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ORIGINAL ARTICLE

Depression, physical activity, energy consumption, and quality of life in OSA patients before and after CPAP treatment

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Abstract
Background A variety of studies have demonstrated improvement in quality of life and depressive symptoms in obstructive sleep apnea (OSA) patients after continuous positive airway pressure (CPAP) treatment. However, very little is known about the effect of OSA treatment on physical activity and energy consumption.
Objectives The aim of this study was to evaluate the changes in depression, physical activity, energy expenditure, and quality of life (QoL) in OSA patients before and after CPAP therapy.
Methods Forty-one patients with OSA as revealed by polysomnography, were included to the study. They responded to the generic World Health Organization Quality of Life (WHOQoL) questionnaire, to the specific-disease Quebec Sleep Questionnaire, and to Center for Epidemiologic Studies Depression Scale (CES-D) in order to evaluate QoL and the incidence of depression. In addition, all patients wore an accelerometer which measured physical activity and energy expenditure during a week. At least 6 months after initiation of CPAP treatment (mean time, 9 months) we re-examined 24 patients who met the compliance with the treatment criteria.
Results Patients after CPAP therapy had significantly higher scores in all domains of the Quebec Sleep Questionnaire and in the domains of physical health/level of independence and psychological health/spirituality of the WHOQoL. Depression scores were also better in CES-D after treatment. However, despite the improvement in QoL and psychological

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status, CPAP therapy had no impact on physical activity and energy expenditure.

Conclusions CPAP therapy improves QoL and lessens depressive symptoms in our group of well-treated OSA patients. However, physical activity and energy expenditure did not present statistically significant improvement in the same group of OSA patients.

Keywords Obstructive sleep apnea syndrome · CPAP · Depression · Quality of Life · Physical activity · Accelerometer

Introduction

Obstructive sleep apnea (OSA) is a disorder characterized by repeated cessation of breathing during sleep due to upper airway collapse. The prevalence of the syndrome is 4 % in men and 2 % in women [1, 2]. The consequences of OSA in suffering patients are cardiovascular, metabolic, and neurocognitive and are related with chronic inflammation and increased cardiovascular morbidity and mortality [3]. Their functional activities and quality of life are poor [4, 5] due to a variety of symptoms such as fatigue, impaired concentration, daytime sleepiness, and depression [6–11]. These symptoms are the result of repetitive apneas and hypopneas along with microarousals during sleep which lead to sleep fragmentation, nocturnal hypoxemia, surges of sympathetic nervous system activity, increase in blood pressure and heart rate, and lack of the restorative function of sleep [12, 13].

Several studies have shown that prompt and appropriate treatment of OSA with continuous positive airway pressure (CPAP) is mandatory to reduce not only the harmful biological effects of the syndrome but also mortality [14, 15]. Treatment with CPAP is considered as treatment of choice. It opens the upper airway pneumatically via constant pressure throughout the respiratory cycle correcting thereby the harmful effects of OSA [16]. Continuous positive airway pressure when used correctly at the appropriate dose of pressure prevents upper airway obstruction and results in improved sleep architecture and daytime symptoms, as well as reduced blood pressure and heart rate, via reduced sympathetic nervous activity, with subsequent cardiovascular risk amelioration [14]. A variety of studies have demonstrated improvement in quality of life and depressive symptoms in OSA patients after CPAP treatment [9, 17–20]. However, very little is known about the effect of OSA treatment on physical activity and energy consumption [21–23]. According to the Physical Activity Guidelines for Americans of the US Department of Health and Human Services [24], normal or increased physical activity reduces the risk of many adverse health outcomes and improves functional and cognitive health.

The aim of this study was to prospectively evaluate depression, physical activity, energy expenditure and quality of life in OSA patients pre- and post-CPAP treatment, hypothesizing an amelioration of all parameters studied.

Patients and methods

Patients

The study population consisted of patients with OSA diagnosed by polysomnography (PSG). All patients were recruited from the outpatient Sleep Clinic of the 1st Department of Respiratory Medicine, "Sotiria" Hospital, Athens University, underwent a full-night diagnostic PSG and were enrolled in the study when their apnea/hypopnea index (AHI) was ≥15. Patients already treated for OSA, patients with coexisting COPD, uncontrolled asthma, severe or unstable cardiovascular disease, neuromuscular disease, or orthopedic problems were excluded. Patients who had depression or were on sedatives or hypnotic medications were also excluded. Moreover, patients were excluded if major life changes that could have an impact on their psychological status and activity had occurred, such as job loss, divorce, or loss of kin. Finally, a sum of 41 OSA patients was included in the study.

Study protocol

The study was carried out from September 2009 to December 2010. A standard prospective protocol of pretreatment (phase I) and at least 6 months posttreatment (phase II) data collection were followed. After enrollment in the study, patients completed two quality of life (QoL) questionnaires and one questionnaire focusing on clinical depression. The level of daytime sleepiness was determined by the Epworth Sleepiness Scale [25]. Afterwards all patients wore an accelerometer for 7 days in order to have a quantitative assessment of physical activity. Every patient from the study population (n=41) underwent a second PSG night for CPAP titration. Next day, a CPAP device, with time meter to help us assure utilization, was given as treatment of choice. We followed them up every month for the relief of symptoms, side effects, and their compliance with the device, for 6 up to 11 months. Patients with CPAP who use less than 5 h/night were excluded from the study. During the follow-up period, eight participants stopped CPAP use after 1 to 3 months, three were lost during the follow-up and four had poor compliance with the treatment during the last 2 months. Moreover, two participants lost their job and were excluded from the study because this event could affect their psychological status. Finally, 24 patients met the criteria for re-examination. After completion of the follow-up period, we collected the posttreatment data (phase II) of each patient. They underwent a full-night PSG using their own CPAP, completed the same questionnaires for quality of life and for clinical depression, and wore the accelerometer for assessment of their physical activity, again for 7 days. All patients included in the study provided informed consent, and the study protocol had the approval of the hospital ethics committee (3075 6/2/2008).

Assessment of quality of life

WHOQoL-bref and national items

It is a generic instrument focusing on quality of life (QoL) [26]. It consists of 30 items that belong to four domains: physical health and level of independence, psychological health and spirituality, social relationships, and environment. The score of each domain range is 4–20. The higher the total score in a domain, the better the individual's QoL in the specific domain.

Quebec Sleep Questionnaire

This is a disease-specific QoL instrument designed to measure health-related QoL changes in patients with OSAS [27]. The Quebec Sleep Questionnaire (QSQ) lists 32 items distributed in five domains: daytime sleepiness, diurnal symptoms, nocturnal symptoms, emotions, and social interactions. The results are presented as the mean score of each domain on a seven-point scale.

Center for Epidemiologic Studies Depression Scale

It is a self-report scale designed to measure depressive symptomatology in the general population [28]. The questionnaire has 20 items concerning symptoms of clinical depression. Each item has a four-point range (0–3). The items have four possible answers scored as follows: never (0), rarely (1), sometimes (2), frequently (3). The total score ranges from 0 to 60 (16–20 mild depression, 21–25 moderate depression, >26 severe depression).

Physical activity: accelerometry

Patients wore the PALlite accelerometer (Pal Technologies Ltd., Glasgow, Scotland) which is a 5×3.5×0.7 cm, 20-g device designed for physical activity monitoring, posture detection, and energy expenditure estimation [29, 30]. The PALlite was securely attached in the patient's ankle by using a belt with Velcro straps 24 h/day for 7 days both in phase I and phase II of the study. It measured energy expenditure in metabolic equivalents and kilocalories, mean number of steps/day, lying time in hours/day, and activity duration in minute/day.

Polysomnography

All participants underwent full night polysomnography (PSG) according to standard techniques which included sleep staging by monitoring of central and occipital channels of electroencephalogram (C4-A1, C3-A2, O1-A2, O2-A1), electrooculogram and electromyograms (submental and anterior tibialis). Airflow was monitored by combined thermistor and nasal pressure transducer signals. Electrocardiogram and heart rate were monitored using the standard limb leads. Respiratory efforts were monitored with piezoelectric transducers placed around the chest and the abdomen. Arterial oxygen saturation was measured continuously by pulse oximetry using a finger probe. Body position was assessed with a body position sensor. All variables were recorded by a computerized system (Alice 5, Philips Respironics, USA). Manual scoring was done in all cases according to the American Academy of Sleep Medicine recommendations [31, 32]. Apnea was defined as the reduction in airflow of ≥90 % of baseline, lasting for at least 10 s. It was classified as an obstructive apnea when associated with the presence of an inspiratory effort, as central apnea in the absence of an inspiratory effort, or as mixed apnea if inspiratory effort was absent in the initial part of the event and present at the final part. Hypopnea was defined as the reduction in baseline airflow or in thoracoabdominal movement of ≥30 % with a ≥4 % desaturation, lasting for at least 10 s. The AHI was calculated as the number of apnea and hypopnea events per hour of sleep. CPAP titration was done manually under the surveillance of a technician.

Statistical analysis

Data are presented as mean±standard deviation (±SD). The distributions of all the examined parameters before and after treatment were tested for normality by the Anderson Darling test for normality. The parameters which were found to be normally distributed before and after treatment were compared with a two-tailed paired t test under the Welch modification for unequal variances. All the other parameters were compared with the non-parametric Wilcoxon two-tailed test. The initial confidence level used was 95 % (a-level=0.05) which is corrected for multiple comparisons, according to the "False Discovery Rate" correction method. All calculations were performed with the R statistical programming language.

Results

Forty-one patients, 35 males, were initially included in the study. More than half of them (24/41, 58 %) were compliant to CPAP treatment and were included in phase II and reevaluated. The mean number (±SD) of CPAP minutes within the sample of patients included in the study was 376.66 min (6.27 h) (±48.42). Baseline anthropometric and sleep study data of both compliant and noncompliant patients are presented in Table 1.

Change of AHI and BMI post-CPAP treatment

AHI was significantly reduced post-CPAP treatment (all patients had AHI<5 during the re-examination PSG with use of their own CPAP). On the contrary, no change was detected in the Body Mass Index (BMI) between the two phases of the study.

Associations of OSA with quality of life and psychological status pre-CPAP treatment

OSA as expressed by AHI was significantly related with higher scores in depressive symptomatology as shown in the Center for Epidemiologic Studies Depression Scale (CES-D) Questionnaire (p=0.01) and with higher scores in the domain of daytime sleepiness of the Quebec Sleep Questionnaire (p=0.01). There is also a correlation between lower oxygen saturation and daytime sleepiness (p=0.01) and the number of obstructive apneas and clinical depression (p=0.04). No correlations were found between the severity of syndrome and the other domains of QSQ and World Health Organization Quality of Life (WHOQoL) questionnaires (Table 2).

Table 1 Anthropometric and sleep study data (n=41)

	Compliant patients (n=24)	Non-compliant patients (n=17)
Gender (male/female)	20/4	15/2
Age (years)	51.88±10.55	52.29±11.32
Weight (kg)	107.4±20.5	99.12±19.73
Height (cm)	177±7.76	176.6±10.06
BMI (kg/m^2)	34.37±6.45	31.75±5.60
Neck perimeter (cm)	43.75±4.27	41.29±5.27
Epworth Sleepiness Scale	8.333±3.96	9.765±4.19
AHI	37.5±22.66	34.1±26.53
Total number of apneas and hypopneas	190.4±123.68	174.9±156.24
Obstructive apnea	105±105.4	112.1±141.48
Central apnea	10.58±25.02	3.706±10.23
Mixed apnea	27.5±61.51	13.35±30.57
Hypopnea	47.29±43.49	45.71±57.46
Lower O_2 saturation %	76.75±13.93	79.88±8.72

Change of quality of life–psychological status post-CPAP treatment

After CPAP therapy, improvement for the domains of the WHOQoL Questionnaire such as physical health and independence (p=0.0018) and psychological health and spirituality (p=0.0357) was noticed. (Table 3; Fig. 1). All domains of the Quebec Sleep Questionnaire present with significant amelioration post-CPAP therapy, precisely: daytime sleepiness (p<0.001), diurnal symptoms (p<0.001), nocturnal symptoms (p<0.001), emotions, and social interactions (p<0.001) (Table 4; Fig. 2). Twenty-two patients out of 41 (53.6 %) presented signs of depressive mood as reflected by a CES-D Scale score ≥16. The effect of CPAP on depression symptomatology was significant and is shown in Table 5 and Fig. 3. The total score improved significantly compared to baseline value for each one of the participants (p=0.0096).

Change of physical activity post-CPAP treatment

None of the physical activity and energy expenditure variables showed any significant change post-CPAP treatment (Table 6; Fig. 4).

Discussion

It is widely known that OSA is related to poor quality of life and impaired physical activity due to symptoms such as fatigue, increased daytime sleepiness, and depression [4–6,

Table 2 Correlation among sleep parameters, depression, and quality of life

	AHI	Lower oxygen saturation
CES-D	P=0.01	P=0.13
QSQ-daytime sleepiness	P=0.01	P=0.01
QSQ-diurnal symptoms	P=0.2	P=0.48
QSQ-nocturnal symptoms	P=0.7	P=0.81
QSQ-emotions	P=0.24	P=0.28
QSQ-social interactions	P=0.36	P=0.43
WHOQoL-physical health and level of independence	P=0.43	P=0.64
WHOQoL-psychological health and spirituality	P=0.11	P=0.59
WHOQoL-social relationships	P=0.2	P=0.97
WHOQoL-environment	P=0.93	P=0.66

Table 3 WHOQoL-Bref and National Items (n=24)

	Score pretreatment	Score posttreatment	*P* value
Physical health and level of independence	12.27±2.26	13.97±1.97	0.0018
Psychological health and spirituality	12.66±2.06	13.66±2.41	0.0357
Social relationships	12.84±2.0	13,97±2.85	0.0632
Environment	13.52±2.07	12.75±2.45	0.2101

Values are given as mean +SD

9–11]. Treatment with CPAP is already shown to ameliorate part of these symptoms, but very little data exist on its impact on physical activity and exercise capacity in OSA patients [21–23]. In the present study, a group of obese OSA patients were prospectively examined as far as quality of life, psychological status, physical activity, and energy consumption were concerned pre- and post-CPAP treatment. The main object of this study was to examine prospectively the influence of CPAP therapy on the activity of OSA patients based on the hypothesis that the improvement both in QoL and in psychological status along with the

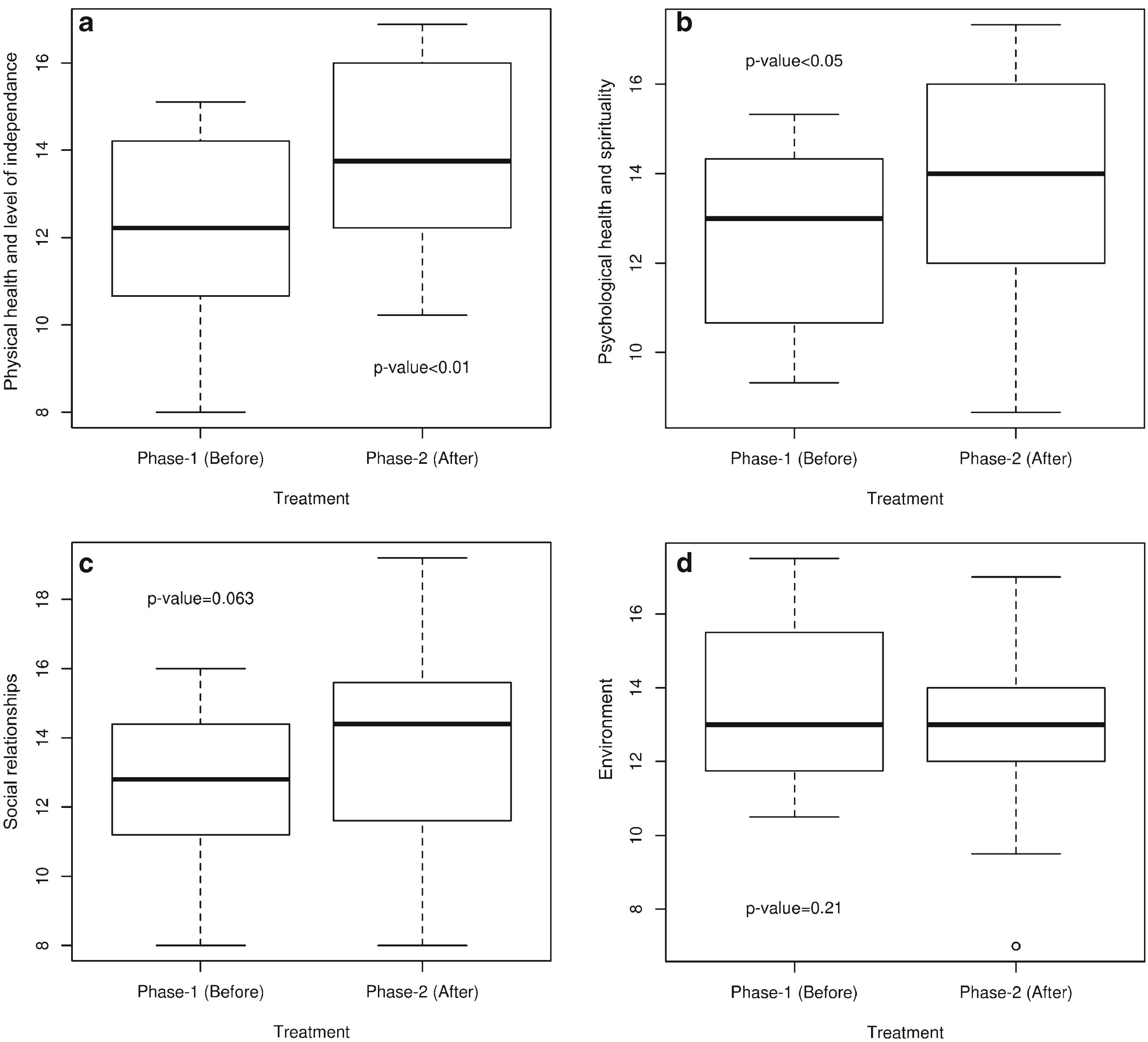

Fig. 1 Comparison of physical health and level of independence (**a**), psychological health and spirituality (**b**), social relationships (**c**), and environment (**d**) of the WHOQoL questionnaire in the study population (n=24) pre- and post-CPAP treatment. Data are described using standard box plots with medians (interquartile range). Differences were statistically significant for the domain of physical health and level of independence (p=0.0018) and psychological health and spirituality (p=0.0357)

Table 4 Quebec Sleep Questionnaire (n=24)

	Score pretreatment	Score posttreatment	P value
Daytime sleepiness	3.983±1.65	6.310±0.66	<0.001
Diurnal symptoms	3.792±1.47	5.513±1.17	<0.001
Nocturnal symptoms	3.540±1.20	6.060±0.66	<0.001
Emotions	3.90±1.17	5.506±1.06	<0.001
Social interactions	3.875±1.45	5.906±1.04	<0.001

Values are given as mean+SD

amelioration of depression symptoms after CPAP treatment could increase physical activity and energy consumption of our OSA patients However, no changes were detected concerning physical activity and energy expenditure despite the aforementioned improvement of quality of life and psychological status.

Based on our findings, OSA patients had impaired quality of life and more than half showed signs of depression based on the Center of Epidemiologic Studies Depression Scale. In the present study, quality of life was examined with the help of two questionnaires, the WHOQoL questionnaire and the Quebec Sleep Questionnaire. Our results are

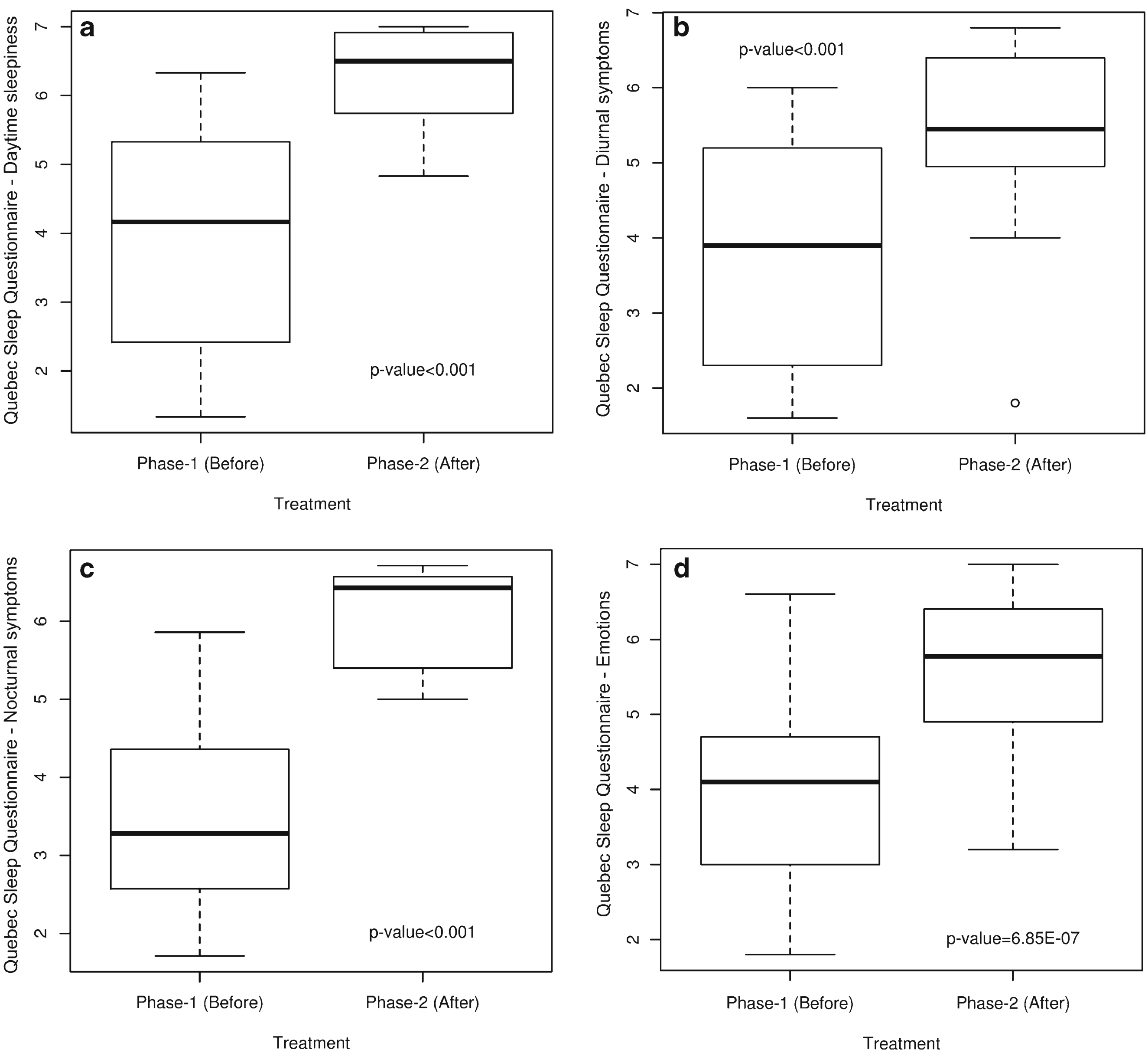

Fig. 2 Comparison of daytime sleepiness (**a**), diurnal symptoms (**b**), nocturnal symptoms (**c**), and emotions (**d**) of the QSQ in the study population (n=24) pre- and post-CPAP treatment. Data are described using standard box plots with medians (interquartile range). Differences were statistically significant for all the domains (p<0.001)

Table 5 CES-D (n=24)

	Score pretreatment	Score posttreatment	*P* value
Total score	18.25±9.41	12.42±7.42	0.0096

Values are given as mean±SD

consistent with previous studies showing the negative impact of OSA on QoL [33] and its improvement with CPAP treatment [17, 18]. More specifically, the WHOQoL questionnaire detected a statistically significant improvement in QoL in the domains of physical health and independence and psychological health and spirituality in the group of our well-treated OSA patients. On the contrary, no differences were found in the domain of the environment probably because OSA is not related to environmental conditions. The disease-specific instrument of health-related QoL Quebec Sleep Questionnaire detected statistical improvement in all domains such as daytime sleepiness, diurnal symptoms, nocturnal symptoms, emotions and social interactions. The QSQ furthermore measured the increase in the domain of social interactions that WHOQoL underestimated. Previous studies have shown comparative results with improvements post-CPAP treatment of domains such as vitality, social functioning, mental health and daily functioning using different scales such as the Short Form 36 questionnaire [34, 35]. A meta-analysis examining 1,256 patients has concluded that CPAP does improve physical domains and vitality

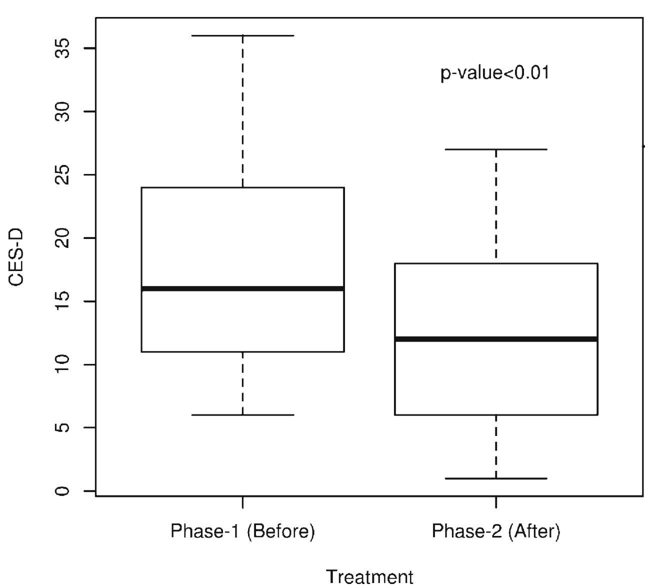

Fig. 3 Comparison of the CES-D in the study population (n=24) pre- and post-CPAP treatment. Data are described using standard box plots with medians (interquartile range). Difference was statistically significant (p<0.01)

Table 6 Accelerometry (n=24)

	Score pretreatment	Score posttreatment	*P* value
Energy expenditure in METh	25.51±0.75	25.61±0.70	0.7147
Energy expenditure in kcal/day	2,184±366.33	2,157±344.21	0.5201
Mean number of steps/day	3,250±2,326.93	2,982±1,954.88	0.6231
Lying time in hours/day	9.446±3.11	8.867±2.61	0.3723
Activity duration in min/day	31.17±21.19	28.42±17.96	0.6068

Values are given as mean±SD

MET metabolic equivalent of task

[36]. Improvement of QoL is partly explained by the beneficial effect of CPAP on parameters such as somnolence, impaired memory, concentration, and irritability [37].

As far as the psychological status of our patients is concerned, in more than half of our OSA patients (54 %), signs of depressive mood were found as reflected by increased CES-D scores, which is almost double the rate of depression encountered in the general Greek population ranging from 17 % to 28 % [38]. Our data are in accordance with previous studies showing increased rates of psychiatric disorders including depression and anxiety in OSA patients reaching up to 60 %. Most importantly, the depressive status of patients was significantly improved after CPAP treatment. Our findings are in line with those of previous studies showing that CPAP treatment has a positive effect on depression levels in OSA patients even when applied for shorter periods of time such as 1 to 3 months [9, 19, 20]. The mechanisms by which CPAP treatment improves depression in OSA seem to include the amelioration of parameters additional to obstructive–hypoxic events such as neural injury, sleepiness, fatigue, loss of libido, and impaired concentration [9].

One of the major findings of the present study is the lack of any improvement in the domain of physical activity and energy expenditure in this group of OSA patients despite the improvement of quality of life and psychological status. Physical activity and energy expenditure were examined by an accelerometer calculating energy expenditure, mean number of steps, lying time, and activity duration pre- and post-CPAP treatment. On diagnosis, decreased physical activity was detected as reflected by the fact that our patients had a mean number of steps/day less than half the normal range or the one of older patients with chronic illnesses (3,278±2,523 vs. 8,500±1,500 or 7,500±1,000, respectively) [39]. No change was found in any of the parameters of physical activity post-CPAP treatment. One would expect

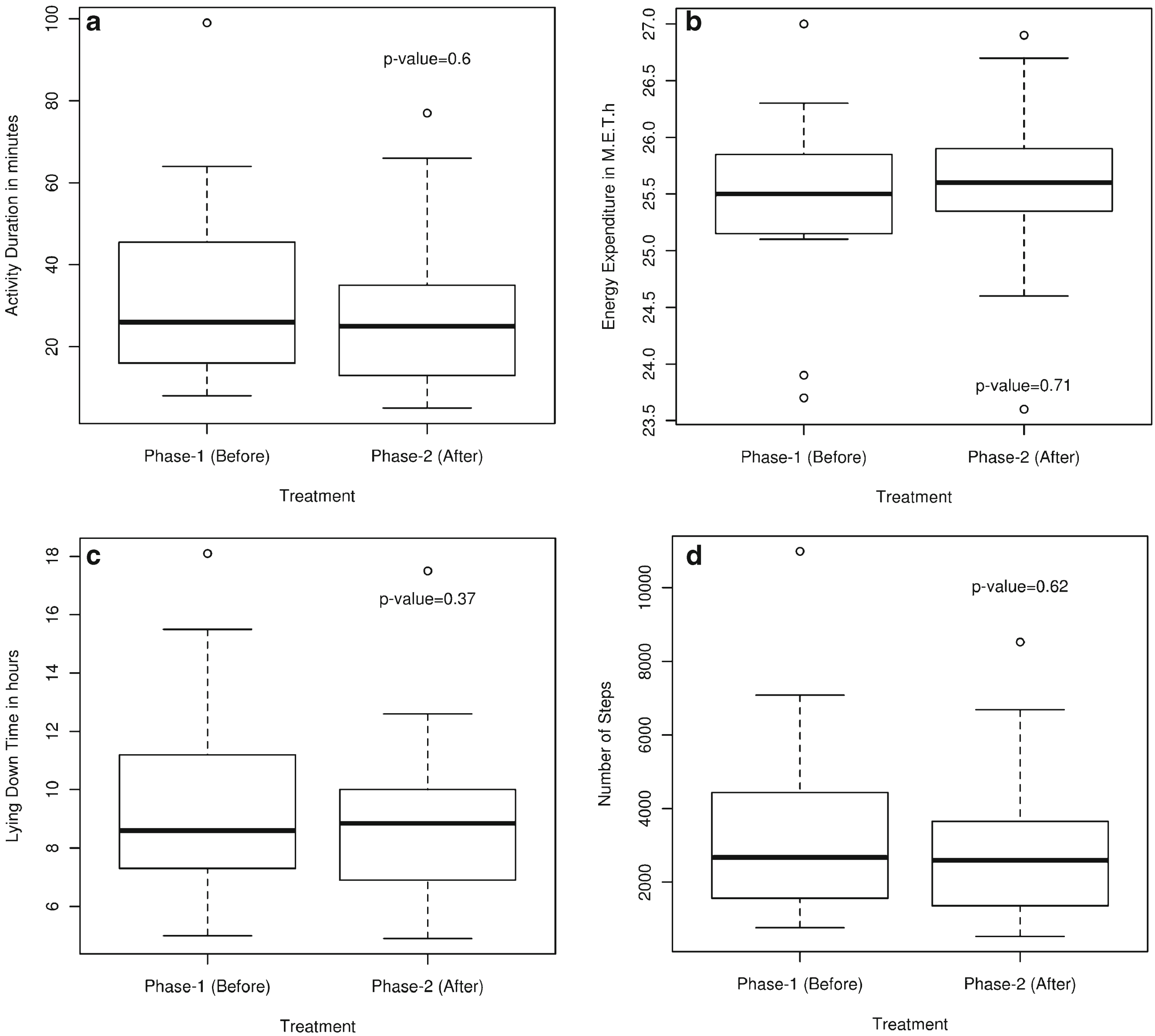

Fig. 4 Comparison of the activity duration in minutes (**a**), energy expenditure in metabolic equivalent of task (*METh*) (**b**), lying down time in hours (**c**), and number of steps (**d**) in the study population (n= 24) pre- and post-CPAP treatment. Data are described using standard box plots with medians (interquartile range). Differences were not statistically significant (p>0.05)

that the amelioration of quality of life and psychological status would lead to a change of the sedentary life style of our patients. Very few data exist in the literature examining the impact of CPAP on energy expenditure in OSA patients [21, 22]. West S. et al. showed no improvement of physical activity after CPAP treatment for a week in men with OSA [22]. We re-examined our OSA patients after longer duration on CPAP treatment, than West et al. did, in order to elucidate the possibility that treatment duration play a role in the lack of activity improvement. However, our hypothesis was not verified. The reasons for these observations are not clear. One could speculate that the increased BMI characterizing our OSA patients did not show any reduction after CPAP treatment, and this could relate to the observed unchanged limited daily activities [40].

In the literature, higher BMI is significantly associated with lower self-efficacy and behavioral and cognitive processes of change [41]. Another explanation can be the longstanding habitual patterns of activity as West et al. pointed out [22]. Someone could argue that the participants wore the accelerometer during different periods of the year (more warm or colder weather, vacations, etc.) and this could influence their activity. In order to minimize the differences between the pre- and posttreatment evaluation of physical activity with accelerometry, we excluded, in both phases of the study, summer time, periods of vacation, and bad weather conditions. Furthermore, a positive change in physical activity often necessitates counseling and the participation in exercise regimens that was not included in our study protocol.

There are some limitations in this study. One limitation is the relatively small number of patients re-examined post-CPAP treatment, the rest being lost during the follow-up or excluded by factors that could have an impact on psychological status and physical activity. Another limitation is the lack of a control group. A control group was not included in the study for two reasons. First, no patient diagnosed with OSA necessitating therapy could be allowed not to receive CPAP treatment and second those patients with poor compliance which could be used as control group were lost from the study during follow-up period.

Probably there is still much work to be done with regard to understanding the reasons of limited physical activity in well-treated OSA patients; however, specific counseling and participation in exercise regimens should accompany CPAP therapy in order to improve the sedentary lifestyle of OSA patients and increase their physical activity.

In conclusion, in our group of patients OSA is related to poor quality of life, depressive symptoms, and reduced physical activity. Treatment with CPAP did not ameliorate their physical activity and energy expenditure besides the detected improvement of quality of life and psychological status.

Conflict of interest The authors declare that they have no conflict of interest.

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