Sleep, Physical Activity, and Diet of Adults during the Second Lockdown of the COVID-19 Pandemic in Greece

Zisis Papazisis 1, Pantelis T. Nikolaidis 2,*, and Georgia Trakada 3

1 Faculty of Mathematics, School of Sciences, University of Ioannina, 451 10 Ioannina, Greece; zisispap3d@gmail.com
2 School of Health and Caring Sciences, University of West Attica, 122 43 Athens, Greece
3 Division of Pulmonology, Department of Clinical Therapeutics, School of Medicine, National and Kapodistrian University of Athens, Alexandra Hospital, 115 28 Athens, Greece; gtrakada@hotmail.com

Abstract: The aim of the present study was to evaluate the possible correlations between sleep, physical activity, and diet in the general population of Greece during the second lockdown due to COVID-19 pandemic. A web-based questionnaire including 28 items was completed by 494 adults (age 31.5 ± 12.4 years). Half of the participants (49.8%) reported good, 44.1% moderate, and 6.1% bad quality of sleep, whereas 17.2% answered that the quality of sleep improved, 56.5% did not change, and 26.3% worsened compared to a normal week. Compared to normal, sleep duration in lockdown increased by 0.24 h (95% CI; 0.13, 0.35; p < 0.001, d = 0.198). More under-weight (32.4%) and obese (34.1%) respondents reported worsened quality of sleep in lockdown compared with normal (25.6%) and overweight participants (22.7%) (p = 0.006, Cramer’s ϕ = 0.191). A small effect for BMI group on sleep duration was observed (p = 0.011, η² = 0.023), where overweight and obese slept less (−0.44 h and −0.66 h, respectively) than normal weight participants. Subjects with the highest percentage of increased food consumption reported decreased sleep duration (p = 0.012) and worsened sleep quality (p = 0.003). Compared with a normal week, physical activity of a high and moderate intensity decreased for 43.0% and 37.0% of participants, did not change in 32.9% and 36.1% of participants, and increased in 24.1% 26.9%, respectively, whereas walking time decreased in 31.3%, did not change in 27.3%, and increased in 41.5% of participants. Increased high and moderate intensity physical activity was related with an improvement in sleep quality (p < 0.001). Those with decreasing walking time reported the highest percentage of decreased sleep quality (p = 0.006) and worsened sleep quality (p = 0.016). In conclusion, both quality and quantity of sleep were impaired during the second lockdown and the observed changes were associated with diet and physical activity.

Keywords: exercise; quality of sleep; sex difference; walking; weight status

1. Introduction

The COVID-19 pandemic and the accompanying lockdown have impacted many aspects of the daily life of adults, including sleep duration and quality [1–3]. For instance, a study on U.S. Americans showed that ~37% had increased sleep duration, whereas ~17% had decreased duration [2], and 45% reported a worsening of sleep quality in research on Italians [4]. Changes in sleep duration were also associated with occupation, as suggested by research reporting no change in health professionals and an increase in the other professionals [5]. In addition, it was observed that hospitalized COVID-10 patients had obesity as the second most common condition [5,6], highlighting the role of weight status. In addition, sleep duration might regulate body weight through its impact on two key hormones (ghrelin and leptin) for appetite regulation [7]. Nevertheless, little information existed on the association of sleep characteristics with weight status, physical activity (PA), and food consumption during lockdown.
According to the International Classification of Sleep Disorders, insomnia disorders, sleep-related breathing disorders, central disorders of hypersomnolence, circadian rhythm sleep-wake disorders, sleep-related movement disorders, parasomnias, and other sleep disorders are categories of sleep disorders [8]. Factors related to sleep quality include sex (men), marital status (married), PA, education, healthy social relations, socioeconomic class, income (positive role), age, pet owners, caffeine intake, smoking, stress, and irregular sleep-wake patterns (negative role) [9,10].

It has been observed that people with obesity presented worsened sleep in lockdown [11]. A shorter sleep duration is a predictor of weight gain, as suggested in a systematic scoping review [12]. Moreover, those with negative changes in sleep quality reported more weight gain than those with positive changes [4]. With regards to the relationship of sleep duration with weight status in Australians, it was found that the odds of overweight/obesity were the greatest for those who slept <6 h, and the risk of overweight/obesity decreased for those with sleep >7 h [13]. Moreover, compared with recommended sleep time (i.e., ≥7 to ≤9 h) in U.S., American black women who were very short sleepers (≤6 h) and long sleepers (>9 h) had a significantly greater body mass index (BMI) [14]. A longer sleep duration was related with a lower BMI in Chinese freshmen [15]. In university students, being overweight showed a higher odds ratio of less sleep than normal weight students [16]. In addition, the relationship between sleep duration and BMI depended on age [17,18], and consequently, age should be considered in studies of sleep characteristics and weight status.

Lack of PA and/or increased food consumption are the most prominent risk factors for an increase in BMI [19]. PA is widely considered to improve sleep quality and is often proposed as a non-pharmacologic treatment to improve sleep [20]. In a recent review [21], it was demonstrated that both acute and regular PA improved sleep quality. The positive effects were generally preserved across lifespan, independently of sex, in a dose–response relationship regarding length, but not intensity, of exercise. PA improved sleep even in patients suffering from insomnia or sleep apnea. Diet is also widely considered an important modifiable factor that has been often proposed to improve sleep duration and quality [22]. Eating schedules, food intake, and energy balance altered the propensity for sleep and sleep architecture [23]. Adults consuming proinflammatory diets are more likely to have a short or long sleep duration, and/or self-reported sleep disturbances [24]. Moreover, a high-fat food intake enhances sleepiness and deteriorated sleep apnea [25].

No information exists so far about these implications during COVID-19 pandemic. Such information would be important for healthcare professionals working with patients with sleep disorders. Therefore, the aim of the present study was to evaluate the possible correlations between sleep and BMI in relation to PA and food intake during the second restrictive measures due to the COVID-19 pandemic in Greece.

2. Materials and Methods

2.1. Study Design

The study design is cross-sectional, where data were collected from 22 March to 7 April 2021 using a questionnaire. This period was characterized by restrictive measures in all domains of daily life, including e-working, e-education, and limited transportation [26]. Because of the lockdown measures during the period of the study, the administration of a paper-and-pencil questionnaire was not feasible. A web-based (Google Forms [27]) questionnaire including 28 items was promoted through social media [28] and was completed by a convenience sample of 500 participants. Inclusion criteria were sex and adult age (≥18 years). Six participants were excluded because of their age (younger than 18 years) resulting in a final sample of 494 adults (age 31.5 ± 12.4 years) who were further analyzed.
2.2. Ethics Approval

The study was approved by the local institutional review board (Alexandra University Hospital, Athens, Greece; approval number 232/3 April 2020). The participants were recruited using social media and—prior to answering the questionnaire—all participants provided informed consent after being informed about the aims and details of the study. It was highlighted in the call for participation in the present study that participation was voluntarily and participants could withdraw at any moment.

2.3. Questionnaire

The questionnaire was available in Greek and its contents are presented in Supplementary Materials. The items about the sociodemographic and sleep characteristics were used previously in a recent study [3]. The items on PA were based on the short version of the International Physical Activity Questionnaire, which has been tested for validity and reliability [29,30]. In addition, a good agreement was observed between self-reported and direct anthropometric measurements, suggesting the further use of self-reported height and weight data for research [31,32].

2.4. Statistical Analysis

All of the statistical and data analyses were performed using IBM SPSS v.26.0 (IBM SPSS Statistics for Windows; Armonk, NY, USA). The figures were created by GraphPad Prism v.7.0 (GraphPad Software, San Diego, CA, USA). Descriptive statistics (mean, standard deviations, and frequencies) were calculated for all of the variables. Participants were classified into two age groups, <43 (total, n = 382; women, n = 225; men, n = 157) and >43 years (total, n = 112; women, n = 71; men, n = 41). In addition, they were grouped into four BMI categories according to the classification of the World Health Organization [33], as follows: under-weight (BMI under 18.5 kg·m$^{-2}$; total, n = 34; women = 34), normal-weight (BMI from 18.5 to 24.9 kg·m$^{-2}$; total, n = 289; women, n = 200; men = 89), overweight (BMI from 25.0 to 29.9 kg·m$^{-2}$; total, n = 128; women, n = 48; men = 80), and obese (BMI greater than 29.9 kg·m$^{-2}$; total, n = 41; women, n = 14; men = 27). A two-way analysis of variance examined the main effects of sex and age group (<43 vs. >43 years) and their interaction on sleep duration. Eta square ($\eta^2$) examined the magnitude of differences in ANOVAs. A dependent t-test examined the differences in sleep duration between lockdown and normal. Cohen’s $d$ evaluated the magnitude of difference in t-test. A between-within subject ANOVA examined the effect of time (normal versus lockdown) and the sex × lockdown interaction—as well as the age group × lockdown interaction within each sex—on sleep duration. A one-way ANOVA evaluated the differences in sleep duration among BMI groups, and a two-way ANOVA tested the sex × BMI group interaction on sleep duration. Chi-square ($\chi^2$) evaluated associations among non-parametric data and Cramér’s phi ($\phi$) assessed the magnitude of such associations. Statistical significance was set at alpha = 0.05.

3. Results

3.1. Demographic Data, Sleep, and Physical Activity

The demographic data, sleep, and PA can be seen in Table 1. In lockdown, women slept more than men by 0.50 h (7.70 ± 1.33h versus 7.20 ± 1.22h; 95% confidence intervals (CIs), 0.27, 0.73; $p < 0.001$, Cohen’s $d = 0.392$). Younger participants slept more than older participants by 0.69 h (7.65 ± 1.30 h versus 6.96 ± 1.19 h; 95% CIs, 0.42, 0.96; $p < 0.001$, Cohen’s $d = 0.554$). No sex × age group interaction on sleep duration was found ($p = 0.221$, $\eta^2 = 0.003$; Figure 1).
Table 1. Demographic data, sleep, and physical activity (PA) of participants (n = 494).

| Variable                  | Outcome                  | n  | %   |
|---------------------------|--------------------------|----|-----|
| Sex                       | Women                    | 296| 59.9|
|                           | Men                      | 198| 40.1|
| Age group                 | <43 years                | 382| 77.3|
|                           | >43 years                | 112| 22.7|
| Marital status            | Unmarried                | 382| 77.3|
|                           | Married                  | 112| 22.7|
| Residence                 | Rural                    | 79 | 16.0|
|                           | Urban                    | 415| 84.0|
| Education                 | Primary                  | 11 | 2.2 |
|                           | Secondary                | 43 | 8.7 |
|                           | Tertiary (a)             | 439| 89.0|
| Job                       | Health professionals     | 46 | 9.3 |
|                           | With physical presence   | 153| 31.0|
|                           | Full-time distance working| 87 | 17.6|
|                           | Part-time distance working| 49 | 9.9 |
|                           | Unemployed               | 39 | 7.9 |
|                           | Student                  | 67 | 13.6|
|                           | Other                    | 53 | 10.7|
| Compliance with measures  | Yes                      | 442| 89.5|
|                           | No                       | 52 | 10.5|
| Presence of COVID-19      | Yes                      | 114| 23.1|
|                           | No                       | 380| 76.9|
| BMI group                 | Under-weight             | 34 | 6.9 |
|                           | Normal-weight            | 289| 58.7|
|                           | Over-weight              | 128| 26.0|
|                           | Obese                    | 41 | 8.3 |
| Change of sleep           | Decrease                 | 107| 22.0|
|                           | No change                | 209| 42.9|
|                           | Increase                 | 171| 35.1|
| Quality of sleep          | Bad                      | 30 | 6.1 |
|                           | Average                  | 217| 44.0|
|                           | Good                     | 246| 49.9|
| Change of quality of sleep| Worsen                   | 130| 26.3|
|                           | No change                | 279| 56.5|
|                           | Improve                  | 85 | 17.2|
| Change of high intensity PA| Decrease                | 200| 43.0|
|                           | No change                | 153| 32.9|
|                           | Increase                 | 112| 24.1|
Figure 1. Sleep duration by sex and age group (a), change of sleep duration in lockdown compared with normal according to sex (b) and age group (c). (a) * difference between age groups at \( p < 0.05 \), # difference at \( p < 0.05 \); (b) * sex \( \times \) change of sleep duration association at \( p < 0.05 \); (c) age group \( \times \) change of sleep duration association at \( p < 0.05 \).

Compared with a normal week, sleep duration in lockdown decreased for 22.0%, did not change for 42.9%, and increased for 35.1% of participants. A sex \( \times \) lockdown association was observed with more women increasing sleep duration than men (\( \chi^2 = 12.777, p = 0.002, \varphi = 0.162 \)). An age \( \times \) lockdown association was shown with younger participants having an increased sleep duration compared with their older counterparts (\( \chi^2 = 31.975, p < 0.001, \varphi = 0.256 \)).

Compared with normal, sleep duration in lockdown increased by 0.24 h (95\% CI; 0.13, 0.35; \( p < 0.001, d = 0.198 \)) (Figure 2). A sex \( \times \) lockdown interaction on sleep duration was observed (\( p = 0.035, \eta^2 = 0.009 \)), where sleep duration increased in women, but not in men. In women, an age group \( \times \) lockdown interaction on sleep duration was shown (\( p = 0.007, \eta^2 = 0.025 \)), where sleep duration increased for participants aged <43 years, but not >43 years. In men, no age group \( \times \) lockdown interaction was found (\( p = 0.590, \eta^2 = 0.002 \)).

Table 1. Cont.

| Variable                                      | Outcome | \( n \) | %     |
|-----------------------------------------------|---------|---------|-------|
| Change of moderate intensity PA               | Decrease| 164     | 37.0  |
|                                               | No change| 160     | 36.1  |
|                                               | Increase| 119     | 26.9  |
| Change of walking                             | Decrease| 150     | 31.3  |
|                                               | No change| 131     | 27.3  |
|                                               | Increase| 199     | 41.5  |
| Change of eating (quantitatively)             | Decrease| 82      | 16.7  |
|                                               | No change| 238     | 48.4  |
|                                               | Increase| 172     | 35.0  |
| Change of eating (qualitatively)              | Decrease| 141     | 28.7  |
|                                               | No change| 224     | 45.6  |
|                                               | Increase| 126     | 25.7  |

(a) Tertiary refers to university studies.
Half of participants (49.8%) reported good, 44.1% moderate, and 6.1% bad quality of sleep, whereas 17.2% answered that the quality of sleep improved, 56.5% did not change, and 26.3% worsened compared with a normal week. Neither a sex × quality of sleep association ($\chi^2 = 1.225, p = 0.542, \varphi = 0.050$) or an age group × quality of sleep association ($\chi^2 = 0.016, p = 0.992, \varphi = 0.006$) were observed. A sex × change of quality of sleep association ($\chi^2 = 6.550, p = 0.038, \varphi = 0.115$) was shown, with more women reporting a change (either worsening or improvement) in quality of sleep than men. No age group × change of quality of sleep association ($\chi^2 = 4.601, p = 0.100, \varphi = 0.097$) was found.

### 3.2. Sleep Characteristics by Body Mass Index Group

A small main effect of BMI group on sleep duration was observed ($p = 0.011, \eta^2 = 0.023$), where overweight and obese participants slept less ($-0.44\, \text{h}$ and $-0.66\, \text{h}$, respectively) than normal weight participants (Figure 3). A BMI group × sex interaction on sleep duration in lockdown was shown ($p = 0.017, \eta^2 = 0.017$), where sleep duration differed among BMI groups in women ($p = 0.001, \eta^2 = 0.053$), but not in men ($p = 0.881, \eta^2 = 0.001$). A BMI group × change of sleep duration association was observed ($\chi^2 = 17.987, p = 0.006, \varphi = 0.193$), with more under-weight, overweight, and obese participants experiencing decreased sleep duration than their normal-weight peers. More under-weight (32.4%) and obese (34.1%) participants reported a worsened quality of sleep in lockdown than normal (25.6%) and overweight participants (22.7%) ($p = 0.006, \text{Cramer’s } \varphi = 0.191$).

### 3.3. Change in Weight, Physical Activity, and Food Consumption

Compared with a normal week, PA of high and moderate intensity decreased for 43.0% and 37.0%, did not change for 32.9% and 36.1%, and increased for 24.1% 26.9% of...
participants, respectively, whereas the time walking decreased for 31.3%, did not change for 27.3%, and increased for 41.5% of participants.

\( \Delta \) weight was associated with a change in PA of high (\( \chi^2 = 54.980, p < 0.001 \)) and moderate intensity (\( \chi^2 = 47.099, p < 0.001 \)), and walking (\( \chi^2 = 22.342, p < 0.001 \)), where those with a decreased weight reported a larger increase of PA of high and moderate intensity, and walking compared to those with no change or gain of weight (Table 2). The magnitude of these associations was larger in PA of high and moderate PA than in walking. In addition \( \Delta \) weight was associated with a change in nutrition quantity (\( \chi^2 = 265.264, p < 0.001 \)) and quality (\( \chi^2 = 124.148, p < 0.001 \)), where those with decreased weight reported decreased food consumption and improved quality of nutrition than those with no change or gain of weight. The magnitude of these associations was larger in the quantity than in the quality of nutrition.

Table 2. Association of changes in body weight with changes in physical activity (PA) and nutrition.

| Variable          | Body Weight                  |          |          |          | Statistic  |
|-------------------|------------------------------|----------|----------|----------|------------|
|                   | Decrease (\%)                | No change (\%) | Increase (\%) | \( \chi^2 \) | p-value    |
| High intensity PA | Decrease 31.4                | 33.7     | 57.0     | \( \chi^2 = 54.980 \) | p < 0.001  |
|                   | No change 20.9               | 45.1     | 27.5     | \( \phi = 0.342 \)  |            |
|                   | Increase 47.7                | 21.1     | 15.5     | \( \phi = 0.326 \)  |            |
| Moderate intensity PA | Decrease 23.8             | 25.9     | 52.5     | \( \chi^2 = 47.099 \) | p < 0.001  |
|                   | No change 31.0               | 44.6     | 32.8     | \( \phi = 0.326 \)  |            |
|                   | Increase 45.2                | 29.5     | 14.8     |     \( \phi = 0.326 \)  |            |
| Walking           | Decrease 24.4                | 23.5     | 41.5     | \( \chi^2 = 22.342 \) | p < 0.001  |
|                   | No change 20.0               | 31.7     | 24.6     | \( \phi = 0.214 \)  |            |
|                   | Increase 55.6                | 44.8     | 33.8     | \( \phi = 0.214 \)  |            |
| Food quantity     | Decrease 60.9                | 8.6      | 2.5      | \( \chi^2 = 265.264 \) | p < 0.001  |
|                   | No change 29.3               | 73.3     | 32.7     | \( \phi = 0.739 \)  |            |
|                   | Increase 9.8                 | 18.2     | 64.8     |          \( \phi = 0.739 \)  |            |
| Food quality      | Worsen 11.0                  | 17.1     | 50.3     | \( \chi^2 = 124.148 \) | p < 0.001  |
|                   | No change 28.6               | 58.3     | 39.2     | \( \phi = 0.495 \)  |            |
|                   | Improve 60.4                 | 24.6     | 10.6     |          \( \phi = 0.495 \)  |            |

3.4. Change of Sleep Characteristics, Weight, Physical Activity, and Food Consumption

\( \Delta \) weight was not related with sleep duration (\( p = 0.316 \)), whereas the association of \( \Delta \) weight with sleep quality was close to statistical significance (\( p = 0.068 \)), with those with weight gain reporting the highest percentage of sleep quality worsening (Table 3). With regards to nutrition, change in food quantity was associated with sleep duration (\( p = 0.012 \)) and sleep quality (\( p = 0.003 \)), where those with the highest percentage of increased food consumption reporting decreased sleep duration and worsened sleep quality. Similarly, those with the highest percentage of worsened food quality reported decreased sleep duration and worsened sleep quality. Finally, increasing high and moderate intensity PA was related with improvement in sleep quality (\( p < 0.001 \)), but not with changes in sleep duration (\( p = 0.628 \) and \( p = 0.376 \), respectively). Those with decreasing walking time reported the highest percentage of decreased sleep quality (\( p = 0.006 \)) and worsened sleep quality (\( p = 0.016 \)).
Table 3. Association of changes in sleep duration and quality with changes in physical activity (PA) and nutrition.

| Variable                  | Sleep Duration | Sleep Quality |
|---------------------------|----------------|---------------|
|                           | Decrease       | No Change     | Increase       | Statistic | Worsen       | No Change     | Improve       | Statistic |
| **Body weight**           |                |               |               |           |             |               |               |           |
| Decrease                  | 15.4           | 44.0          | 40.7          | $\chi^2 = 4.728$ | 26.1       | 51.1          | 22.8          | $\chi^2 = 8.753$ |
| No change                 | 24.7           | 44.6          | 30.6          | $p = 0.316$   | 22.2       | 63.0          | 14.8          | $p = 0.068$   |
| Increase                  | 23.9           | 41.1          | 35.0          | $\varphi = 0.100$ | 32.2       | 52.8          | 15.1          | $\varphi = 0.135$ |
| **High intensity PA**     |                |               |               |           |             |               |               |           |
| Decrease                  | 24.5           | 41.5          | 34.0          | $\chi^2 = 2.593$ | 36.3       | 53.9          | 9.8           | $\chi^2 = 32.096$ |
| No change                 | 20.5           | 45.5          | 34.0          | $p = 0.062$   | 18.4       | 63.3          | 18.4          | $p < 0.001$   |
| Increase                  | 19.3           | 40.4          | 40.4          | $\varphi = 0.074$ | 20.0       | 50.0          | 29.6          | $\varphi = 0.259$ |
| **Moderate intensity PA** |                |               |               |           |             |               |               |           |
| Decrease                  | 26.8           | 41.5          | 31.7          | $\chi^2 = 4.231$ | 36.5       | 54.5          | 9.0           | $\chi^2 = 23.982$ |
| No change                 | 18.9           | 47.0          | 34.1          | $p = 0.376$   | 19.9       | 65.0          | 15.1          | $p < 0.001$   |
| Increase                  | 23.1           | 38.8          | 38.0          | $\varphi = 0.097$ | 24.4       | 50.4          | 25.2          | $\varphi = 0.229$ |
| **Walking**               |                |               |               |           |             |               |               |           |
| Decrease                  | 27.5           | 35.3          | 37.3          | $\chi^2 = 14.639$ | 35.5       | 50.3          | 14.2          | $\chi^2 = 12.133$ |
| No change                 | 17.3           | 55.6          | 27.1          | $p = 0.006$   | 19.5       | 64.7          | 15.8          | $p = 0.016$   |
| Increase                  | 22.4           | 38.8          | 38.8          | $\varphi = 0.173$ | 25.4       | 54.1          | 20.5          | $\varphi = 0.157$ |
| **Food quantity**         |                |               |               |           |             |               |               |           |
| Decrease                  | 21.7           | 36.1          | 42.2          | $\chi^2 = 12.947$ | 26.1       | 56.6          | 17.2          | $\chi^2 = 16.045$ |
| No change                 | 18.8           | 51.0          | 30.1          | $p = 0.012$   | 18.9       | 65.0          | 16.0          | $p = 0.003$   |
| Increase                  | 26.1           | 35.2          | 38.6          | $\varphi = 0.161$ | 35.7       | 46.4          | 17.9          | $\varphi = 0.178$ |
| **Food quality**          |                |               |               |           |             |               |               |           |
| Worsen                    | 35.0           | 28.7          | 36.4          | $\chi^2 = 35.985$ | 40.4       | 47.3          | 12.3          | $\chi^2 = 31.352$ |
| No change                 | 18.9           | 52.9          | 28.2          | $p < 0.001$   | 20.1       | 65.1          | 14.8          | $p < 0.001$   |
| Improve                   | 22.1           | 42.8          | 35.1          | $\varphi = 0.269$ | 21.7       | 51.2          | 27.1          | $\varphi = 0.249$ |

4. Discussion

The present study depicted that lockdown due to the COVID 19 pandemic affected sleep, physical activity, and food consumption in the general population of Greece. Sleep quality deteriorated when compared with a normal week. A worse quality of sleep was reported more often by under-weight and obese participants than normal and overweight participants. Furthermore, decreased physical activity and increased food consumption were associated with the aggravation of sleep quality.

During the COVID-19 pandemic, Greek authorities applied restrictive measures like public commuting and travelling restrictions, educational institutes’ closure, and the enforcement of tele-working practices in two periods (first lockdown from 23 March 2020 for 43 days and the second lockdown from 7 November 2020 for 210 days). The measures put in place in Greece were among the strictest in Europe, and people were experiencing sudden and major changes in their daytime routines. All parts of life were affected, including sleep, physical activity, and diet.

The observed increase in sleep duration and the affected quality of sleep during lockdown in our study were in agreement with previous research [34,35]. The impact of lockdown on sleep characteristics was more pronounced in the younger participants in the present study, which was also in line with previous research [2]. An explanation of the impact of the lockdown on sleep characteristics of the younger age group was that this age group might be characterized by more anxiety as a result of less stable socio-economic status compared with older participants [2,36]. Nevertheless, it should be highlighted that the mean sleep duration of participants was within the physiological range of 7–8 h [37]; thus, the focus of the present study was more on the variation of sleep duration rather than the mean score.

Our findings that overweight and obese participants slept less than normal weight participants, and that more under-weight and obese participants reported a worsened quality of sleep in lockdown than normal and overweight participants indicated a favorable profile of normal-weight status for sleep. It is well documented that obesity is associated with decreased sleep duration and poor sleep quality [38]. Although sleep is a completely sedentary activity, it does not lead to weight gain [39]. Both a short and long sleep duration were associated with obesity risk [40]. Moreover, a decrease in sleep duration was associated with an increased energy and fat intake [41]. The association of decreased sleep duration with increased weight might be attributed to biological mechanisms including
hormonal changes and metabolites [42,43]. For instance, optimal sleep duration was related to less desire for high calorie foods in overweight young adults [44]. Furthermore, pathological conditions associated with obesity could lead to unrefreshing and short sleep, like obstructive sleep apnea (OSA) [39].

The COVID-19 pandemic had affected weight-related behaviors, including healthy eating and physical activity, especially among adults with high BMI [45]. Moreover, limited access to fresh food due to lockdown led towards a greater consumption of highly processed foods, and those with long shelf lives that are usually high in salt, sugar, and saturated fat that provide only a transient sensation of fullness [46]. During the last decades, obesity has become a major health issue, with a prevalence of 65–70% in UK and US adult populations [47].

More exercise and less food consumption are the gold standards for normal weight. We demonstrated that even in lockdown, with preserved daytime activities, those with decreased weight reported a larger increase of PA of a high and moderate intensity and walking, decreased food consumption, and improved quality of nutrition compared with those with no change or a gain in weight. Moreover, increased PA and decreased food consumption were associated with an increased quantity and quality of sleep. Previous data also suggest that PA and diet improve sleep, and are often proposed as modifiable, non-pharmacologic treatments for sleep complains [21,22].

A limitation of the present study is that information on smoking and health status was not included in the analysis, and it was acknowledged that smoking, pain, stress, depression, and other health conditions were associated with a poor quality of sleep [48,49]. An association of psychological factors such as level of stress, anxiety, and depression with sleep disorders has also been demonstrated during lockdown [50,51]. With regards to marital status, a traditional classification was used (i.e., married versus non-married), whereas it was recognized that other status could also be included, e.g., people living together but un-married or information about the number of children. On the other hand, the strength of the study was the inclusion data on two major correlates of weight status (i.e., PA and food consumption), which were also shown to be associated with changes in sleep characteristics.

5. Conclusions

In conclusion, sleep was impaired during the second lockdown of the COVID19 pandemic. However, participants with adequate physical activity, balanced diet, and normal weight retained a good sleep quality. Considering the findings of the present study, healthcare professionals working with patients with sleep disorders and scientists interested in this field should consider the variation of the impact of lockdown on sleep characteristics according to BMI, diet, and PA.

Supplementary Materials: The following are available online at https://www.mdpi.com/article/10.3390/ijerph18147292/s1. Table S1: Content of the questionnaire.

Author Contributions: Conceptualization, Z.P., P.T.N. and G.T.; methodology, Z.P., P.T.N. and G.T.; software, Z.P.; validation, Z.P.; formal analysis, Z.P.; investigation, Z.P.; resources, Z.P.; data curation, Z.P.; writing—original draft preparation, Z.P., P.T.N. and G.T.; writing—review and editing, Z.P., P.T.N. and G.T.; visualization, Z.P.; supervision, G.T.; project administration, G.T. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: The study was conducted according to the guidelines of the Declaration of Helsinki, and was approved by the Institutional Review Board of “Alexandra” University Hospital, Athens, Greece (approval number 232/3 April 2020).

Informed Consent Statement: Informed consent was obtained from all of the subjects involved in the study.
Data Availability Statement: All of the data used in the present study can be provided by the corresponding author upon reasonable request.

Acknowledgments: The voluntarily participation of all of the subjects is gratefully acknowledged.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Stewart, N.H.; Koza, A.; Dhaon, S.; Shoushtari, C.; Martinez, M.; Arora, V.M. Sleep in Frontline Healthcare Workers During the COVID-19 Pandemic: A Social Media Study. J. Med. Internet Res. 2021, 23, e27331. [CrossRef]

2. Batool-Anwar, S.; Robbins, R.; Ali, S.H.; Capasso, A.; Foreman, J.; Jones, A.M.; Tozan, Y.; DiClemente, R.J.; Quan, S.F. Examining changes in sleep duration as associated with the onset of the COVID-19 pandemic: Who is sleeping and who is not? MedRxiv 2021, 1, 1–5.

3. Trakada, A.; Nikolaidis, P.T.; Andrade, M.D.S.; Pucinnelli, P.; Economou, N.T.; Steiropoulos, P.; Knechtle, B.; Trakada, G. Sleep During “Lockdown” in the COVID-19 Pandemic. Int. J. Environ. Res. Public Health 2020, 17, 19094. [CrossRef]

4. Micheletti Cremasco, M.; Mulasso, A.; Moroni, A.; Testa, A.; Degani, R.; Rainoldi, A.; Rabaglietti, E. Relation among Perceived Weight Change, Sedentary Activities and Sleep Quality during COVID-19 Lockdown: A Study in an Academic Community in Northern Italy. Int. J. Environ. Res. Public Health 2021, 18, 2943. [CrossRef] [PubMed]

5. Nikolic, M.; Simovic, S.; Novkovic, L.; Jokovic, V.; Djokovic, D.; Muric, N.; Bazic Sretenovic, D.; Jovanovic, J.; Pantic, K.; Cekerevac, I. Obesity and sleep apnea as a significant comorbidities in COVID—A case report. Obes. Res. Clin. Pract. 2021, 15, 281–284. [CrossRef]

6. Louie, T.; Kwan, B.; Susanto, C.; Ng, A. Respiratory failure, clinical course and community management of COVID-19 patients in a large Australian cohort. Intern. Med. J. 2021, 51, 334–340. [CrossRef] [PubMed]

7. Taheri, S.; Lin, L.; Austin, D.; Young, T. Short sleep duration is associated with reduced leptin, elevated ghrelin, and increased body mass index. PLoS Med. 2004, 1, e62. [CrossRef]

8. Sateia, M.J. International classification of sleep disorders-third edition: Highlights and modifications. Chest 2014, 146, 1387–1394. [CrossRef] [PubMed]

9. Wang, F.; Biró, É. Determinants of sleep quality in college students: A literature review. Explore 2021, 17, 170–177. [CrossRef]

10. Varghese, N.E.; Lugo, A.; Ghislandi, S.; Colombo, P.; Pacifici, R.; Gallus, S. Sleep dissatisfaction and insufficient sleep duration in the Italian population. Sci. Rep. 2020, 10, 17943. [CrossRef]

11. Brown, A.; Flint, S.W.; Kalea, A.Z.; O’Kane, M.; Williams, S.; Batterham, R.L. Negative impact of the first COVID-19 lockdown upon health-related behaviours and psychological wellbeing in people living with severe and complex obesity in the UK. EClinicalMedicine 2021, 34, 100796. [CrossRef]

12. Chew, H.S.J.; Lopez, V. Global Impact of COVID-19 on Weight and Weight-Related Behaviors in the Adult Population: A Scoping Review. Int. J. Environ. Res. Public Health 2021, 18, 1876. [CrossRef]

13. Deacon-Crouch, M.; Begg, S.; Skinner, T. Is sleep duration associated with overweight/obesity in Indigenous Australian adults? BMC Public Health 2020, 20, 1229. [CrossRef] [PubMed]

14. Ash, T.; Kang, A.; Hom, C.; Risica, P.M. Association between sleep duration and differences between weekday and weekend sleep with body mass index & waist circumference among Black women in Sistertalk II. Sleep Health 2020, 6, 797–803. [CrossRef] [PubMed]

15. Yang, Y.; Miao, Q.; Zhu, X.; Qin, L.; Gong, W.; Zhang, S.; Zhang, Q.; Lu, B.; Ye, H.; Li, Y. Sleeping time, BMI, and Body Fat in Chinese Freshmen and Their Interrelation. Obes. Facts 2020, 13, 179–190. [CrossRef]

16. Sa, J.; Choe, S.; Cho, B.Y.; Chaput, J.P.; Kim, G.; Park, C.H.; Chung, J.; Choi, Y.; Nelson, B.; Kim, Y. Relationship between sleep and obesity among U.S. and South Korean college students. BMC Public Health 2020, 20, 96. [CrossRef] [PubMed]

17. Grandner, M.A.; Schopfer, E.A.; Sands-Lincoln, M.; Jackson, N.; Malhotra, A. Relationship between sleep duration and body mass index depends on age. Obesity 2015, 23, 2491–2498. [CrossRef]

18. Rusu, A.; Bala, C.; Graur, M.; Creteanu, G.; Morosanu, M.; Radulian, G.; Popa, A.R.; Timar, R.; Pircalaboiu, L.; Roman, G. Sleep duration and body mass index: Modifying effect of self-rated stress and age. Results of a cross-sectional population-based study. Eat. Weight. Disord. 2019, 24, 1089–1097. [CrossRef]

19. Grasdalsmoen, M.; Eriksen, H.R.; Lonning, K.J.; Sivertsen, B. Physical exercise and body-mass index in young adults: A national survey of Norwegian university students. BMC Public Health 2019, 19, 1354. [CrossRef]

20. Buman, M.P.; King, A.C. Exercise as a Treatment to Enhance Sleep. Am. J. Lifestyle Med. 2010, 4, 500–514. [CrossRef]

21. Kline, C.E.; Hillman, C.H.; Bloodgood Sheppard, B.; Tennant, B.; Conroy, D.E.; Macko, R.F.; Marquez, D.X.; Petruzzello, S.J.; Powell, K.E.; Erickson, K.I. Physical activity and sleep: An updated umbrella review of the 2018 Physical Activity Guidelines Advisory Committee report. Sleep Med. Rev. 2021, 58, 101489. [CrossRef]

22. Peuhkuri, K.; Silvola, N.; Korpela, R. Diet promotes sleep duration and quality. Nutr. Res. 2012, 32, 309–319. [CrossRef] [PubMed]

23. Duan, D.; Gu, C.; Polotsky, Y.Y.; Jun, J.C.; Pham, L.V. Effects of Dinner Timing on Sleep Stage Distribution and EEG Power Spectrum in Healthy Volunteers. Nat. Sci. Sleep 2021, 13, 601–612. [CrossRef]

24. Kase, B.E.; Liu, J.; Wirth, M.D.; Shivappa, N.; Hebert, J.R. Associations between dietary inflammatory index and sleep problems among adults in the United States, NHANES 2005-2016. Sleep Health 2021, 7, 273–280. [CrossRef]
25. Trakada, G.; Steiropoulos, P.; Zarougoulidis, P.; Nena, E.; Papanas, N.; Maltezos, E.; Bouros, D. A fatty meal aggravates apnea and increases sleep in patients with obstructive sleep apnea. Sleep Breath. Schlaf Atm. 2014, 18, 53–58. [CrossRef] [PubMed]

26. Available online: https://en.wikipedia.org/wiki/COVID-19_pandemic_in_Greece (accessed on 7 July 2021).

27. Available online: https://www.google.com/forms/about/ (accessed on 7 July 2021).

28. Turk, T.; Elhady, M.T.; Rashid, S.; Abdelkhalek, M.; Nasef, S.A.; Khallaf, A.M.; Mohammed, A.T.; Attia, A.W.; Adhikari, P.; Amin, M.A.; et al. Quality of reporting web-based and non-web-based survey studies: What authors, reviewers and consumers should consider. PLoS ONE 2018, 13, e0194239. [CrossRef] [PubMed]

29. Ács, P.; Veress, R.; Rocha, P.; Dóczi, T.; Raposa, B.L.; Baumann, P.; Ostojic, S.; Pérmusz, V.; Makai, A. Criterion validity and reliability of the International Physical Activity Questionnaire-Hungarian short form against the RM42 accelerometer. BMC Public Health 2021, 21, 381. [CrossRef]

30. Sember, V.; Méh, K.; Soric, M.; Starc, G.; Rocha, P.; Jurak, G. Validity and Reliability of International Physical Activity Questionnaires for Adults across EU Countries: Systematic Review and Meta Analysis. Int. J. Environ. Res. Public Health 2020, 17, 7161. [CrossRef] [PubMed]

31. Davies, A.; Wellard-Cole, L.; Rangan, A.; Allman-Farinelli, M. Validity of self-reported weight and height for BMI classification: A cross-sectional study among young adults. Nutrition 2020, 71, 110622. [CrossRef]

32. Hodge, J.M.; Shah, R.; McCullough, M.L.; Gapstur, S.M.; Patel, A.V. Validation of self-reported height and weight in a large, nationwide cohort of U.S. adults. PLoS ONE 2020, 15, e0231229. [CrossRef]

33. Weir, C.B.; Jan, A. BMI classification percentile and cut off points. In StatPearls; StatPearls Publishing: Treasure Island, FL, USA, 2021.

34. Blume, C.; Schmidt, M.H.; Cajochen, C. Effects of the COVID-19 lockdown on human sleep and rest-activity rhythms. Curr. Biol. CB 2020, 30, R795–R797. [CrossRef]

35. Wu, T.; Jia, X.; Shi, H.; Niu, J.; Yin, X.; Xie, J.; Wang, X. Prevalence of mental health problems during the COVID-19 pandemic: A systematic review and meta-analysis. J. Affect. Disord. 2021, 281, 91–98. [CrossRef]

36. Taylor, M.R.; Agho, K.E.; Stevens, G.J.; Raphael, B. Factors influencing psychological distress during a disease epidemic: Data from Australia’s first outbreak of equine influenza. BMC Public Health 2008, 8, 347. [CrossRef]

37. Mezick, E.J.; Matthews, K.A.; Hall, M.; Kamarck, T.W.; Buysse, D.J.; Owens, J.F.; Reis, S.E. Intra-individual variability in sleep duration and fragmentation: Associations with stress. Psychoneuroendocrinology 2009, 34, 1346–1354. [CrossRef]

38. Beccuti, G.; Pannain, S. Sleep and obesity. Curr. Opin. Clin. Nutr. Metab. Care 2011, 14, 402–412. [CrossRef]

39. Chaput, J.P.; Klingenberg, L.; Sjödin, A. Do all sedentary activities lead to weight gain: Sleep does not. Curr. Opin. Clin. Nutr. Metab. Care 2010, 13, 601–607. [CrossRef]

40. Lin, C.L.; Lin, C.P.; Chen, S.W.; Wu, H.C.; Tsai, Y.H. The association between sleep duration and overweight or obesity in Taiwanese adults: A cross-sectional study. Obes. Res. Clin. Pract. 2018, 12, 384–388. [CrossRef] [PubMed]

41. St-Onge, M.P.; Roberts, A.L.; Chen, J.; Kelleman, M.; O’Keeffe, M.; Jones, P.J. Short sleep duration increases energy intake but does not change energy expenditure in normal-weight individuals. Am. J. Clin. Nutr. 2011, 94, 410–416. [CrossRef] [PubMed]

42. Hense, S.; Bayer, O. Sleep duration and overweight. Bundesgesundheitsblatt Gesundh. Gesundl. 2011, 54, 1337–1343. [CrossRef] [PubMed]

43. Pappandreou, C.; Camacho-Barcia, L.; García-Gavilán, J.; Hansen, T.T.; Hjorth, M.F.; Halford, J.C.G.; Sales-Salvadó, J.; Sjödin, A.; Bulló, M. Circulating metabolites associated with objectively measured sleep duration and sleep variability in overweight/obese participants: A metabolomics approach within the SATIN study. Sleep 2019, 42, zsz030. [CrossRef] [PubMed]

44. Tasali, E.; Chapotot, F.; Wroblewski, K.; Schoeller, D. The effects of extended bedtimes on sleep duration and food desire in overweight young adults: A home-based intervention. Appetite 2014, 80, 220–224. [CrossRef] [PubMed]

45. Robinson, E.; Boyland, E.; Chisholm, A.; Harrold, J.; Maloney, N.G.; Marty, L.; Mead, B.R.; Noonan, R.; Hardman, C.A. Obesity, eating behavior and metabolic disturbances during COVID-19 lockdown: A study of UK adults. Appetite 2021, 156, 104853. [CrossRef]

46. Tan, M.; He, F.J.; MacGregor, G.A. Obesity and COVID-19: The role of the food industry. BMJ 2020, 369, m2237. [CrossRef]

47. Available online: www.cdc.gov/nchs/fastats/obesity-overweight.htm (accessed on 7 July 2021).

48. Altun, I.; Cinar, N.; Dede, C. The contributing factors to poor sleep experiences in the university students: A cross-sectional study. J. Res. Med. Sci. Off. J. Isfahan Univ. Med. Sci. 2012, 17, 557–561.

49. Choi, S.H.; Terrell, J.E.; Pohl, J.M.; Redman, R.W.; Duffy, S.A. Factors associated with sleep quality among operating engineers. J. Community Health 2013, 38, 597–602. [CrossRef]

50. Gupta, R.; Grover, S.; Basu, A.; Krishnan, V.; Tripathi, A.; Subramanyam, A.; Nischal, A.; Hussain, A.; Mehra, A.; Ambekar, A.; et al. Changes in sleep pattern and sleep quality during COVID-19 lockdown. Indian J. Psychiatry 2020, 62, 370–378. [CrossRef]

51. Gualano, M.R.; Lo Moro, G.; Voglino, G.; Bert, F.; Siliquini, R. Effects of Covid-19 Lockdown on Mental Health and Sleep Disturbances in Italy. Int. J. Environ. Res. Public Health 2020, 17, 4779. [CrossRef]