presence and severity of anxiety symptoms and each item is rated in a Likert scale, from 1 (not at all) to 4 (very much so), based on what they feel the current moment. Scores range from 20 to 80 and the higher the score, the higher the level of anxiety (Spielberger, Gorsuch & Lushene, 1994).

Patient Health Questionnaire (PHQ-9) is the Major Depressive Disorder (MDD) module of the full PHQ. It assesses the presence of depressive symptoms over the past 2 weeks and monitors their severity. It consists of 9 items and the scores range from 0 to 27. Higher scores are associated with decreased functional status and increased symptom-related problems. The last item is not included in the scores, although it can be used as an indicator of the patients' overall impairment. A score greater than 10 indicates a major mood disorder of sufficient severity to warrant treatment, whereas scores greater than 15 (moderately severe) or 20 (severe) indicate an urgent need for immediate treatment (Kroenke, Spitzer & Williams, 2001).

Physical Activity Questionnaire (*IPAQ*) is used for the evaluation of physical activity. It assesses vigorous, moderate, walking and sitting activities, over the previous 7-day period. A total activity score comes from the summation of the duration (in minutes) and frequency (days). Only activities lasting 10 minutes or more are to be included. (Craig et al., 2003).

Basic Need Satisfaction in Exercise Questionnaire is a 14-item self-report scale used to assess whether the needs of autonomy, competence and relatedness are satisfied, in a Likert-type scale ranging from 1 to 7. Higher scores indicate higher needs' satisfaction for those tend to continue exercising systematically or those who tend to start exercising systematically (Vlachopoulos & Michailidou, 2006).

2.3 Procedure

The study was approved by Internal Ethics Committee of the Department of Physical Education and Sport Science, University of Thessaly, prior to subject enrollment. In collaboration with the University Hospital of Larisa, Greece, a list of OSA patients was provided. The initial contact with the patients was made via telephone, during which they were informed about the cause of the study, the time needed and the importance of having face-to-face meetings. They were informed that during the meeting they would fill several questionnaires addition, that their participation would be voluntary and that the data would be anonymous.

During the meetings with the patients that agreed to take part in the study, they were asked to read the consensus form and sign their consent. They were informed that they were free to ask any question and that they could stop the procedure anytime they wanted. Ultimately, none interrupted the whole process and several questionnaires were filled by the patients and some by the researchers, when needed.

2. RESULTS

Participants scored minimal on depression. However, 27% of the patients showed depressive scores on the BDI-II within the clinical range (>14). (Beck, Steer & Brown, 1996). Likewise, on the PHQ-9, 27% of the patients showed psychometric diagnosis of major or other depressive disorders, according to the cutoff score (≥10) (Kroenke et al., 2001). They also scored lower to higher normal on daytime sleepiness (Murry, official website of ESS) and they showed moderate trait and marginally high state anxiety (Kayikcioglu, Bilgin, Seymenoglu & Deveci, 2017). Finally, they scored moderate to high need satisfaction. Descriptive statistics and Cronbach's Alpha and coefficients are presented in Table 2.

Correlations showed a statistically significant moderate positive relationship between depression and sleepiness, a significant moderate to large positive relationship between depression and state anxiety and a significant large positive relationship between depression and trait anxiety. Additionally, depression showed a significant moderate negative relationship with competence and autonomy. Sleepiness revealed a significant moderate positive relationship with METS moderate. Competence showed a significant high and moderate positive relationship with total METS and relatedness, respectively and a significant moderate negative relationship with trait anxiety. Trait anxiety yielded a significant high positive relationship with state anxiety, while moderate and low METS showed significant moderate and large positive relationships with total METS, respectively. Finally, a moderate positive relationship between BMI and depression was found, even though non-significant. Correlations between all variables are presented in Table 3.

T-tests were computed to test for differences in sleepiness and depression between exercisers and non-exercisers. For sleepiness, the analysis showed non-significant differences, $t(49) = 1.37$, $p = .18$. For depression, the analysis showed significant differences, $t(49) = 1.75$, $p < .05$, with exercisers having lower depression scores than non-exercisers. The mean scores for the two groups on sleepiness and depression are represented in Table 4.

Two one-way MANOVAS were performed to test for differences on the two dimensions of anxiety (state, trait) and the three dimensions of basic need satisfaction (competence, autonomy, relatedness). For anxiety, the analysis revealed non-significant multivariate effect, $F(2,48) = .98$ $p = .38$. For basic need satisfaction, the analysis revealed non-significant multivariate effect $F(3,47) = 2.28$, $p =.91$. Examination of the univariate effects showed a significant effect for competence, $F(1,49) = 6.99$, $p < 0.5$ and non-significant effects for autonomy, $F(1,49) = 2.84$, $p = .98$ and relatedness, $F(1,49) = .43$, $p = .52$, showing that exercisers feel more competent than non-exercisers. The mean scores of the two groups are also presented in Table 4.

To examine the degree to which low moderate or high METs could predict sleepiness, a regression analysis with a stepwise method was employed. Results yielded a significant prediction $F(1,36) = 5.78$, $p < .05$. The model explained 11% of the variance of sleepiness (see Table 5). The examination of each METs showed that only METs moderate contributed significantly to the prediction (beta = -.34)

To examine the degree to which basic need satisfaction could predict METs total, another regression analysis with a stepwise method was employed. Results yielded a significant prediction $F(1,46) = 7.30$, $p < .05$. The model explained 14% of the variance of METS total (see Table 6). The examination of each dimension of the basic need satisfaction showed that only competence contributed significantly to the prediction (beta = .37).

3. DISCUSSION

This study aimed at examining the relationship of depression and anxiety with PA as measured in Metabolic Equivalents (METS; Jette et al., 1990) and daytime sleepiness in patients diagnosed with OSA, based on basic need satisfaction (Self-Determination Theory - Ryan & Deci, 2000).

We identified that daytime sleepiness was positively associated with depression. This finding is congruent with previous studies (e.g., Reynolds et al., 1984; Bixler et al., 2005; Kjelsberg et al., 2005), suggesting that OSA patients with increased levels of sleepiness during the day reported a higher risk of depression. In addition, a negative relationship was found between daytime sleepiness and METS of moderate intensity. This finding is in line with previous research (e.g: Loprinzi & Cardina, 2011; McClain et al., 2014) displaying the negative relationship between exercise and daytime sleepiness in general population and showing that PA is inversely related to daytime sleepiness. This fact applied to those meeting the PA guidelines of World Health Organization (WHO, 2010). When it comes to OSA, lack of regular exercise in men with OSA is significantly associated with excessive daytime sleepiness (Basta et al., 2008). More significantly, studies have shown that exercise has a significant impact on reducing sleepiness (e.g: Norman et al. 2000; Desplan et al., 2014).

Depression was associated positively with state/trait anxiety in our study, suggesting their coexistence in OSA patients, just like it is reported in other studies (Harris et al., 2009; Ejaz et al., 2011; Lee, Han, & Ryu, 2015). Also, depression was negatively associated with the needs of autonomy and competence, which supports previous research in depressive population, as less competence and autonomy satisfaction for exercise has been related to greater vulnerability in experiencing depression (Haase et al., 2010; Morres et al., 2017). Any study examining the relationship of depression and needs of competence and autonomy for exercise in OSA patients, though, wasn't found. Ultimately, even non-significantly, we found that depression is positively associated with Body Mass Index (BMI), indicating that higher BMI is associated with higher rates of depression and vice versa (Zhao et al., 2009; Baumeister & Härter, 2007). When it comes to OSA patients, higher BMI has been associated with depression, but only with the cognitive dimension of BDI-II (Aloia et al., 2005).

The need of competence was positively associated with METS total in our study, supporting previous research that reports that greater need satisfaction of competence is associated with higher exercising behavior (eg: Vlachopoulos & Michailidou, 2006; Vlachopoulos & Neikou, 2007). However, no study, at least to our knowledge, has previously examined this relationship regarding OSA patients. Additionally, competence was positively related to autonomy, just like in other studies (Vlachopoulos & Michailidou, 2006; Moreno-Murcia et al., 2012) and negatively related to trait anxiety, showing that when the participants were feeling more autonomous and competent, they were less likely to experience and report stable negative emotions. Though, again, no study, to our knowledge, seems to have explored before the latter relationship.

Given that daytime sleepiness was strongly and negatively associated with METS moderate, we wanted to examine further the differences between exercisers and non-exercisers. In our study, no statistical significant differences were found. This result occurred probably because non-exerciser and exercisers were, respectively, marginally higher and lower compared to the OSA cutoff score indicating some symptoms of sleepiness (OSA cutoff score = >10). Thus, exercisers seem to belong to a normal population range with lower normal symptoms of sleepiness (mean= 4.83), while non-exercisers represent a marginally not clinically defined group, as they revealed higher normal symptoms of sleepiness (mean= 6.42).

In line to our study, previous research has shown that sleepiness is associated with increased depression in OSA patients. Specifically, *Reynolds* et al. (*1984*) found that more depressed men were complaining more frequently about excessive daytime sleepiness than the less depressed, pointing the importance of being assessed for depression in case of experiencing feelings of sleepiness (Bixler et al., 2005). A strong association between sleepiness and depression scores regarding OSA patients, was also evidenced in both *Kjelsberg's et al.,* (*2005*) and *Ishman's et al.,* (*2010*) studies. In the first study (Kjelsberg's et al., 2005) the researchers used hospitalized population, showing that higher depression is associated with higher sleepiness. In the latter (Ishman's et al., 2010), the researchers compared OSA to other diseases and found that OSA patients with daytime sleepiness are more likely to have depression. What is more, in the study of *Basta et al.,* (*2008*) depression acted as a significant predictor of sleepiness in patients with OSA.

Given the association between depression and sleepiness and the link of sleepiness to PA, we also wanted to examine the potential differences in depression between exercisers and non-exercisers. Indeed, a difference was found in favor of exercisers, who showed lower depression scores. This result could be attributed to that, generally, physical exercise is associated with lower levels of depression (e.g., Goodwin, 2003). In accordance with this finding, in the meta-analysis of *Morres et al.*, (*2018*) it was found that aerobic exercise can lower the depression levels in patients diagnosed with Major Depressive Disorder (MDD). In another study with

MDD patients, it was also reported that moderate exercise could be as effective as pharmacotherapy, minimizing the depressive symptoms at the end of a 4-month treatment and leading to a persistence of this improvement for at least 6 months after the treatment. Especially in cases that exercise was continued over time (Babyak et al., 2000).

Likewise, *Cooney's et al*. (*2013*) review, which included RCTs examining the effectiveness of physical exercise on depression, found that exercise is moderately more effective than control interventions (e.g., placebo or no therapy) and no less effective than pharmaceutical or psychological therapies in reducing depression. Furthermore, not only exercise but also general physical activity was found to contribute to lower depression. For example, *Strawbridge et al*. (*2002*) which included cross-sectional and longitudinal analyses found that physical activity (frequency of long walks, exercise, sports, and swimming), can act as a protective factor on subsequent depression.

Given our finding that OSA patients who exercise show reduced levels of depression and as depression is positively related to sleepiness, a potential scenario could be that when depression is lowered, the feelings and complaints of daytime sleepiness could be reduced too. However, further research is needed to draw causal inferences.

Comparing exercisers to non-exercisers in state and trait anxiety no difference was found showing that both groups experience moderate level of trait and marginally high level of state anxiety. Instead, comparing our patients in basic need satisfaction, we found that exercisers feel more competent than non-exercisers, albeit competence was positively and significantly related to autonomy. This finding is congruent with previous research, suggesting that psychological need satisfaction and most importantly autonomy and competence satisfaction is associated with exercise adherence (Wilson & Fraser, 2002; Wilson et al., 2003), especially when it comes to habitual exercisers who might have internalized the importance of a systematic physical activity, thus making it part of their actual identity (Wilson et al., 2009).

Our data analysis focused on METS of moderate intensity, as it revealed the highest negative relationship with OSA symptom. Particularly, we found that exercise of moderate intensity predicted significantly lower levels of daytime sleepiness showing and supporting that exercise programs (e.g., aerobic) in OSA patients, can reduce daytime sleepiness (Norman et al. 2000).

Generally, decreased exercise frequency in general population (e.g: Chasens, Sereika, Weaver & Umlauf, 2007) and a lack of regular PA in OSA patients (Basta et al., 2008), has been associated significantly with excessive daytime sleepiness, pointing out the importance of exercise in promoting healthy aging and maintaining the functional ability. In accordance to that, RCT studies conducted in OSA patients support this finding· for example, both *Schutz et al. (2013*) and *Desplan et al. (2014*), compared exercise to control groups (CPAP/OA and one-month education activity session, respectively) and found that exercise could modify and reduce subjective sleepiness. Likewise, *Kline et al.,* (*2012*), compared low-intensity stretching treatment to moderate-intensity aerobic and resistance training, in their RCT. They found that PA contributed to the improvement of daytime sleepiness. Notably, moderate-intensity exercise was preferred in those studies, except for Desplan et al., that didn't mention the exercise's intensity. Additionally, the RCT of *Ackel-D'Elia et al*. (*2012*), showed that adjusted exercise (to each patient's needs) can be effectively combined with a primary treatment (CPAP) and reduce subjective excessive sleepiness, maintaining the improvement even after 1 week off treatment. However, *Norman et al.* (*2000*) found that even though exercise training can have a positive effect on OSA symptoms, it cannot stand alone but rather as an adjunct therapy in the conservative management of patients with mild-moderate OSA.

The finding that PA can reduce daytime sleepiness is also supported by several meta-analyses. For example, *Aiello et al.,* (*2016*), who included RCTs and observational studies, found that exercise training can reduce daytime sleepiness. In line with that, other meta-analyses (Ifthikar et al., 2017; Ifthikar et al., 2014; Mendelson et al., 2018), who recruited RCTs, reported the significant contribution of PA to the improvement of sleepiness, when compared to control conditions including CPAP, MAD or dietary loss/advice.

Generally, OSA patients have a sedentary lifestyle (Igelström et al., 2013; Igelström, Emtner, & Lindberg, 2013), which is linked to higher obesity (King et al., 2001), increased AHI level (Redolfi et al., 2009) and increased daytime sleepiness (Chasens et al., 2007). In line with previous studies, we found that 65% of our sample did not satisfy items 1-4 in IPAQ and thus, they were defined as a sample of not meeting the physical activity guidelines, recommending at least 150min of moderate intensity per week or 75min of vigorous intensity per week (WHO, 2010). Hence, we wanted to examine whether basic need satisfaction could predict physical activity participation, as according to *Deci* & *Ryan* (*2000*), the psychological needs of autonomy, competence and relatedness are “organismic necessities that are crucial for one’s psychological growth, integrity and well-being”.

In our study, only the need of competence seemed to predict METS total, albeit competence was positively correlated with the need of autonomy.

In line with our finding, *Smith et al.* (*2007*) found that there may be an association between the subjective competence and the amount of exercise, regardless of BMI and AHI, meaning that OSA patients may want to start exercising, but they lack of confidence in their ability to. So, competence is defined as the perceived effectiveness and a need to succeed at optimally challenging tasks, while extending one's skills and attaining desirable outcomes (Ryan & Deci, 2000; Luyckx & Vansteenkiste, 2009).

Previous research supports our finding in general population· *Vlachopoulos* and *Michailidou* (*2006*) examined the predictive validity of the Basic Psychological Needs in Exercise Scale (BPNES) in exercise participants and they found that competence was the stronger and only significant predictor of concentration during exercise, attitude towards exercise, intention for continued exercise participation and the exercise frequency. In another study conducted by *Vlachopoulos and Neikou* (*2007*) in organized exercise programs the need of competence was the main predictor of exercise attendance and exercise adherence or drop out. What is more, *Rahman et al.,* (*2011*) found that autonomy and competence satisfaction during a 12-week supervised program predicted habitual physical exercise. Especially competence satisfaction was higher in program completers than the non-completers, suggesting that those with higher confidence in their ability to exercise were more likely to complete the program. Similarly, an intervention in exercise domain showed that people who participated in exercise programs based on SDT, reported greater competence satisfaction and positive affect (Edmunds et al., 2008). Interestingly, *Lovell et al.,* (*2016*) found that satisfaction of competence in exercising mothers was more related to group settings than individual settings, suggesting that, probably, the receiving feedback provided by the instructors and the co-exercisers or/and by direct comparison, contributed to this finding.

Other studies though, have reported controversial findings suggesting that: a) even though need for competence and relatedness are important for exercise adoption stages, for inactive working women, autonomy satisfaction was even more important in the adherence phase (Kinnafick, Thøgersen-Ntoumani, & Duda, 2014) and that b) the needs for autonomy and relatedness are more important for sport continuance and dropout than the need for competence, at least in adolescence (Calvo et al., 2010). Concerning OSA, interestingly, no study was found, in which competence predicts exercise in OSA patients.

In order for an individual to feel competent, he/she must engage in an activity which is considered stimulating, optimally challenging and adjusted to one's skill level, because if it is very easy it can be boring, while if it is very difficult it can result in anxiety and avoidance (Deci, 1975). On the other part, via participating in activities that arouse curiosity and afford challenge, they will be allowed to test and expand their capabilities (Deci & Ryan (Eds.) 2002).

A way of enhancing one's perceived competence is via providing positive feedback (Ryan, 1982). Negative feedback, on the contrary, thwarts the sense of competence (Deci & Cascio, 1972), especially when it is provided in a critical manner (Vallerand & Reid, 1984). Furthermore, by giving choice and avoiding external rewards not only perceived competence but also autonomy can be fostered (Deci & Ryan, 2000), which is in line with the positive relationship we found between the two variables. Modeling, is another way of enhancing sense of competence, as important others and their persistence in their own competence-relevant actions could affect an individual (Deci & Ryan (Eds.) 2002) Finally, presenting clear and neutral information about behavior and outcomes, developing appropriate goals and reinforcing self-motivational statements could enhance perceived competence (Silva et al., 2008).

Generally, psychological need satisfaction not only contributes to CPAP adherence in OSA patients, but it has also been proved to help in improving sleep quality and reducing daytime dysfunction, through mindfulness and the acceptance of sleep-interfering thoughts (Campbell et al., 2015). Additionally, need satisfaction seems to contribute to several other life domains. For example, it has been reported that a) in working contexts (Reis et al., 2000; Baard, Deci & Ryan, 2004), b) in health contexts, like dental treatment (Munster Halvari et al., 2010), obesity treatment (Williams et al., 1996) or tobacco cessation (Williams et al., 2006), c) in interpersonal contexts (*Eberhart* & *Hammen*, *2006*), d) in academic contexts (Cole, 1990; Smári, Pétursdóttir & Porsteinsdóttir, 2001) and e) in residential contexts (O'Connor & Vallerand, 1994; Kasser, 1999), when the needs are satisfied, depression and depressive feelings are less likely to be experienced.

To conclude, for over two decades, clinical studies have revealed an association between depression and OSA, even though their relationship is rather complex and their causal relationship is yet to be examined. Nevertheless, it has been found that in both diagnosed and undiagnosed OSA patients, the rates of depression are high, ranging from 5 to 63%, according to review conducted by Ejaz et al. (2011). Additionally, according to another review (Harris et al., 2009), OSA patients seem to report higher rates of depression compared to community settings (3-5%) and primary care (5-10%).

Five of the main sources of epidemiological data for major depressive disorder (MDD) are: a) the Epidemiologic Catchment Area (ECA) study, using the Diagnostic Interview Schedule (DIS) based on DSM-III, b) the National Comorbidity Survey (NCS) using the Diagnostic and Statistical Manual of Mental Disorders-Third Edition Revised, c) the National Comorbidity Replication Survey (NCS-R) using the World's Health Organisation (WHO) Composite International Diagnostic Interview (CIDI), based on DSM-IV, d) the National Epidemiologic Survey on Alcoholism and Related Conditions (NESARC), using the Alcohol Use Disorder and Associated Disabilities Interview Schedule–DSM-IV Version (AUDADIS-IV) and e) the National Survey on Drug Use and Health. The aforementioned studies, which have been outlined by *Strine et al.,* (*2008a*), report that the current depressive symptoms rate ranges between 3.0% and 8.6%, a 12-month depression rate between 5.3% and 7.7%, and a lifetime depression rate of between 5.2% and 16.2% .

A cross-sectional community study by the European Outcome of Depression International Network (ODIN) comprising five countries used both International Statistical Classification of Diseases and Related Health Problems (ICD-10) and DSM-IV in an attempt to examine depression prevalence. A mean 12-month prevalence of 6.6% was reported based on the ICD-10 and a mean 12-month prevalence of 6.7% was reported by DSM-IV (Ayuso-Mateos et al., 2001).

According to the PHQ-9, in our study 14 patients (27%) showed a psychometric diagnosis of major or other depressive disorder. Specifically, 5 patients showed major depressive disorder and 9 patients showed other depressive disorder. Based on the BDI-II, a total of 14 patients (27%) showed scores of depressive symptoms within the clinical range. Particularly, 8 patients scored mild depression (14-19 BDI-II score), 5 patients scored moderate depression (20-28 BDI-II) and, finally, 1 patient scored severe depression (29-63).

Depression is prevalent in other health disorders as well. For example, approximately 15% of patients with cardiovascular disease (CVD) were found to have major depression (Colquhoun et al., 2013). Additionally, in a review conducted by *Van Ede, Yzermans and Brouwer* (*1999*), individuals with Chronic Obstructive Pulmonary Disease (COPD), like asthma, reported a depression rate ranging from 7 to 42%. In a more recent study, it was found that 19.4% of people with asthma were also diagnosed with current depression (in contrast to 7.7% for those without asthma) and for those with a diagnosis of lifetime depression, the depression rate was 30.6% in contrast to 14.4% (Strine et al., 2006). Finally, that obesity has also been associated with increased risk of depression (e.g: Dong, Sanchez, & Price, 2004; Luppino et. al., 2010). Specifically, it has been reported that people with a diagnosis of depression (either current or lifetime) are 60% more likely to be obese (Strine et al., 2008b).

4. CONCLUSION

The aim of the present study was threefold. Our first aim was to determine whether there are any interactions between our variables in OSA patients· the basic psychological needs of competence, autonomy and relatedness and depression, anxiety and daytime sleepiness. Secondly, we wanted to examine whether SDT contributes to the adoption of PA among OSA patients and thirdly, whether PA can have an actual impact on improving daytime sleepiness associated with OSA. The results showed that there are several statistically significant positive and negative relationships between the variables and that exercisers were feeling more competent and experienced lower depression than non-exercisers. Most importantly, it was found that PA of moderate intensity predicted lower levels of daytime sleepiness in OSA patients and that competence satisfaction predicts significantly PA participation.

Given our findings, in OSA patients, depression is linked to daytime sleepiness meaning their coexistence in the sleeping disorder. Hopefully, based on our results, we may suggest that provision of physical activities that lay on competence satisfaction can actually increase the patients' PA participation. In addition to that, PA of moderate intensity may act as a viable treatment to the core and most disabling OSA symptom, which is linked to psychosocial morbidity, accidents and poor quality of life· daytime sleepiness. Finally, as exercisers were found to be less depressed than non-exercisers, we could suppose that when daytime sleepiness is reduced, then depression is lowered too. When it comes to STAI no significant findings were reported, pointing out the importance of further research for examining and supporting the present results.

REFERENCES

Ackel d'Elia, C., da Silva, A. C., Silva, R. S., Rita, L., & Bittencourt, A. (2012). Effects of exercise training associated with continuous positive airway pressure treatment in patients with obstructive sleep apnea syndrome, *Sleep and Breathing, 16*(3), 723–735. https://doi.org/10.1007/s11325-011-0567-0

Aiello, K. D., Caughey, W. G., Nelluri, B., Sharma, A., Mookadam, F., & Mookadam, M. (2016). Effect of exercise training on sleep apnea: A systematic review and meta-analysis. *Respiratory Medicine*, *116*, 85–92. https://doi.org/10.1016/j.rmed.2016.05.015

Ainsworth, B. E., Haskell, W. L., Herrmann, S. D., Meckes, N., Jr, D. R. B., Tudor-locke, C., … Leon, A. S. (2011). Second Update of Codes and MET Values. *Official Journal of the American College of Sports Medicine*, (39), 1575–1581. https://doi.org/10.1249/MSS.0b013e31821ece12

Al Lawati, N. M., Patel, S. R., & Ayas, N. T. (2009). Epidemiology, Risk Factors, and Consequences of Obstructive Sleep Apnea and Short Sleep Duration. *Progress in Cardiovascular Diseases*, *51*(4), 285–293. http://doi.org/10.1016/j.pcad.2008.08.001

Aloia, M. S., Arnedt, J. T., Smith, L., Skrekas, J., Stanchina, M., Millman, R. P. (2005). Examining the construct of depression in obstructive sleep apnea syndrome. *Sleep Medicine, 6*(2), 115-121, https://doi.org/10.1016/j.sleep.2004.09.003

American Psychiatric Association. (2000). Practice Guideline for the Treatment of Patients with Major Depressive Disorder (2nd ed.). Washington, DC: American Psychiatric Association.

Araghi, M. H., Chen, Y.-F., Jagielski, A., Choudhury, S., Banerjee, D., Hussain, S., … Taheri, S. (2013). Effectiveness of Lifestyle Interventions on Obstructive Sleep Apnea (OSA): Systematic Review and Meta-Analysis. *Sleep*, *36*(10), 1553–1562. https://doi.org/10.5665/sleep.3056

Ayuso-Mateos, J. L., Vazquez-Barquero, J. L., Dowrick, C., Lehtinen, V., Dalgard, O. S., Casey, P., et al. (2001). Depressive disorders in Europe: Prevalence figures from the ODIN study. *British Journal of Psychiatry, 179*(4), 308–316. https://doi.org/10.1192/bjp.179.4.308

Baard, P. P., Deci, E. L. & Ryan, R. M. (2004). Intrinsic Need Satisfaction : A Motivational Basis of Performance and Well-Being in Two Work Settings.

2045–2068. *Journal of Applied Social Psychology, 34,* 2045-2068. https://doi:10.1111=j.1559-1816.2004.tb02690.x

Babyak, M., Blumenthal, J. A., Herman, S., Khatri, P., Doraiswamy, M., Moore, K., et al. (2000). Exercise treatment for major depression: Maintenance of therapeutic benefit at 10 months. *Psychosomatic Medicine, 62*, 633–38

Ball, K., Burton, N. W., & Brown, W. J. (2009). A prospective study of overweight, physical activity, and depressive symptoms in young women. *Obesity, 17*, 66-71.

Bardwell, W. A., Berry, C. C., Ancoli-israel, S., & Dimsdale, J. E. (1999). Psychological correlates of sleep apnea. *Journal of Psychosomatic Research, 47*(6), 583–596.

Bartholomew, K. J., Ntoumanis, N., Ryan, R. M., Bosch, J. A., & Thøgersen-Ntoumani, C. (2011). Self-determination theory and diminished functioning: The role of interpersonal control and psychological need thwarting. *Personality and Social Psychology Bulletin*, *37*(11), 1459–1473. https://doi.org/10.1177/0146167211413125

Barvaux, V. A., Aubert, G., & Rodenstein, D. O. (2000). Weight loss as a treatment for obstructive sleep apnoea. *Sleep Medicine Reviews*, *4*(5), 435–452. https://doi.org/10.1053/smrv.2000.0114

Basta, M., Lin, H. M., Pejovic, S, Sarrigiannidis, A., Bixler, E. O., Vgontzas, A. N. (2008). Lack of regular exercise, depression, and degree of apnea are predictors of excessive daytime sleepiness in patients with sleep apnea: Sex differences. *Journal of Clinical Sleep Medicine, 4,* 19-25.

Baumeister, H., Härter, M: (2007). Mental disorders in patients with obesity in comparison with healthy probants. *International Journal of Obesity, 31,* 1155-1164.

Beck, A. T., Steer, R. A., Beck, J. S., & Newman, C. F. (1993). Hopelessness , Depression , Suicidal Ideation , and Clinical Diagnosis of Depression. *The American Association of Suicidology, 23*(2), 139-145.

Beck, A. T., Steer, R. A., Brown, G. K. (1996). Beck depression inventory-II. *San Antonio* , 78(2), 490-498.

Beiter, R., Nash, R., Mccrady, M., Rhoades, D., Linscomb, M., Clarahan, M., & Sammut, S. (2015). The prevalence and correlates of depression , anxiety , and stress in a sample of college students. *Journal of Affective Disorders*, *173*, 90–96. https://doi.org/10.1016/j.jad.2014.10.054

Bixler, E. O., Vgontzas, A. N., Ten Have, T., Tyson, K., & Kales, A. (1998). Effects of Age on Sleep Apnea in Men. *American Journal of Respiratory and Critical Care Medicine*, *157*(1), 144–148. https://doi.org/10.1164/ajrccm.157.1.9706079

Bixler, E. O., Vgontzas, A. N., Lin, H. M., Calhoun, S. L., Vela-Bueno, A., Kales, A. (2005). Excessive daytime sleepiness in a general population sample: the role of sleep apnea, age, obesity, diabetes, and depression. *J Clin Endocrinol Metab*, *90*, 4510–5.

Black, A. E., & Deci, E. L. (2000). The Effects of Instructors' Autonomy Support and Students ' Autonomous Motivation on Learning Organic Chemistry : A Self-Determination Theory Perspective, *Science Education, 84*,740–756.

Blumenthal, J. A., Babyak, M. A., Moore, K. A., Craighead, W. E., Herman, S., Khatri, P., Waugh, R., Napolitano, M. A., Forman, L. M., Appelbaum, M., Dpraoswamy, P. M., Krishnan, K. R. (1999). Effects of exercise training on older patients with major depression. *Archives of Internal Medicine,159*, 2349-2356.

Blumenthal, J. A., Babyak, M. A., Doraiswamy, P. M., Watkins, L., Hoffman, B. M., Barbour, K. A., Herman, S., Craighead, W. E., Brosse, A. L., Waugh, R., Hinderliter, A., Sherwood, A. (2007). Exercise and pharmacotherapy in the treatment of major depressive disorder. *Psychosomatic Medicine*, *69*, 587-596.

Borak, J., Cieslicki, J.K., Koziej, M., Matuszewski, A. &. Zielinski, J. (1996). Effects of CPAP treatment on psychological status in patients with severe obstructive sleep apnoea. *Sleep. Res*, *5*, 123–127.

Bradley, T. D., & Floras, J. S. (2009). Obstructive sleep apnoea and its cardiovascular consequences. *The Lancet*, *373*(9657), 82–93. http://doi.org/10.1016/S0140-6736(08)61622-0

Bravata, D. M., Sico, J., Fragoso, C. A. V., Miech, E. J., Matthias, M. S., Lampert, R., … Yaggi, H. K. (2018). Diagnosing and Treating Sleep Apnea in Patients With Acute Cerebrovascular Disease. *Journal of the American Heart Association* https://doi.org/10.1161/JAHA.118.008841

Britton, P. C., Williams, G. C., & Conner, K. R. (2008). Self-Determination Theory , Motivational Interviewing , and the Treatment of Clients With Acute Suicidal Ideation. *Journal of Clinical Psychology,* *64*(1), 52–66. https://doi.org/10.1002/jclp

Broström, A., Fridlund, B., Ulander, M., Sunnergren, O., Svanborg, E., & Nilsen, P. (2011). A mixed method evaluation of a group-based educational programme for CPAP use in patients with obstructive sleep apnea, *Journal of Evaluation in*

Clinical Practice, 19, 173–184. https://doi.org/10.1111/j.1365-2753.2011.01797.x

Broström, A., Nilsen, P., Johansson, P., Ulander, M., Strömberg, A., Svanborg, E., & Fridlund, B. (2010). Putative facilitators and barriers for adherence to CPAP treatment in patients with obstructive sleep apnea syndrome : A qualitative content analysis, *Sleep Medicine, 11*, 126–130. https://doi.org/10.1016/j.sleep.2009.04.010

Brown, G. K., Henriques, G. R., Xie, S. X., Hollander, J. E., & Beck, A. T. (2005). Cognitive Therapy for the Prevention of Suicide Attempts: A randomized cotrolled trial. *Journal of the American Medical Association*, *294*(5), 563–570.

Buckworth, J., & Dishman, R. K. (2002). Exercise psychology. Champaign, IL: *Human Kinetics.*

Calvo, T. G., Cervello, E., Jimenez, R., Iglesias, D., & Murcia, J. A. M. (2010). Using self-determination theory to explain sport persistence and dropout in adolescent athletes. *Spanish Journal of Psychology, 13*(2), 677–684.

Campbell, R., Vansteenkiste, M., Delesie, L. M., Mariman, A. N., Soenens, B., Tobback, E., … Vogelaers, D. P. (2015). Examining the role of psychological need satisfaction in sleep : A Self-Determination Theory perspective, *77*, 199–204. https://doi.org/10.1016/j.paid.2015.01.003

Campos-Rodriguez, F., Martinez-Garcia, M. A., de la Cruz-Moron, I., Almeida-Gonzalez, C., Catalan-Serra, P., & Montserrat, J. M. (2012). Cardiovascular mortality in women with obstructive sleep apnea with or without continuous positive airway pressure treatment: a cohort study. *Annals of Internal Medicine*, *156*, 115–122. http://doi.org/10.1059/0003-4819-156-2-201201170-00006

Caspersen, C. J., & Christenson, G. M. (1985). Physical Activity , Exercise , and Physical Fitness : Definitions and Distinctions of Health-Related Research. *Public Health Rep, 100,* 126-31

Cavanagh, J., Carson, A., Sharpe, M., & Lawrie, S. (2003). Psychological autopsy studies of suicide : a systematic review. *Psychological Medicine, 33*(3), 395–405. https://doi.org/10.1017/S0033291702006943

Chasens, E.R., Sereika, S.M., Weaver, T.E., & Umlauf, M.G. (2007). Daytime sleepiness, exercise, and physical function in older adults. *J. Sleep Res. 16*, 60–65. https://doi.org/10.1111/j.1365-2869

Chatzisarantis, N. L., & Hagger, M. S. (2009). Effects of an intervention based on selfdetermination theory on self-reported leisure-time physical activity participation. *Psychology and Health, 24*, 29-48.

Chirinos, J. A., Gurubhagavatula, I., Teff, K., Rader, D. J., Wadden, T. A., Townsend, R., Pack, A. I. (2014). CPAP, Weight Loss, or Both for Obstructive Sleep Apnea. *New England Journal of Medicine*, *370*(24), 2265–2275. http://doi.org/10.1056/NEJMoa1306187

Chirkov, V., Ryan, R. M., & Kim, Y. (2003). Differentiating Autonomy From Individualism and Independence : A Self-Determination Theory Perspective on Internalization of Cultural Orientations and Well-Being. *Journal of Personality and Social Psychology, 84*(1), 97-110. https://doi.org/10.1037/0022-3514.84.1.97

Cintra, F., Poyares, D., Rizzi, C. F., Risso, T. T., Skomro, R., Montuori, E., … Tufik, S. (2009). Cardiorespiratory response to exercise in men and women with obstructive sleep apnea. *Sleep Medicine*, *10*(3), 368–373. https://doi.org/10.1016/j.sleep.2008.04.006

Cole, D., A. (1990). Relation of social and academic competence to depressive symptoms in childhood. *Journal of Abnormal Psychology., 99*(4), 422-429 http://dx.doi.org/10.1037/0021-843X.99.4.422

Colley, R. C., Garriguet, D., Janssen, I., Craig, C. L., Clarke, J., Tremblay, M. S. (2011). Physical activity of Canadian Adults: Accelerometer data from the 2007 to 2009 Canadian Health Measures Survey. Statistics Canada, *Health Reports 22*(1), 1-8.

Colquhoun, D.M., Bunker, S.J., Clarke, D.M., Glozier, N., Hare, D.L., Hickie, I.B., Tatoulis, J., Thompson, D.R., Tofler, G.H., Wilson, A., Branagan, M.G. (2013). Screening, referral and treatment for depression in patients with coronary heart disease. *Med J, 198*, 483–484.

Cooney, G. M., Dwan, K., Greig, C.A., Lawlor, D. A., Rimer, J., Waugh, F. R., McMurdo, M., Mead, G. E. (2013). Exercise for depression. *Cochrane Database of Systematic Reviews,* (9). https://doi.org/10.1002/14651858.CD004366

Craig, C. L., Marshall, A. L., Sjostrom, M., … Oja, P. (2003). International physical activity questionnaire: 12-country reliability and validity. *Med Sci Sports Exerc., 35,* 1381–1395.

Daley, A. (2008). Exercise and Depression: A Review of Reviews. *Journal of Clinical Psychology in Medical Settings, 15,* 140–147. https://doi.org/10.1007/s10880-008-9105-z

Deci, E. L. (1975). Intrinsic motivation. New York: Plenum

Deci, E. L., & Cascio, W. F. (1972). Changes in intrinsic motivation as a function of negative feedback and threats. Presented at the meeting of the Eastern Psychological Association, Boston.

Deci, E. L., & Ryan, R. M. (1985). Intrinsic motivation and self-determination in human behavior. New York: Plenum Press

Deci, E. L., Ryan, R., M. (2000). The “what” and “why” of goal pursuits: human needs and the self-determination of behavior. *Psychological Inquiry, 11*(4), 227–268.

Deci, E. L., & Ryan, R. M. (2015). *Self-Determination Theory*. *International Encyclopedia of the Social & Behavioral Sciences: Second Edition* (Second Edition, Vol. 11). Elsevier. https://doi.org/10.1016/B978-0-08-097086-8.26036-4

Deci, E. L., and Ryan, R. M. (Eds.). (2002). Handbook of Self-Determination Research. Rochester: University of Rochester Press.

Demyttenaere, K. (2003). Risk factors and predictors of compliance in depression. *European Neuropsychopharmacology, 13*, 69-75.

Dong, C., Sanchez, L. E., and Price, R. A. (2004). Relationship of obesity to depression: a family-based study. *International Journal of Obesity, 28*, 790–795. https://doi.org/10.1038/sj.ijo.0802626

Department of Health. (2004). Choosing health? Choosing activity: A consultation on how to increase physical activity. London, UK: Department of Health/Department of Culture Media and Sport.

Desplan, M., Mercier, J., Sabaté, M., Ninot, G., Prefaut, C., & Dauvilliers, Y. (2014). A comprehensive rehabilitation program improves disease severity in patients with obstructive sleep apnea syndrome : a pilot randomized controlled study. *Sleep Medicine*, *15*(8), 906–912. https://doi.org/10.1016/j.sleep.2013.09.023

Donaghy, M., & Taylor, A. H. (2010). Current controversies: should practitioners promote physical activity as a treatment for depression? *Journal of the Royal College of Physicians Edinburgh, 40*, 132-135.

Duda, J. L., Williams, G. C., Ntoumanis, N., Daley, A., Eves, F. F., Mutrie, N., et al. (2014). Effects of a standard provision versus an autonomy supportive exercise referral programme on physical activity, quality of life and well-being indicators: a cluster randomised controlled trial. *International Journal of Behavioral Nutrition and Physical Activity, 11*(1) https://doi.org/10.1186/1479-5868-11-10

Dunn, A. L., Trivedi, M. H., & O'Neal, H. A. (2001). Physical activity dose-response effects on outcomes of depression and anxiety. *Medical Science and Sports Exercise, 33,* 587-597.

Durán, J., Esnaola, S., Rubio, R., & Iztueta, A. (2001). Obstructive sleep apnea–hypopnea and related clinical features in a population-based sample of subjects aged 30 to 70 yr. *Am J Respir Crit Care Med*, *163*, 685–689.

Dwyer, L. A., Horney, M. J., Smith, L. G.E., Oei, T. P. S., & Dingle, G. A. (2011). Participant autonomy in cognitive-behavioral group therapy: An integration of Self-Determination and cognitive behavioral theories. *Journal of Social and Clinical Psychology, 30,* 24-46. https://doi:10.1521/jscp.2011.30.1.24

Eberhart, N. K., & Hammen, C. L. (2006). Interpersonal predictors of onset of depression during the transition to adulthood, *Personal Relationships, 13*, 195–206. https://doi:10.1111=j.1475-6811.2006.00113.x

Edmunds, J., Ntoumanis, N., Duda, J.L. (2006). A test of self-determination theory in the exercise domain. *J Appl Soc Psychol, 36*(9), 2240–2265.

Edmunds, J., Ntoumanis, N., Duda, J.L. (2008). Testing a self-determination theory-based teaching style intervention in the exercise domain. *European Journal of Social Psychology, 38,* 375–388. https://doi.org/10.1002/ejsp.463

Engleman, H. M., & Douglas, N. J. (2004). Sleep · 4: Sleepiness, cognitive function, and quality of life in obstructive apnoea/hypopnoea syndrome. *Thorax*, *59*(7), 618–622. https://doi.org/10.1136/thx.2003.015867

Ejaz, S. M., Khawaja, I. S., Bhatia, S., & Hurwitz, T. D. (2011). Obstructive sleep apnea and depression: A review. *Innovations in Clinical Neuroscience*, *8*(8), 17–25.

Epstein L.J., Kristo, D., Strollo, P., Friedman, N., Malhotra, A., Patil, S., & Ramar, K. (2009). Clinical Guideline for the Evaluation , Management and Long-term Care of. *J Clin Sleep Med*, *5*(3), 263–276.

Fava, M., Graves, L. M., Benazzi, F., Scalia, M. J., Iosifescu, D. V., Alpert, J. E., et al. (2006). A cross-sectional study of the prevalence of cognitive and physical symptoms during long-term antidepressant treatment. *Journal of Clinical Psychiatry, 67*, 1754-1759.

Ferrand, C., Martinent, G., & Durmaz, N. (2014). Psychological need satisfaction and well-being in adults aged 80 years and older living in residential homes : Using a self-determination theory perspective. *Journal of Aging Studies*, *30*, 104–111. https://doi.org/10.1016/j.jaging.2014.04.004

Ferguson, K. A., Cartwright, R., Rogers, R., & Schmidt-nowara, W. (2006). Oral Appliances for Snoring and Obstructive Sleep Apnea : A Review. *Sleep, 29,* 244-62.

Ferguson, K. A., Ono, T., Lowe, A. A., Keenan, S. P., & Fleetham, J. A. (1996). A randomized crossover study of an oral appliance vs nasal-continuous positive airway pressure in the treatment of mild-moderate obstructive sleep apnea. *Chest*, *109*(5), 1269–1275. http://doi.org/10.1378/chest.109.5.1269

Fidan, F., Ünlü, M., Sezer, M., Geçici, Ö., & Kara, Z. (2007). Compliance to CPAP treatment and effects of treatment on anxiety and depression in patients with obstructive sleep apnea syndrome. *Tuberk Toraks*, *55*, 271-277.

Fogel, R. B., Malhotra, A., Pillar, G., Pittman, S. D., Dunaif, A., & White, D. P. (2001). Increased Prevalence of Obstructive Sleep Apnea Syndrome in Obese Women with Polycystic Ovary Syndrome. *The Journal of Clinical Endocrinology & Metabolism*, *86*(3), 1175–1180. https://doi.org/10.1210/jcem.86.3.7316

Fortier, M.S., Duda, J. L., Guerin, E., Teixeira, P. J., (2012). Promoting physical activity:development and testing of self-determination theory-based interventions. *International Journal of Behavioral Nutrition and Physical Activity.*, 9:20. http://dx.doi.org/10.1186/1479-5868-9-20

Fournier, J. C., DeRubeis, R. J., Hollon, S. D., Dimidjian, S., Amsterdam, J. D., Shelton, R. C., et al. (2010). Antidepressant drug effects and depression severity: a patient-level analysis. *Journal of the American Medical Association, 303*, 47-53.

Franklin, K. A., & Lindberg, E. (2015). Obstructive sleep apnea is a common disorder in the population-A review on the epidemiology of sleep apnea. *Journal of Thoracic Disease*, *7*(8), 1311–1322. https://doi.org/10.3978/j.issn.2072-1439.2015.06.11

Fremont, J., & Craighead, L. W. (1987). Aerobic exercise and cognitive therapy in the treatment of dysphoric moods. *Cognitive Therapy Research*, *11*, 241-251.

Gibson, G. J. (2004). Obstructive sleep apnoea syndrome: Underestimated and undertreated. *British Medical Bulletin*, *72*, 49–64. https://doi.org/10.1093/bmb/ldh044

Giles, T.L., Lasserson, T.J., Smith, B., White, J., Wright, J.J., & Cates, C.J. (2006). Continuous positive airways pressure for obstructive sleep apnoea in adults. *The Cochrane Database of Systematic Reviews*, (1). https://doi.org/10.1002/14651858.CD001106

Goodwin, R. D. (2003) Association between physical activity and mental disorders among adults in the United States. *Preventive Medicine, 36*(6), 698–703. https://doi.org/10.1016/S0091-7435(03)00042-2

Grunstein, R. R., Stenlöf, K., Hedner, J. A., Peltonen, M., Karason, K., & Sjöström, L. (2007). Two year reduction in sleep apnea symptoms and associated diabetes incidence after weight loss in severe obesity. *Sleep*, *30*(6), 703–710. https://doi.org/10.1093/sleep/30.6.703

Guilleminault, C., & Abad, V. C. (2004). Obstructive sleep apnea. *Current Treatment Option in Neurology*, 6(4), 309–317

Guilleminault, C., Korobkin, R., & Winkle, R. (1981). A Review of 50 Children with Obstructive Sleep Apnea Syndrome, *Lung, 159,* 275–287.

Haensel, A., Norman, D., Natarajan, L., Bardwell, W. A., Ancoli-Israel, S., & Dimsdale, J. E. (2007). Effect of a 2 week CPAP treatment on mood states in patients with obstructive sleep apnea: A double-blind trial. *Sleep and Breathing*, *11*(4), 239–244. https://doi.org/10.1007/s11325-007-0115-0

Hallal, P. C., Andersen, L. B., Bull, F. C., Guthold, R., Haskell, W., & Ekelund, U. (2012). Global physical activity levels: surveillance progress, pitfalls, and prospects. *Lancet, 380*, 247–257.

Hamilton, M. (1983). The clinical distinction between anxiety and depression. *British Journal of Clinical Pharmacology, 15,* 165–169.

Harris, M., Glozier, N., Ratnavadivel, R., & Grunstein, R. R. (2009). Obstructive sleep apnea and depression. *Sleep Medicine Reviews*, *13*(6), 437–444. https://doi.org/10.1016/j.smrv.2009.04.001

Henke, K. G., Grady, J. J., & Kuna, S. T. (2001). Effect of Nasal Continuous Positive Airway Pressure on Neuropsychological Function in Sleep Apnea–Hypopnea Syndrome. *American Journal of Respiratory and Critical Care Medicine*, *163*(4), 911–917. https://doi.org/10.1164/ajrccm.163.4.9910025

Heinzer, R., Vat, S., Marques-Vidal, P., et al. (2015). Prevalence of sleep-disordered breathing in the general population: the HypnoLaus study. *Lancet Respir Med*; *3*(4) 310–18. https://doi.org/:10.1016/S2213-2600(15)00043-0.

Ho, M. L., & Brass, S. D. (2011). Obstructive sleep apnea. *Neurology International*, *3*(3), 15. https://doi.org/10.4081/ni.2011.e15

Hodgins, H. S., Weibust, K. S., Weinstein, N., Shiffman, S., Miller, A., Coombs, G., … Weinstein, N. (2010). *T*he Cost of Self-Protection: Threat Response and

Performance as a Function of Autonomous and Controlled Motivations. *Personality and Social Psychology Bulletin*, *36*(8), 1101–1114. https://doi.org/10.1177/0146167210375618

van Hoof, L. M. M., & van Hooft E. A. J. (2006). Work-related boredom and depressed mood from a daily perspective: the moderating roles of work centrality and need satisfaction. *Work & Stress, 30*(3), 209-227. https://doi.org/10.1080/02678373.2016.1206151

Horstmann, S., Hess, C. W., Bassetti, C., Gugger, M., & Mathis, J. (2000). Sleepiness-Related Accidents in Sleep Apnea Patients. *Sleep, 23*, 383-89.

Hoth, K. F., Zimmerman, M. E., Meschede, K. A., Arnedt, J. T., & Aloia, M. S. (2013). Obstructive sleep apnea: Impact of hypoxemia on memory. *Sleep and Breathing*, *17*(2), 811–817. https://doi.org/10.1007/s11325-012-0769-0

Iftikhar, I. H., Bittencourt, L., Youngstedt, S. D., Ayas, N., Cistulli, P., Schwab, R., … Magalang, U. J. (2017). Comparative efficacy of CPAP, MADs, exercise-training, and dietary weight loss for sleep apnea: a network meta-analysis. *Sleep Medicine*, *30*, 7–14. https://doi.org/10.1016/j.sleep.2016.06.001

Iftikhar, I. H., Kline, C. E., & Youngstedt, S. D. (2014). Effects of exercise training on sleep apnea: A meta-analysis. *Lung*, *192*(1), 175–184. https://doi.org/10.1007/s00408-013-9511-3

Igelström, H., Emtner, M., & Lindberg, E. (2013). Physical activity and sedentary time in persons with obstructive sleep apnea and overweight enrolled in a randomized controlled trial for enhanced physical activity and healthy eating, *Sleep and Breathing, 17*(4), 1257–1266. https://doi.org/10.1007/s11325-013-0831-6

Igelstrom, H., Emtner, M., Lindberg, E., & Åsenlof, P. (2013). Level of agreement for Measuring Moderate to Vigorous Physical Activity and Sedentary Time in People With Obstructive Sleep Apnea and Obesity. *Physical Therapy*, *93*(1), 50–59, https://doi.org/10.2522/ptj.20120123

Igelstrom, H., Emtner, M., Lindberg, E., & Åsenlof, P. (2014). Tailored behavioral medicine intervention for enhanced physical activity and healthy eating in patients with obstructive sleep apnea syndrome and overweight. *Sleep Breath, 18*, 655–668. https://doi.org/10.1007/s11325-013-0929-x

Ishman, S.L., Cavey, R. M., Mettel, T. L., Gourin, C. G. (2010). Depression, sleepiness, and disease severity in patients with obstructive sleep apnea. *The Laryngoscope, 120,* 2331–2335.

Jette, M., Sidney, K., Blumchen, G. (1990). Metabolic equivalents (METS) in exercise testing, exercise prescription, and evaluation of functional capacity. *Clin. Cardiol. 13*, 555-65.

Joiner, T. (2005). Why people die by suicide. Cambridge, MA: Harvard University Press.

Johns, M. W. (1991). A new method for measuring daytime sleepiness: The Epworth Sleepiness Scale. *Sleep, 14,* 540–5.

Jordan, A. S., McSharry, D. G., & Malhotra, A. (2014). Adult obstructive sleep apnoea. *The Lancet*, *383*(9918), 736–747. https://doi.org/10.1016/S0140-6736(13)60734-5

Judge, T. A., & Ilies, R. (2004). Affect and Job Satisfaction : A Study of Their Relationship at Work and at Home. *Journal of Applied Psychology*, 89(4), 661–673. https://doi.org/10.1037/0021-9010.89.4.661

Kasser, G. & Ryan, R., M. (1999). The Relation of Psychological Needs for Autonomy and Relatedness to Vitality , Well-Being , and Mortality in a Nursing Home. *Journal of Applied Social Psychology, 29*(5), 935–954.

Kayikcioglu, O., Bilgin, S., Seymenoglu, G. & Artuner, D. (2017). State and Trait Anxiety Scores of Patients Receiving Intravitreal Injections. *Biomedicine Hub, 2,* 1-5. https://doi.org/10.1159/000478993

Kinnafick, F., Thøgersen-Ntoumani, C., & Duda, J. L. (2014). Physical activity adoption to adherence, lapse, and dropout: A self-determination theory perspective. *Qualitative Health Research, 24*, 706-718.

King, G. A., Fitzhugh, E. C., Bassett, D., McLaughlin, J. E., Strath, S. J., Swartz, A. M. & Thompson, D. L. (2001). Relationship of leisure-time physical activity and occupational activity to the prevalence of obesity. *International Journal of Obesity, 25*, 606-612. https://doi.org/10.1038/sj.ijo.0801583

Kirsch, I., Deacon, B. J., Huedo-Medina, T. B., Scoboria, A., Moore, T. J., & Johnson, B. T. (2008). Initial severity and antidepressant benefits: a meta-analysis of data submitted to the Food and Drug Administration. *Public Library of Science Medicine, 5*. https://doi.org/10.1371/journal.pmed.0050045

Kline, C. E., Patrick, C. E., Ewing, G. B., Burch, J. B., Blair, S. N., Durstine, J. L., … Youngstedt, S. D. (2011). The Effect of Exercise Training on Obstructive Sleep Apnea and Sleep Quality: A Randomized Controlled Trial. *Sleep, 34*(12), 1631–1640, https://doi.org/10.5665/sleep.1422

Kline, C. E., Ewing, G. B., Burch, J. B., Blair, S. N., Durstine, J. L., Davis, J. M. et al. (2012). Exercise training improves selected aspects of daytime functioning in adults with obstructive sleep apnea. *Journal of Clinical Sleep Medicine, 8*(4), 357–365.

Kjelsberg, F. N., Ruud, E. A., & Stavem, K. (2005). Predictors of symptoms of anxiety and depression in obstructive sleep apnea. *Sleep Medicine*, *6*(4), 341–346. https://doi.org/10.1016/j.sleep.2005.02.004

Koestner, R., Losier, G. F. (2002): Distinguishing three ways of being internally motivated: a closer look at introjection, identification, and intrinsic motivation. In Handbook of self-determination research. Edited by Deci, E. L., Ryan, R.M. Rochester, NY: University of Rochester Press; 101–121.

Korkiakangas, E. E., Alahuhta, M. A., & Laitinen, J. H. (2009): Barriers to regular exercise among adults at high risk or diagnosed with type 2 diabetes: a systematic review. *Health Promot Int*, *24*, 416–427.

Kribbs, N.B., Pack, A.I., Kline, L.R., Getsy, J.E., Schuett, J.S., Henry, J.N., Maislin, G., Dinges, D.F. (1993). Effects of one night without nasal CPAP treatment on sleep and sleepiness in patients with obstructive sleep apnea. *American Review of Respiratory Disease*, *147*, 1162–1168. https://doi.org/10.1164/ajrccm/147.4.887

Kroenke, K., Spitzer, R.L., Williams, J.B., (2001). The PHQ-9: validity of a brief depression severity measure. *J. Gen. Intern. Med. (16),* 606–613.

Lee, S. A., Han, S. H., & Ryu, H. U. (2015). Anxiety and its relationship to quality of life independent of depression in patients with obstructive sleep apnea. *Journal of Psychosomatic Research*, *79*(1), 32–36. https://doi.org/10.1016/j.jpsychores.2015.01.012

Loprinzi, P. D., Cardinal, B. J. (2011). Association between objectively-measured physical activity and sleep, NHANES 2005-2006. *Mental Health and Physical Activity, 4*, 65–69.

Lovell, G. P., Gordon, J. A., Mueller, M. B., Mulgrew, K., & Sharman, R. (2016). Satisfaction of basic psychological needs, self-determined exercise motivation, and psychological well-being in mothers exercising in group-based versus individual-based contexts. *Health Care for Women International, 37,* 568–582.

Luppino, F. S., de Wit, L. M., Bouvy, P. F., Stijnen, T., Cuijpers, P., Penninx. B. W., *et al* (2010). Overweight, obesity, and depression: a systematic review and meta-analysis of longitudinal studies. *Arch Gen Psychiatry, 67*, 220–229.

Luyckx, K., & Vansteenkiste, M. (2014). Basic Need Satisfaction and Identity Formation : Bridging Self-Determination Basic Need Satisfaction and Identity Research, *Journal of Counseling Psychology*, *56*(2), 276–288. https://doi.org/10.1037/a0015349

Luyster, F. S., Buysse, D. J., Strollo, P. J. (2010). Comorbid insomnia and obstructive sleep apnea: challenges for clinical practice and research. *Journal of Clinical Sleep Medicine : JCSM : Official Publication of the American Academy of Sleep Medicine*, *6*(2), 196–204. Retrieved from http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=20411700%5Cnhttp://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=2854710&tool=pmcentrez&rendertype=abstract

Macey, P. M., Woo, M. A., Kumar, R., Cross, R. L., & Harper, R. M. (2010). Relationship between obstructive sleep apnea severity and sleep, depression and anxiety symptoms in newly-diagnosed patients. *PLoS ONE*, *5*(4), 1–6. https://doi.org/10.1371/journal.pone.0010211

Macey, P. M., Kumar R., Yan-Go F. L., Woo M. A., Harper R. M. (2012). Sex Differences in White Matter Alterations Accompanying Obstructive Sleep Apnea, *Sleep*, *35*(12), 1603–1613. https://doi.org/10.5665/sleep.2228

Manni, R., Terzaghi, M., Arbasino, C., Sartori, I., Galimberti, C. A., & Tartara, A. (2003). Obstructive sleep apnea in a clinical series of adult epilepsy patients: Frequency and features of the comorbidity. *Epilepsia*, *44*(6), 836–840. https://doi.org/10.1046/j.1528-1157.2003.55702.x

Markland, D. (1999). Self-determination moderates the effects of perceived competence on intrinsic motivation in an exercise setting. *Journal of Sport & Exercise Psychology, 21*, 351–361.

Martínez-García, M.-A., Campos-Rodríguez, F., Catalán-Serra, P., Soler-Cataluña, J.-J., Almeida-Gonzalez, C., De la Cruz Morón, I., … Montserrat, J.-M. (2012). Cardiovascular Mortality in Obstructive Sleep Apnea in the Elderly: Role of Long-Term Continuous Positive Airway Pressure Treatment. *American Journal of Respiratory and Critical Care Medicine*, *186*(9), 909–916. http://doi.org/10.1164/rccm.201203-0448OC

Martinsen, E. W., Hoffart, A., & Solberg O. (1989). Aerobic and non-aerobic forms of exercise in the treatment of anxiety disorders. *Stress Medicine, 5,* 115-120.

Mather, A. S., Rodriguez, C., Guthrie, M. F., McHarg, A. M., Reid, I. C., & McMurdo, M. E. (2002). Effects of exercise on depressive symptoms in older adults with poorly responsive depressive disorder. *British Journal of Psychiatry, 180*, 411-415.

Matthias, M. S., Chumbler, N. R., Bravata, D. M., Yaggi, H. K., Ferguson, J., Austin, C., … Matthias, M. S. (2014). Challenges and Motivating Factors Related to Positive Airway Pressure Therapy for Post-TIA and Stroke Patients Challenges and Motivating Factors Related to Positive Airway Pressure Therapy for Post-TIA and Stroke Patients. *Behavioral Sleep Medicine*, *12*, 143–157. https://doi.org/10.1080/15402002.2013.778200

McClain, J. J., Lewin, D. S., Laposky, A. D., Kahle, L., & Berrigan D. (2014). Associations between physical activity, sedentary time, sleep duration and daytime sleepiness in US adults. *Preventive Medicine, 66,* 68–73.

McEntee, R. J., & Haglin, R. P. (1999). Cognitive group therapy and aerobic exercise in the treatment of anxiety. *Journal of College Student Psychotherapy, 13*, 37-55.

McDonough, M. H., & Crocker, P. R. E. (2007). Testing self-determination as a mediator of the relationship between psychological needs and affective and behavioral outcomes. *Journal of Sport and Exercise Psychology, 29*, 645–63.

McEvoy, R. D., Antic, N. A., Heeley, E., Luo, Y., Ou, Q., Zhang, X., & Anderson, C. S. (2016). CPAP for Prevention of Cardiovascular Events in Obstructive Sleep Apnea. *New England Journal of Medicine*, *375*(10), 919–931. http://doi.org/10.1056/NEJMoa1606599

McIntosh, J. L., & Drapeau, C. W. (for the American Association of Suicidology). (2012). U.S.A. suicide 2010: Official final data. Washington, DC: American Association of Suicidology. Retrieved from http://www.suicidology.org/

Mead, G. E., Morley, W., Campbell, P., Greig, C. A., McMurdo, M., & Lawlor, D. A. (2009). Exercise for depression. *Cochrane Database Systematic Reviews,* (3). https://doi.org/10.1002/14651858.CD004366.pub4

Means, M. K., Lichstein, K. L., Edinger, J. D., Taylor, D. J., Durrence, H. H., Husain, a M., … Radtke, R. a. (2003). Changes in depressive symptoms after continuous positive airway pressure treatment for obstructive sleep apnea. *Sleep Breath.*, *7*, 31–42. https://doi.org/10.1007/s11325-003-0031-x

Mendelson, M., Bailly, S., Marillier, M., Flore, P., Borel, J. C., Vivodtzev, I., … Pépin, J. L. (2018). Obstructive sleep apnea syndrome, objectively measured physical activity and exercise training interventions: A systematic review and meta-analysis. *Frontiers in Neurology*, *9*(FEB). https://doi.org/10.3389/fneur.2018.00073

Mendelson, M., Tamisier, R., Laplaud, D., Dias-domingos, S., Baguet, J., Moreau, L., Pe, J. (2014). Low Physical Activity Is a Determinant for Elevated Blood

Pressure in High Cardiovascular Risk Obstructive Sleep Apnea, *Respiratory Care*, *59*(8), 1218–1227. https://doi.org/10.4187/respcare.02948

Miller, W. R., & Rollnick, S. (2002). Motivational interviewing: Preparing people for change. New York: Guildford Press.

Moreno-Murcia, J. A., Martínez-Galindo, C., Moreno-Pérez, V., Marcos, P. J., & Borges, F. (2012). Confirmation of the Basic Psychological Needs in Exercise Scale (BPNES) With a Sample of People who do Healthy Exercise. *Journal of sports science & medicine*, *11*(1), 141–146.

Morgenthaler, T.I., Kapen, S., Lee-Chiong, T., Alessi, C., Boehlecke, B., Brown, T., Coleman, J., Friedman, L., Kapur, V., Owens, J., et al. (2006). Practice parameters for the medical therapy of obstructive sleep apnea. *Sleep, 29*, 1031–1035.

Morres, I.D., Hatzigeorgiadis, A., Comoutos, N., Ploumpidis, D. Economou, M., Sideri, E., Maridakis, A., Stamouli, M., Pikouli, K., Loukadakis, M. Theodorakis, Y. (2017). Motivating adult outpatients with major depressive disorder towards physical activity: A self- determination approach. *Journal of Sports Sciences,* Vol 35, No1, S1-S113, pp s39-s40.

Morres, I., Hatzigeorgiadis, A., Stathi, A., Comoutos, N., Arpin-Cribbie, C., Krommidas, C., Theodorakis, Y. (2019). Aerobic exercise for adult patients with major depressive disorder in mental health services: a systematic review and meta-analysis. *Depress. Anxiety. 36* (1), 39–53. https://doi.org/10.1002/da.22842

Mortimore, I. L., Marshall, I., Wraith, P. K., Sellar, R. J., & Douglas, N. J. (1998). Neck and total body fat deposition in nonobese and obese patients with sleep apnea compared with that in control subjects. *American Journal of Respiratory and Critical Care Medicine*, *157*(1), 280–283. https://doi.org/10.1164/ajrccm.157.1.9703018

Munster Halvari, A. E., Halvari, H., Bjørnebekk, G., & Deci, E. L. (2010). Motivation and anxiety for dental treatment : Testing a self-determination theory model of oral self-care behaviour and dental clinic attendance. *Motiv Emot, 34*, 15–33. https://doi.org/10.1007/s11031-010-9154-0

Muñoz, A., Mayoralas, L. R., Barbé, F., Pericás, J., & Agustí, A. G. N. (2000). Long-term effects of CPAP on daytime functioning in patients with sleep apnoea syndrome. *European Respiratory Journal*, *15*(4), 676–681. https://doi.org/10.1034/j.1399-3003.2000.15d09.x

Murry, J. W. The Epworth Sleepiness Scale: Reference range of normal ESS scores, retrieved from https://epworthsleepinessscale.com/about-the-ess/

Naëgelé, B., Launois, S. H., Mazza, S., Feuerstein, C., Pépin, J., & Lévy, P. (2006). Which Memory Processes are Affected in Patients With Obstructive Sleep Apnea ? An Evaluation of 3 Types of Memory. *Sleep, 29,*533-44.

Norman, J. F., Essen, S. G. Von, Fuchs, R. H., & Mcelligott, M. (2000). Exercise Training Effect on Obstructive Sleep Apnea Syndrome, *Sleep Research Online 3*(3), 121-129.

O'Connor, B. P., & Vallerand, R. J. (1994). Motivation, self-determination, and person-environment fit as predictors of psychological adjustment among nursing home residents. *Psychology and Aging, 9,* 189–194. https://doi.org/10.1037=0882-7974.9.2.189

Palmer, L. J., Buxbaum, S. G., Larkin, E., Patel, S. R., Elston, R. C., Tishler, P. V., & Redline, S. (2003). A Whole-Genome Scan for Obstructive Sleep Apnea and Obesity. *The American Journal of Human Genetics*, *72*(2), 340–350. https://doi.org/10.1086/346064

Peppard, P. E., & Young, T. (1992). Exercise and Sleep-Disordered Breathing : an Association Independent of Body Habitus. S*leep*, *27*(3), 480–484. https://doi.org/10.1093/sleep/27.3.480

Prior, L., Wood, F., Lewis, G., & Pill, R. (2003). Stigma revisited, disclosure of emotional problems in primary care. *Social Science & Medicine, 56*, 2191-2200.

Punjabi, N. M. (2008). The Epidemiology of Adult Obstructive Sleep Apnea. *Proceedings of the American Thoracic Society*, *5*(2), 136–143. https://doi.org/10.1513/pats.200709-155MG

Raglin, J. S. (1997). Anxiolytic effects of physical activity. In: Morgan WP, editor. Physical activity and mental health. Washington, DC: Taylor & Francis, p. 107-126.

Rahman, R. J., Thogersen-Ntoumani, C., Thatcher, J., & Doust, J. (2011). Changes in need satisfaction and motivation orientation as predictors of psychological and behavioural outcomes in exercise referral. *Psychology & Health, 26,* 1521–1539. https://doi.org/10.1080/08870446.2010.538849

Redolfi, S., Yumino, D., Ruttanaumpawan, P., Yau, B., Su, M., Lam, J., & Bradley, T. D. (2009). Relationship between Overnight Rostral Fluid Shift and Obstructive Sleep Apnea in Nonobese Men. *American Journal of Respiratory and Critical Care Medicine, 179,* 241–246. https://doi.org/10.1164/rccm.200807-1076OC

Reis, H. T., Seldon, K. M., Gable, S. L., & Ryan, R. M. (2000). Daily Well-Being : The Role of Autonomy , Competence , and Relatedness, *Personality and Social Psychology Bulletin, 26,* 419–435.

Rezaeitalab, F., Moharrari, F., Saberi, S., Asadpour, H., & Rezaeitalab, F. (2014). The correlation of anxiety and depression with obstructive sleep apnea syndrome. *J Res Med Sci, 19*(3), 205– 210.

Reynolds, C. F., Kupfer, D. J., McEachran, A. B., Taska, L. S., Sewitch, D. E., Coble, P. A. (1984). Depressive psychopathology in male sleep apneics. *J Clin Psychiatry, 45*, 287-290.

Rossini, G. J. (2009). Obstructive Sleep Apnea And Obesity. *The Journal of Lancaster General Hospital.* 4(4), 139-142.

Ryan, R. M. (1982). "Control and information in the intrapersonal sphere: An extension of cognitive evaluation theory." *Journal of Personality and Social Psychology, 43*,450-461.

Ryan, R. M. (2009). Self - determination Theory and Wellbeing. *WeD Research Review 1*, 1–2. https://doi.org/10.1002/9780470479216.corpsy0834

Ryan, R. M., & Deci, E. L. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *American Psychologist*, *55*(1), 68–78. https://doi.org/10.1037/0003-066X.55.1.68

Ryan, R. M., Williams, G. C., Patrick, H., Deci, E. L. (2009): Self-determination theory and physical activity: The dynamics of motivation in development and wellness. *Hellenic Journal of Psychology, 6*, 107–124.

Sánchez, A. N. A. I., Buela-casal, G., Bermudez, M.P. & Casas-Maldonado, F. (2001). The effects of continuous positive air pressure treatment on anxiety and depression levels in apnea patients. *Psychiatry and Clinical Neurosciences,* 641–646.

Sampol, G., Muñoz, X., Sagalés, M. T., Martí, S., Roca, A., Dolors De La Calzada, M., … Morell, F. (1998). Long-term efficacy of dietary weight loss in sleep apnoea/hypopnoea syndrome. *European Respiratory Journal*, *12*(5), 1156–1159. https://doi.org/10.1183/09031936.98.12051156

Saunamaki, T., & Jehkonen, M. (2007). Depression and anxiety in obstructive sleep apnea syndrome: A review. *Acta Neurologica Scandinavica*, *116*(5), 277–288. http://doi.org/10.1111/j.1600-0404.2007.00901.x

Schmidt-Nowara, W., Lowe, A., Wiegand, L., Cartwright, R., Perez-Guerra, F. & Menn, S. (1995). Oral appliances for the treatment of snoring and obstructive sleep apnea: a review. *Sleep, 18,* 501-10.

Schröder, C. M., & O'Hara, R. (2005). Depression and Obstructive Sleep Apnea (OSA). *Annals of General Psychiatry*, *4*(1), 1–8. http://doi.org/10.1186/1744-859X-4-13

Schutz, T., Cunha, T., Moura-Guimaraes, T., Luz, G., Ackel-D´Elia, C., Alves, E., … Bittencourt, L. (2013). Comparison of the effects of continuous positive airway pressure, oral appliance and exercise training in obstructive sleep apnea syndrome. *Clinics*, *68*(8), 1168–1174. https://doi.org/10.6061/clinics/2013(08)17

Scottish Intercollegiate Guidelines Network (2003). The Scottish Intercollegiate Guidelines Network (SIGN): Management of obstructive sleep apnoea/hypopnoea syndrome in adults, a national clinical guideline. *Scottish Medical Journal*, (June), 51–52.

Senaratna, C. V., Perret, J. L., Lodge, C. J., Lowe, A. J., Campbell, B. E., Matheson, M. C. & Dharmage, S. C. (2017). Prevalence of obstructive sleep apnea in the general population: A systematic review. *Sleep Medicine Reviews*, *34*, 70–81. https://doi.org/10.1016/j.smrv.2016.07.002

Sengul, Y. S., Ozalevli, S., & Oztura, I. (2011). The effect of exercise on obstructive sleep apnea : a randomized and controlled trial, *Sleep and Breathing, 15*(1), 49–56. https://doi.org/10.1007/s11325-009-0311-1

Servantes, D. M., Pelcerman, A., Salvetti, X. M., Salles, A. F., De Albuquerque, P. F., De Salles, F. C. A., … Filho, J. A. O. (2012). Effects of home-based exercise training for patients with chronic heart failure and sleep apnoea: A randomized comparison of two different programmes. *Clinical Rehabilitation*, *26*(1), 45–57. https://doi.org/10.1177/0269215511403941

Sforza, E., Saint, M. M., Barthelemy, J. C., & Roche, F. (2016). Mood disorders in healthy elderly with obstructive sleep apnea: a gender effect. *Sleep Med. 19*, 57-62.

Shapiro, D. H. (1982): Overview: clinical and physiological comparison of meditation with other self-control strategies. *Am J Psychiatry, 139(*3), 267-274.

Sharafkhaneh, A., Giray, N., Richardson, P. Young, T., & Hirshkowitz, M. (2005). Association of psychiatric disorders and sleep apnea in a large cohort. *SLEEP,28*(11), 1405-1411.

Sheldon, K. M., Joiner, T. E., Pettit, J. W., & Williams, G. (2003). Reconciling Humanistic Ideals and Scientific Clinical Practice, *Clinical Psychology Science and Practice, 10*, 302–315. https://doi.org/10.1093/clipsy/bpg026

Sheldon, K., M. & Krieger, L. S. (2007). Personality and Social Psychology Bulletin Understanding the Negative Effects of Legal Education on Law Students : A Longitudinal Test of Self-Determination Theory. *Personality and Social Psychology Bulletin*, *33*(6), 883–897. https://doi.org/10.1177/0146167207301014

Silva, M. N., Markland, D. A., Minderico, C. S., Vieira, P. N., Castro, M. M., Coutinho, S. R., et al. (2008). A randomized controlled trial to evaluate self-determination theory for exercise adherence and weight control: Rationale and intervention description. *BMC Public Health, 8*(1), 234

Silva, R. P., Martinez, D., Pedroso, M. M., Righi, C. G., Martins, E. F., Silva, L. M. T., … Fiori, C. Z. (2017). Exercise , Occupational Activity , and Risk of Sleep Apnea : A Cross-Sectional Study, *Journal of Clinical Sleep Medicine, 13*(2), 97–204.

Simpson, L., McArdle, N., Eastwood, P.R., Ward, K.L., Cooper, M.N., Wilson, A.C., Hillman, D.R., Palmer, L.J., Mukherjee, S. (2015). Physical inactivity is associated with moderate-severe obstructive sleep apnea. *Journal of Clinical Sleep Medicine, 11*, 1091–9.

Singh, N. A., Stavrinos, T. M., Scarbek, Y., Galambos, G., Liber, C., Fiatarone, & Singh M. A. (2005). A randomized controlled trial of high versus low intensity weight training versus general practitioner care for clinical depression in older adults. *Journal of Geriatrics, 60A*, 768-776.

Sisson, S. B., Katzmarzik, P. T. (2008): International prevalence of physical activity in youth and adults. *Obesity Reviews, 9,* 606–614.

Smári, J., Pétursdóttir, G., & Porsteinsdóttir, V. (2001). Social anxiety and depression in adolescents in relation to perceived competence and situational appraisal. *Journal of Adolescence, 24*, 199–207. https://doi:10.1006=jado.2000.0338

Smith, S. S., Doyle, G., Pascoe, T., Douglas, J. A., Hon, M., & Jorgensen, G. (2007). Intention to Exercise in Patients with Obstructive Sleep Apnea, *Journal of Clinical Sleep Medicine, 3*(7).

Smith, P. L., Gold, A. R., Meyers, D. A., Ph, D., Haponik, E. F., & Bleecker, E. R. (1985). Weight Loss in Mildly to Moderately Obese Patients with Obstructive Sleep Apnea. *Ann Intern Med, 103,* 850-855. https://doi:10.7326/0003-4819-103-6-850

Soenes, B., Luyckx, K., Vansteenkiste, M., Luyten, P., Duriez, B., & Goossens, L. (2008). Maladaptive Perfectionism as an Intervening Variable between Psychological Control and Adolescent Depressive Feelings: A Three-Wave Longitudinal Study. *Journal of Family Psychology, 22,* 465-474. https://doi.org/10.1037/0893-3200.22.3.465

Sorensen, M., (2006). Motivation for physical activity of psychiatric patients when physical activity was offered as part of treatment. *Scand J Med Sci Sports, 16*, 391–398. https://doi.org/10.1111/j.1600-0838.2005.00514.x

Spielberger, C. D., Gorsuch, R. L., & Lushene, T. E. (1994). State-TraitAnxiety Inventory. Madrid: TEA

Spielberger, C. D., Gonzalez-Reigosa, F., Martinez-Arratia, A., Natalicio, L. F. S., & Natalicio, D. S. (1971). Development of the Spanish edition of the state-trait anxiety inventory. *Interamerican Journal of Psychology, 5,* 145-158.

Strawbridge, W. J., Deleger, S., Roberts, R. E., & Kaplan, G. A. (2002). Physical Activity Reduces the Risk of Subsequent Depression for Older Adults, *American Journal of Epidemiology*, 156(4), 328–334. https://doi.org/10.1093/aje/kwf047

Strine, T. W., Mokdad, A. H., Balluz, L. S., Gonzalez, O., Crider, R., Berry, J. T., & Kroenke, K. (2008a). Depression and anxiety in the United States: Findings from the 2006 Behavioral Risk Factor Surveillance System. *Psychiatric Services, 59*, 1383-1390

Strine ,T. W., Mokdad, A. H., Dube, S. R., Balluz, L. S., Gonzalez, O., Berry, J. T., Manderscheid, R., & Kroenke, K. (2008b). The association of depression and anxiety with obesity and unhealthy behaviors among community-dwelling US adults. *General Hospital Psychiatry 30,* 127-137.

Strine, T.W., Mokdad, A.H., Balluz, L.S., Berry, J. T., & Gonzalez, O. (2006). Impact of depression and anxiety on quality of life, health behaviors, and asthma control among adults in the United States with asthma, *Journal of Asthma, 45*, 123–133.

Taylor, A. H. (2010). Physical activity and depression in obesity. In C. Bouchard, & P. T. Katzmarzyk (Eds.), Physical activity and obesity (2nd ed.). Champaign, Ill.: Human Kinetics.

Telch, M. J., Lucas, J. A., Schmidt, N. B., Hanna, H. H., Jaimez, T. L., & Lucas, R. A. (1993). Group cognitivebehavioral treatment of panic disorder. *Behavior Research and Therapy, 31,* 279–287.

Thomasouli, M. A., Brady, E. M., Davies, M. J., Hall, A. P., Khunti, K., Morris, D. H., & Gray, L. J. (2013). The impact of diet and lifestyle management strategies for obstructive sleep apnoea in adults: A systematic review and meta-analysis of randomised controlled trials. *Sleep and Breathing*, *17*(3), 925–935. https://doi.org/10.1007/s11325-013-0806-7

Tucker, R. P., & Wingate, L. R. (2014). Basic Need Satisfaction and Suicidal Ideation : A Perspective on Interpersonal Suicide Risk and Suicidal Thinking, *Archives of Suicide Research, 18*(3), 282–294. https://doi.org/10.1080/13811118.2013.824839

U.S. Department of Health and Human Services (2000). Healthy People 2010: Understanding and improving health (2nd ed.). Washington, DC: U.S. Government Printing Office.

U.S. Department of Health and Human Services (2008). Physical Activity Guidelines Advisory Committee: Physical activity guidelines advisory committee report. Washington DC.

Vallerand, R. J., Koestner, R., & Pelletier, L. G. (2008). Reflections on self-determination theory. *Canadian Psychology*, *49*(3), 257–262. https://doi.org/10.1037/a0012804

Vallerand, R. J. & G. Reid. (1984). "On the causal effects of perceived competence on intrinsic motivation: A test of cognitive evaluation theory". *Journal of Sport Psychology, 6,* 94-102.

Verwimp, J., Ameye, L., & Bruyneel, M. (2013). Correlation between sleep parameters, physical activity and quality of life in somnolent moderate to severe obstructive sleep apnea adult patients. *Sleep and Breathing*, *17*(3), 1039–1046. https://doi.org/10.1007/s11325-012-0796-x

Vlachopoulos, S. P., & Michailidou, S. (2006). Development and initial validation of a measure of autonomy, competence, and relatedness in exercise: The basic psychological needs in Exercise Scale. *Measurement in Physical Education and Exercise Science, 10,* 179–201. https://doi.org/10.1207/s15327841mpee1003_4

Vlachopoulos, S. P., & Neikou, E. (2007). A prospective study of the relationships of autonomy, competence, and relatedness with exercise attendance, adherence, and dropout. *Journal of Sports Medicine and Physical Fitness, 47*, 475-482.

Wegner, M., Helmich, I., Machado, S., Nardi, A. E., Arias-Carrion, O., & Budde, H. (2014.) Effects of exercise on anxiety and depression disorders: review of meta-analyses and neurobiological mechanisms. *CNS & Neurological Disorders -*

Drug Targets, 13(6), 1002–1014. https://doi.org/10.2174/1871527313666140612102841

Weman-Josefsson, K., Lindwall, M., & Ivarsson, A. (2015). Need satisfaction, motivational regulations and exercise: moderation and mediation effects. *International Journal of Behavioral Nutrition and Physical Activity,* 1-11. https://doi.org/10.1186/s12966-015-0226-0

Wei, M., Shaffer, P. A., Young, S. K., & Zakalik, R. A. (2005). Adult Attachment , Shame , Depression , and Loneliness : The Mediation Role of Basic Psychological Needs Satisfaction, *Journal of Counseling Psychology,* 52(4), 591–601. https://doi.org/10.1037/0022-0167.52.4.591

Wiesner, T., Windle, M., & Freeman, A., (2005). Work stress, substance use and depression in young adults: An examination of main and moderator effect models. *Journal of Occupational Health Psychology, 10,* 83-96.

Williams, G. C., McGregor, H. A., Sharp, D., Levesque, C., Kouides, R. W., Ryan R. M., & Deci, E. L. (2006). Testing a self-determination theory intervention for motivating tobacco cessation: supporting autonomy and competence in a clinical trial. *Health Psychol, 25*, 91-101.

Williams, G. C., Grow, V. M., Freedman, Z. R., Ryan, R. M., & Deci, E. L. (1996). Motivational predictors of weight loss and weight-loss maintenance. *J Pers Soc Psychol, 70*, 115-126.

Wilson, P. M., & Fraser, S. N. (2002). Examining the psychometric properties of the behavioural regulation in exercise questionnaire. *Measurement in Physical Education and Exercise Science, 6,* 1-121

Wilson, P. M., Mack, D. E., Blanchard, C. M., & Gray, C. E. (2009). The role of perceived psychological need satisfaction in exercise-related affect. *Hellenic Journal of Psychology, 6*, 183-206.

Wilson, P., & Rodgers, W. (2003). The relationship between perceived autonomy support exercise regulations and behavioural intentions in women. *Psychology of Sport & Exercise, 5,* 229-242,

Wilson, P. M., Rodgers, W. M., Blanchard, C. M., & Gessell, J. G. (2003). The relationship between psychological needs, self-determined motivation, exercise attitudes and physical fitness. *Journal of Applied Social Psychology, 33,* 2373-2392.

Wilson, P. M., Rodgers, W. M., Murray, T. C., Longley, K., & Muon, S. (2006). Examining the contributions of perceived psychological need satisfaction to well-being in exercise. *Journal of Applied Biobehavioral Research, 11*, 243–264.

Wilson, P. M., Rodgers, W. M., & Fraser, S. N. (2002). Examining the psychometric properties of the behavioural regulation in exercise questionnaire. *Measurement in Physical Education and Exercise Science, 6*, 1–21.

Wilson, P. M., Rodgers, W. M., Fraser, S. N., & Murray, T. C. (2004). Relationships between exercise regulations and motivational consequences in university students. *Research Quarterly for Exercise & Sport, 75,* 81-91.

World Health Organization (WHO). (1995). Exercise for health: WHO/FIMS Committee on Physical Activity for Health. *Bulletin of the World Health Organization, 73*, 135-136.

World Health Organization (WHO). (2010). Global recommendations on physical activity for health. Geneva: World Health Organization.

World Health Organization. Global Health Observatory Data Repository. (2011). Available from: http://apps.who.int/ghodata/

World Health Organization (WHO). (2012). The world health report 2001—mental health: new understanding, new hope. http://www.who.int/

Young, T., Evans, L., Finn, L., & Palta, M. (1997). Estimation of the clinically diagnosed proportion of sleep apnea syndrome in middle-aged men and women. *Sleep*, *20*(9), 705–706. https://doi.org/10.1093/sleep/20.9.705

Young, T., Palta, M., Dempsey, J., Scatrud, J., Weber, S., & Badr, S.(1993). The occurrence of sleep-disordered breathing among middle-aged adults. *The new England Journal of Medicine,* 328: 1230–1235.

Young, T., Peppard, P. E., & Gottlieb, D. J. (2002). Epidemiology of obstructive sleep apnea: A population health perspective. *American Journal of Respiratory and Critical Care Medicine*, *165*(9), 1217–1239. https://doi.org/10.1164/rccm.2109080

Zhao, G., Ford, E. S., Dhingra, S., Li, C., Strine, T. W., Mokdad, A. H. (2009). Depression and anxiety among US adults: Associations with body mass index. *International Journal of Obesity, 33*(2), 257–66.

APPENDIX

Table 1. Demographic information of the sample

	N; %	Age	
Total group	51; -	Mean= 50.75	SD=10.16
Males	38; 74,5%		
Females	13; 25,5%		
Marital Status			
Single	5; 9,8%		
Married	40; 78,4%		
Divorced	3; 5,9%		
Widowed	1; 2%		
Not reported	2; 3,9%		
Education			
Students	1; 2%		
Primary	8; 15,7%		
Secondary	27; 52,9%		
Tertiary	12; 23,5%		
Not reported	3; 5,9%		
Job Status			
Employed	33; 64,7%		
Unemployed	16; 31,4%		
Retired	9; 17,6%		
Not reported	2; 3,9%		
Smoking			
Smokers	19; 37,3%		
Non-Smokers	32, 62,7%		
Cigarettes per day	Mean= 18.84 SD= 13.68		
Cigarettes previous day	Mean=15.89 SD= 9.23		
BMI	Mean= 33.86 SD= 7.01		

N= Number; SD= Standard Deviation; BMI: Body Mass Index

Table 2. Descriptive Statistics and Cronbach's alpha of outcome measures

Patients (N=51)	Cronbach Alpha	Mean	SD
Epworth	.69	5.86	4.01
BDI	.85	10.29	7.57
Anxiety			
State Anxiety	.85	45.59	8.23
Trait Anxiety	.82	41.00	7.68
Need Satisfaction			
Competence	.95	4.61	1.67
Autonomy	.84	4.63	1.33
Relatedness	.92	5.77	1.41
METS			
METS total		321.96	372.38
METS high		19.27	103.47
METS moderate		48.31	130.87
METS low		248.62	329.17

Epworth: Sleepiness Scale; BDI: Beck Depression Inventory; METS: Metabolic Equivalents

Table 3. Correlations between Sleepiness, Depression, METS, Psychological Needs, Anxiety and BMI

Variables	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*
1. Epworth												
2. BDI	.35*											
Anxiety												
3. State Anxiety	.11	.56**										
4. Trait Anxiety	.22	.74**	.73**									
Psychological Needs												
5. Competence	-.16	-.36**	-.10	-.32*								
6. Autonomy	-.25	-.33*	.09	-.21	.61**							
7. Relatedness	-.22	-.10	-.09	.01	.13	.43**						
METS												
8. METS total	-.17	-.20	-.12	-.21	.37**	.19	.01					
9. METS low	-.03	-.17	-.11	-.17	.25	.10	-.06	.89**				
10. METS mod	-.31*	-.15	-.08	-.15	.23	.09	.06	.35*	.01			
11. METS high	-.06	.01	.02	-.04	.25	.26	.14	.28	.02	-.07		
12. BMI	-.03	.30	.19	.18	-.18	-.06	-.11	-.22	-.24	-.02	.04	

Epworth: Sleepiness Scale; BDI: Beck Depression Inventory; METS: Metabolic Equivalents; BMI: Body Mass Index; *p < .05; **p < .01

Table 4. Comparisons between exercisers and non-exercisers on outcome measures

	Exercisers (N=18)		Non-Exercisers (N=33)	
	M	SD	M	SD
Epworth	4.83	4.12	6.42	3.90
BDI	7.83*	4.59	11.64	8.54
Anxiety				
State Anxiety	44.33	7.90	46.27	8.44
Trait Anxiety	39.00	6.77	49.09	8.02
Need Satisfaction				
Competence	5.40*	1.29	4.18	1.71
Autonomy	5.05	1.35	4.40	1.29
Relatedness	5.94	1.50	5.67	1.36

*Exercisers were less depressed and were feeling more competent than non-exercisers ($p < .05$)

Table 5. Stepwise Regression Analysis for Sleepiness

	Beta	t	p	F	R^2 change
Significant Predictor				5.79*	.11
METS mod	-.34	-2.41	.020*		
Excluded Predictors					
METS lo	-.03	-.21	.84		
METS hi	-09	-.62	.54		

METS mod: Metabolic equivalents moderate; METS lo: Metabolic equivalents low; METS hi: Metabolic equivalents high; *p < .05

Table 6. Stepwise Regression Analysis METS total

	Beta	t	p	F	R^2 change
Significant Predictor				.37*	.14
Competence	.37	2.70	.010*		
Excluded Predictors					
Autonomy	-.09	-.47	.64		
Relatedness	-.04	-.25	.80		

METS total: Metabolic equivalents total; *p < .05