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ECLB-COVID19 Consortium

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Globally altered sleep patterns and physical activity levels by confinement in 5056 individuals: ECLB COVID-19 international online survey

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ABSTRACT: Symptoms of psychological distress and disorder have been widely reported in people under quarantine during the COVID-19 pandemic; in addition to severe disruption of peoples' daily activity and sleep patterns. This study investigates the association between physical-activity levels and sleep patterns in quarantined individuals. An international Google online survey was launched in April 6th, 2020 for 12-weeks. Forty-one research organizations from Europe, North-Africa, Western-Asia, and the Americas promoted the survey through their networks to the general society, which was made available in 14 languages. The survey was presented in a differential format with questions related to responses "before" and "during" the confinement period. Participants responded to the Pittsburgh Sleep Quality Index (PSQI) questionnaire and the short form of the International Physical Activity Questionnaire. 5056 replies (59.4% female), from Europe (46.4%), Western-Asia (25.4%), America (14.8%) and North-Africa (13.3%) were analysed. The COVID-19 home confinement led to impaired sleep quality, as evidenced by the increase in the global PSQI score (4.37 ± 2.71 before home confinement *vs.* 5.32 ± 3.23 during home confinement) ($p < 0.001$). The frequency of individuals experiencing a good sleep decreased from 61% (n = 3063) before home confinement to 48% (n = 2405) during home confinement with highly active individuals experienced better sleep quality ($p < 0.001$) in both conditions. Time spent engaged in all physical-activity and the metabolic equivalent of task in each physical-activity category (i.e., vigorous, moderate, walking) decreased significantly during COVID-19 home confinement ($p < 0.001$). The number of hours of daily-sitting increased by ~2 hours/days during home confinement ($p < 0.001$). COVID-19 home confinement resulted in significantly negative alterations in sleep patterns and physical-activity levels. To maintain health during home confinement, physical-activity promotion and sleep hygiene education and support are strongly warranted.

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INTRODUCTION

The Coronavirus Disease 2019 (COVID-19) has appeared in December 2019 and has been characterized as the first pandemic caused by a coronavirus and is under intense global scrutiny. Due to the rapid and high frequency of human-to-human transmission, the incidence and mortality of COVID-19 have been rapidly growing worldwide early 2020 [1].

Up to December 05th, 2020, more than 66 million laboratory-confirmed COVID-19 cases, including 1.52 million deaths, have been reported worldwide, of which the majority were reported within the Americas (43%), followed by Europe (29%) [2].

With the rapid spread of COVID-19 outbreak globally, the World Health Organization (WHO) has recommended the implementation of public health measures, such as isolation of all individuals suspected of infection with this disease for a 14-day quarantine period, while respective governments have also introduced "social distancing" and "lock-downs" of entire populations of varying severity to mitigate the spread of COVID-19 [3].

These approaches restrict the mobility, daily activities [5, 6], and social interactions [4, 6] of the individuals. Consequently, an increase in the prevalence of symptoms of psychological distress and disorder (e.g., depression, anxiety, negative feelings, emotional exhaustion, somatic symptoms, panic disorder) have been widely reported in people under quarantine [4, 7–10].

As people around the world have been facing prolonged and stressful periods of confinement during the COVID-19 pandemic [11], psychological problems could potentially disrupt sleep patterns and life in general [12–14]. It is noteworthy that deviations in sleep patterns and poor sleep quality are associated with increased risks of cardiovascular, respiratory, metabolic, and cognitive diseases, poor quality of life, and even early mortality [15, 16, 17, 18, 19]. More specifically, it is widely accepted that alterations in sleep patterns/quality can lead to an increased systemic inflammation [20, 21] and impaired immune system [22, 23], which are crucial for the development and progression of COVID-19 [1]. Adequate sleep is of paramount importance, especially given the protective role that it can play against COVID-19 [23, 24].

Both acute and chronic physical-activity (PA) participation, known by their beneficial effects on overall health [25,26,27] could be compromised during periods of home confinement [28–31]. Moreover, the associated reduction in daily levels of PA could negatively affect sleep [32], which in turn could contribute to an impaired immune system [24].

Studies investigating the association between PA levels and sleep patterns during COVID-19 home confinement are currently scarce. In a small sample of Spanish adults (n = 20), Sañudo et al. [33] investigated, using objective (i.e., accelerometers) and subjective (i.e., International Physical Activity Questionnaire (IPAQ); and Pittsburgh Sleep Quality Index (PSQI)) tools, the association between PA levels and sleep patterns during COVID-19 home confinement. Using multiple regression analyses, the authors reported significant associations between PA levels and sleep quality, suggesting that deep sleep can be significantly predicted by the number of hours sitting per day and engagement in moderate-to-vigorous PA [33].

In a previous preliminary study of the "Effects of home Confinement on multiple Lifestyle Behaviours during the COVID-19 outbreak (ECLB-COVID19)'' project, Ammar et al. [4] reported, in a sample of 1047 respondents to an international electronic survey, that "before to during confinement" change in total score (Δ) of the PSQI questionnaire was negatively correlated with the Δ level of PA, i.e. a decrease in PA was associated with a worsening of sleep quality. Clearly, additional studies, with adequate sample sizes, were needed to better discern the association between sleep patterns and PA levels during COVID-19 home confinement.

Therefore, the aims of this study were to (i) evaluate, in a large sample of individuals, the effects of COVID-19 home confinement on sleep patterns and PA levels, and (ii) investigate the association between PA levels and sleep quality.

We hypothesize that COVID-19 home confinement would negatively affect sleep quality and PA levels of quarantined individuals and that an association between sleep quality and PA level would exist.

MATERIALS AND METHODS

Online survey has been recently identified as a flexible qualitative research tool which prioritizes qualitative research values and harness the rich potential of qualitative data [34]. With the online delivery options, such tools are powerful digital solutions to answer different research questions in time of pandemics, when social distancing is recommended [4–7, 35]. To elucidate the behavioral and lifestyle consequences of COVID-19 restrictions, an international online survey on mental health and multidimensional lifestyle behaviours during home confinement (ECLB-COVID19) was launched in April 2020. ECLB-COVID19 was opened on 1 April 2020, tested by the project's steering group for a period of one week and disseminated worldwide from 6 April to 28 June 2020 (12 weeks). Forty-one research organizations from Europe, North-Africa, Western-Asia, and the Americas promoted dissemination and administration of the survey. ECLB-COVID19 was administered in 14 languages including English, German, French, Arabic, Spanish, Portuguese, Slovenian, Dutch, Persian, Italian, Greek, Russian, Indian, and Malayalam. The survey included 64 questions on health, mental well-being, mood, life satisfaction, and multidimensional lifestyle behaviours (PA, diet, social participation, sleep, technology use, need of psychosocial support). All questions were presented in a differential format, to be answered directly in sequence regarding "before" and "during" confinement conditions [4–7]. The study was conducted according to the Declaration of Helsinki. The protocol and the consent form were fully approved (identification code: 62/20) by the Otto von Guericke University Ethics Committee, Magdeburg, Germany.

2.1. Sample size

The sample size was calculated according to the following predictive equation [36].

$$N = \frac{(Z_{\alpha/2}{}^{2}\, p\, q)}{\text{Delta}^{2}}$$

Where "n" was the number of needed participants; "$Z_{\alpha/2}$" was the two-tailed normal deviate for type 1 error ($Z_{\alpha/2} = 3.29$ for 99.9% level of significance); "q" was equal to "1- p"; "Delta" was the accuracy (= 1.5%), and "p" was the percentage of change from "before" to "during" confinement period. The "p" was identified from our preliminary study [4] which sought to investigate the immediate impact of the COVID-19 pandemic on mental health and lifestyle behavior. The latter authors found that 12% ($p = 0.12$) of participants experienced a decrease in sleep quality. The calculated sample size was therefore 5080 consecutive participants. The assumption of 4% for duplicate participants, entry errors and eligibility of inclusion and exclusion criteria gave a revised sample of 5291 participants [5291 = 5080/ (1.0–0.04)].

2.2. Survey Development and Promotion

The ECLB-COVID19 electronic survey was designed by a steering group of multidisciplinary scientists and academics (i.e., human science, sport science, neuropsychology, and computer science) at the University of Magdeburg (principal investigator), the University of Sfax, the University of Münster and the University of Paris-Nanterre, following a structured review of the literature. The survey was then reviewed and edited by over 50 colleagues and experts worldwide. The survey was uploaded and shared on the Google online survey platform. A link to the electronic survey was distributed worldwide by consortium colleagues via a range of methods: invitation via e-mails, shared in consortia faculties official pages, ResearchGate™, LinkedIn™, WhatsApp™, Facebook™ and Twitter™. The general public were also randomly involved in the dissemination plans through the promotion of the ECLB-COVID19 survey in their personal networks. The survey included an introductory page describing the background and the aims of the survey, the consortium, ethics information for participants and the option to choose one favorite language [4–7]. This survey was open for all people worldwide, aged 18 years or older. People with cognitive decline or impairment were excluded. Before completing the survey, individuals voluntarily consented to anonymously participate in this study, allowing the use of their answers for research purposes.

2.3. Data Privacy and Consent of Participation

The ECLB-COVID-19 study gave special care to data privacy and security and protection of the collected data against any unauthorized access by third parties, During the informed consent process, surveyed participants were ensured (i) all data would be used only for research purposes and (ii) answers were anonymous and confidential according to Google's privacy policy. Participants were not permitted to provide their names or contact information. Additionally, participants were able to stop study participation and leave the questionnaire at any stage before the submission process; if doing so, their responses would not be saved. Responses were saved only by clicking on the provided "submit" button. Participants were requested to be honest in their responses [4–7].

2.4. Survey Questionnaires

The ECLB-COVID-19 is a multicountry electronic survey designed to assess eventual changes in multiple lifestyle behaviours during the COVID-19 outbreak. Therefore, a collection of validated and/or crisis oriented brief questionnaires were included [4–7]. These questionnaires assessed demographic information, mental well-being (Short Warwick-Edinburgh Mental Well-being Scale (SWEMWBS; [4, 7]), mood and feeling (Short Mood and Feelings Questionnaire (SMFQ; [4, 7])), sleep quality (Pittsburgh Sleep Quality Index (PSQI; [4])), PA (International Physical Activity Questionnaire Short Form (IPAQ-SF; [4, 5])), life satisfaction (Short Life Satisfaction Questionnaire for Lockdowns (SLSQL; [4, 6])), diet behaviours (Short Diet Behaviours Questionnaire for Lockdowns (SDBQL; [4, 5])), social participation (Short Social Participation Questionnaire for Lockdowns (SSPQL; [4, 6])), and some key questions assessing the technology-use behaviours (Short Technology-use Behaviours Questionnaire for Lockdowns (STBQL; [4])), and the need of psychosocial support [4]. Reliability of the shortened and/or newly adopted questionnaires was tested by the project steering group through piloting, prior to survey administration. These brief crisis-oriented questionnaires demonstrated good to excellent test–retest reliability coefficients ($r = 0.84–0.96$). A multilanguage validated version already existed for the majority of these questionnaires and/or questions. However, for questionnaires that did not already exist in multilingual versions, we followed the procedure of translation and back-translation, with an additional review for all language versions from the international scientists of our consortium. As a result, a total number of 64 items were included in the ECLB-COVID-19 online survey in a differential format (i.e., each item or question requested two answers, one regarding the period before and the other regarding the period during confinement). The participants were guided to compare the situations [4–7]. Given the large number of questions included, the present paper focuses on the IPAQ-SF and the PSQI questionnaires. A copy of the complete ECLB-COVID19 survey's questionnaires has been previously published as supplementary file (https://doi.org/10.1371/journal.pone.0240204.s001) [7].

PSQI

The sleep quality was assessed by the PSQI [37]. The PSQI had been extensively validated in different cultures and populations [38]. The questionnaire was composed of 19 questions representing one of the seven components of sleep quality: subjective sleep quality, sleep latency, sleep duration, sleep efficiency, sleep disturbance, sleep medication intake, and daytime dysfunction. Each component score was rated on a 3-point scale, leading to a sum of up to 21 points. PSQI scores > 5 and ≤ 5 indicated poor and good sleep quality, respectively [37].

IPAQ-SF

According to the official IPAQ-SF guidelines, data from the IPAQ-SF are summed within each item (i.e., vigorous intensity, moderate intensity and walking) to estimate the total amount of time spent engaged in PA per week [39, 40]. Total weekly PA (MET-min·week^{-1}) was estimated by adding the products of reported time for each item by a Metabolic equivalent of task (MET) value that was specific to each category of PA. We assigned two different sets of MET values. The first set was the original values (original IPAQ) based on the official IPAQ guidelines for young and middle-aged adult (18–65 years old): vigorous PA = 8.0 METs, moderate PA = 4.0 METs and walking = 3.3 METs. The other set used modified values (modified IPAQ), which we had devised for use with elderly adults (> 65 years old), as reported by Stewart et al. [41] and Yasunaga et al. [42]: vigorous PA = 5.3 METs, moderate PA = 3.0 METs and walking = 2.5 METs. Additionally, we added total PA (sum of performed vigorous, moderate and walking activity) as a fourth item and sitting time as a fifth item.

Based on the IPAQ recommendations for scoring protocol, participants of the study were classified in three different groups based on the MET–min/wk of the sum of walking, moderate-intensity physical activities, and vigorous-intensity physical activities: lowly active (< 600 MET–min/wk); moderately active (600 MET–min/wk ≤ PA < 3000 MET–min/wk) and highly active (≥ 3000 MET–min/wk) (http://www.ipaq.ki.se).

2.5. Data analysis

Data were reported as means (standard deviations) for continuous variables or percentages for categorical variables. All statistical analyses were performed using the commercial statistical software STATISTICA (StatSoft, Paris, France, version 10.0) and Microsoft Excel® 2010. Using the Shapiro–Wilks W-test, normality of the data distribution was not confirmed. To examine PA, sedentary behavior, and sleep differences induced by the home confinement, comparisons among pre-, and during- home confinement were carried out using Wilcoxon signed-rank tests. The difference between the total PA energy expenditure in individual experiencing good and bad sleep before and during home confinement was examined using the U Mann-Whitney test. Cross-table Chi-squared (X^2) analysis was used to assess the changes compared with those before home confinement, and the results are presented as numbers (n) and proportions (%). Effect size (ES) for non-parametric tests was calculated using Rosenthal [43] formula: ES = Z/√N. ESs were interpreted as follows: small (0.10 – < 0.30), medium (0.30 – < 0.50), and large (≥ 0.50) [43]. The Spearman correlation (rho) was utilized to assess the relationship between the "before-during" confinement change (Δ) in PSQI and total PA scores. "Rho" was considered "high" when it was > 0.70, "good" when it was between 0.50–0.70, "fair" if it was between 0.30–0.50 and "weak or no association" if it was < 0.30 [44]. The Kruskal-Wallis test was used to assess the effect of PA levels on PSQI total score at before or at during home confinement. Statistical significance was accepted as $p < 0.05$.

RESULTS

Data set selection and sample description

By the 28th of June 2020, 5276 responses were collected. Removal of duplicate participants (n = 106) and responses including

TABLE 1. Demographic characteristics of the participants (N = 5056).

Variables	N	(%)
Sex		
Female	3004	(59.4%)
Male	2052	(40.6%)
Continent		
Europe (28 countries)	2347	(46.4%)
Western-Asia (13 countries)	107	(21.2%)
America (12 countries)	747	(14.8%)
North-Africa (5 countries)	654	(12.9%)
Others (16 countries)	237	(4.7%)
Age (years)		
18–35	2864	(56.6%)
36–55	1675	(33.1%)
> 55	517	(10.2%)
Education level		
Master/doctorate degree	2042	(40.4%)
Bachelor's degree	1646	(32.6%)
Professional degree	437	(8.6%)
High school graduate, diploma or the equivalent	737	(14.6%)
No schooling completed	194	(3.8%)
Marital status		
Single	2281	(45.1%)
Married/Living as couple	2537	(50.2%)
Widowed/Divorced/Separated	238	(4.7%)
Employment status		
Employed for wages	2286	(45.2%)
Self-employed	411	(8.1%)
Out of work/Unemployed	298	(5.9%)
Student	1561	(30.9%)
Retired	197	(3.9%)
Unable to work	26	(0.5%)
Problem/unemployment caused by COVID-19	184	(3.6%)
Other	93	(1.8%)
Health status		
Healthy	4525	(89.5%)
With risk factors for cardiovascular disease	486	(9.6%)
With cardiovascular disease	45	(0.9%)
Excluded participants		
Age < 18 years	29	
With cognitive decline and/or neurodegenerative diseases	32	

TABLE 2. Subjective sleep quality recorded before and during home confinement.

Parameters	Means ± SD		Δ (Δ%)	T (Wilcoxon)	Z	P-value	ES
	Before	During					
Sleep latency (min)	22.6 ± 34.5	31.2 ± 41.5	8.6 (38.2%)	237984	29.25	< 0.001	0.411
Sleep duration (h)	7.19 ± 1.4	7.61 ± 1.69	0.41 (5.7%)	875154	20.20	< 0.001	0.284
Subjective sleep quality (AU)	0.9 ± 0.7	1.14 ± 0.86	0.24 (26.9%)	328522	20.38	< 0.001	0.287
Time in bed (h)	7.96 ± 1.51	8.44 ± 1.71	0.48 (6%)	2171459	23.34	< 0.001	0.328
Sleep efficiency (AU)	0.4 ± 0.81	0.47 ± 0.89	0.06 (15.5%)	385823	4.98	< 0.001	0.070
Sleep disturbance (AU)	1.2 ± 0.68	1.38 ± 0.74	0.18 (14.7%)	168658	19.17	< 0.001	0.270
Daytime dysfunction (AU)	0.73 ± 0.69	0.89 ± 0.77	0.17 (22.8%)	356160	15.72	< 0.001	0.221
Use of sleep medication (AU)	0.18 ± 0.59	0.23 ± 0.68	0.04 (22.1%)	32495	5.88	< 0.001	0.083
Total score of PSQI (AU)	4.37 ± 2.71	5.32 ± 3.23	0.95 (21.7%)	1528349	24.69	< 0.001	0.347

SD: Standard difference; Δ%: % change from before to during confinement period; AU: arbitrary unit; ES: effect size; PSQI: Pittsburgh Sleep Quality Index

data entry errors (n = 51) resulted in a selection of 5119 participants. A screening of participants' health status and ages for eligibility against inclusion and exclusion criteria led to the exclusion of 32 participants with cognitive decline/impairment and 29 participants aged < 18 years old. The present study focuses on the final selected data set (i.e., 5056 participants from 74 countries). Overall, 59.4% of the sample were females. Geographical breakdowns were from European (46.4%), Western-Asian (25.4%), America (14.8%), and North-African (13.3%) countries. Age, education levels, and health, employment and marital statuses are presented in Table 1.

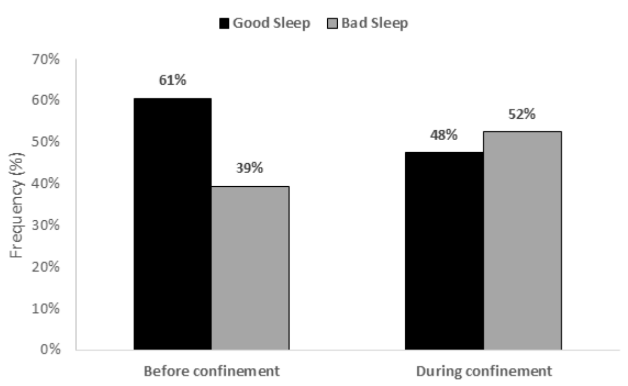

FIG. 1. Frequency (%) of individuals experiencing a good (PSQI score ≤ 5) and bad sleep (PSQI score > 5) before and during home confinement.
PSQI: Pittsburgh Sleep Quality Index

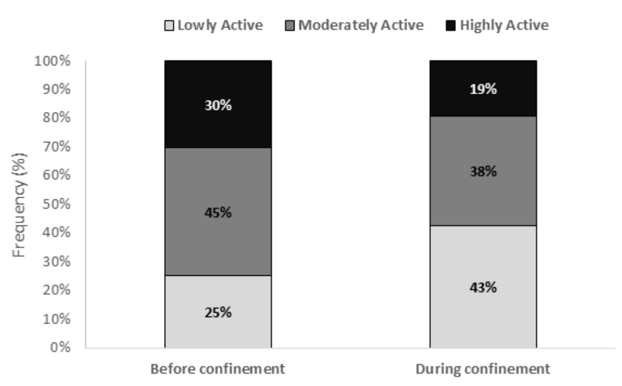

FIG. 2. Classification of participants according to International Physical Activity Questionnaire Short Form (IPAQ-SF) scoring before and during home confinement.

TABLE 3. Responses to the short form of the International Physical Activity Questionnaire recorded before and during home confinement.

Parameters		Means ± SD		Δ (Δ%)	T (Wilcoxon)	Z	P-value	ES
		Before	During					
Vigorous intensity	Days/week	2.33 ± 2.11	1.86 ± 2.13	-0.47 (20%)	1220828	17.03	< 0.001	0.240
	min/week	49 ± 58.3	35.8 ± 52.1	-13.2 (26.9%)	494879	23.87	< 0.001	0.336
	MET values	1445 ± 2464	993 ± 2059	-453 (31.3%)	1226820	20.74	< 0.001	0.292
Moderate intensity	Days/week	2.28 ± 2.14	1.74 ± 2.08	-0.54 (23.7%)	935708	19.56	< 0.001	0.275
	min/week	41.8 ± 49.3	30.9 ± 43.9	-10.9 (26.1%)	436869	21.89	< 0.001	0.308
	MET values	574 ± 967	397 ± 845	-177 (30.9%)	1012786	20.53	< 0.001	0.289
Walking	Days/week	3.8 ± 2.52	2.66 ± 2.54	-1.14 (30%)	981277	28.69	< 0.001	0.403
	min/week	42.2 ± 46.7	31.8 ± 39.6	-10.4 (24.7%)	987734	19.69	< 0.001	0.277
	MET values	657 ± 933	429 ± 724	-228 (34.8%)	1578357	22.95	< 0.001	0.323
All physical activity	Days/week	5.51 ± 2.23	4.38 ± 2.75	-1.13 (20.5%)	550235	29.64	< 0.001	0.417
	min/week	133 ± 113.4	98.5 ± 102.3	-34.5 (26%)	1280759	29.83	< 0.001	0.420
	MET values	2677 ± 3416	1818 ± 2883	-858 (32.1%)	2242350	27.34	< 0.001	0.385
Sitting	Hours/day	5.4 ± 3.16	7.37 ± 3.9	+1.97 (-36.5%)	364959	41.95	< 0.001	0.590

SD: Standard difference; Δ%: % change from before to during confinement period; ES: effect size; MET: Metabolic equivalent of task

PSQI

Responses to the PSQI questionnaire recorded before and during home confinement are presented in Table 2.

Compared to before home confinement, all PSQI components increased ($p < 0.001$) during home confinement with a medium ES for sleep latency and time in bed, and small ES for sleep duration, the score of the subjective sleep quality, the score of sleep efficiency, the score of sleep disturbances, the score of daytime dysfunction, and the use of sleep medication score. Accordingly, the total score of PSQI increased by ~1 point with a medium ES during compared to before home confinement ($p < 0.001$).

Figure 1. shows the frequencies of surveyed individuals experiencing good and bad sleep before and during the confinement.

The frequency of individuals experiencing a good sleep decreased from 61% (n = 3063) before home confinement to 48% (n = 2405) during home confinement, whereas the frequency of individuals experiencing a bad sleep increased from 39% (n = 1993) before home confinement to 52% (n = 2651) during home confinement (X^2 of Mac Nemar = 324.06, $p < 0.001$, ES = 0.253).

IPAQ-SF

Responses to the IPAQ-SF recorded before and during home confinement are presented in Table 3.

Compared to before home confinement, the number of days/week and minutes/day of vigorous intensity, moderate intensity and walking activities recorded during home confinement decreased with $p < 0.001$, $0.24 \leq ES \leq 0.40$ and $20 \leq \Delta(\%) \leq 30$. In addition, MET values of these PA categories were significantly lower at during compared to before home confinement with $p < 0.001$, ES = 0.3 and $31 \leq \Delta(\%) \leq 35$.

In total, the number of days/week and minutes/day as well as the MET values of all PA recorded during home confinement significantly decreased compared to before home confinement with $p < 0.001$, ES = 0.4 and $21 \leq \Delta(\%) \leq 32$. However, the number of hours/day of sitting increased by ~2 hours/days during compared to before home confinement ($p < 0.001$, ES = 0.590: large).

The classification of respondents according to IPAQ-SF scoring before and during home confinement are presented in Figure 2.

As figure 2 shows, compared to before home confinement, the frequency of high and moderate active participants decreased by 11% and 7%, respectively, while the frequency of low active participants increased by 18%.

Relationship between sleep quality and PA

Δ total score of PSQI was negatively correlated to Δ all PA ($p < 0.001$, rho = -0.149, rho: weak). The total PA energy expenditure in individual experiencing good and bad sleep before and during home confinement is shown in Figure 3.

Compared to individual experiencing bad sleep, the total PA energy expenditure of individual experiencing good sleep was significantly

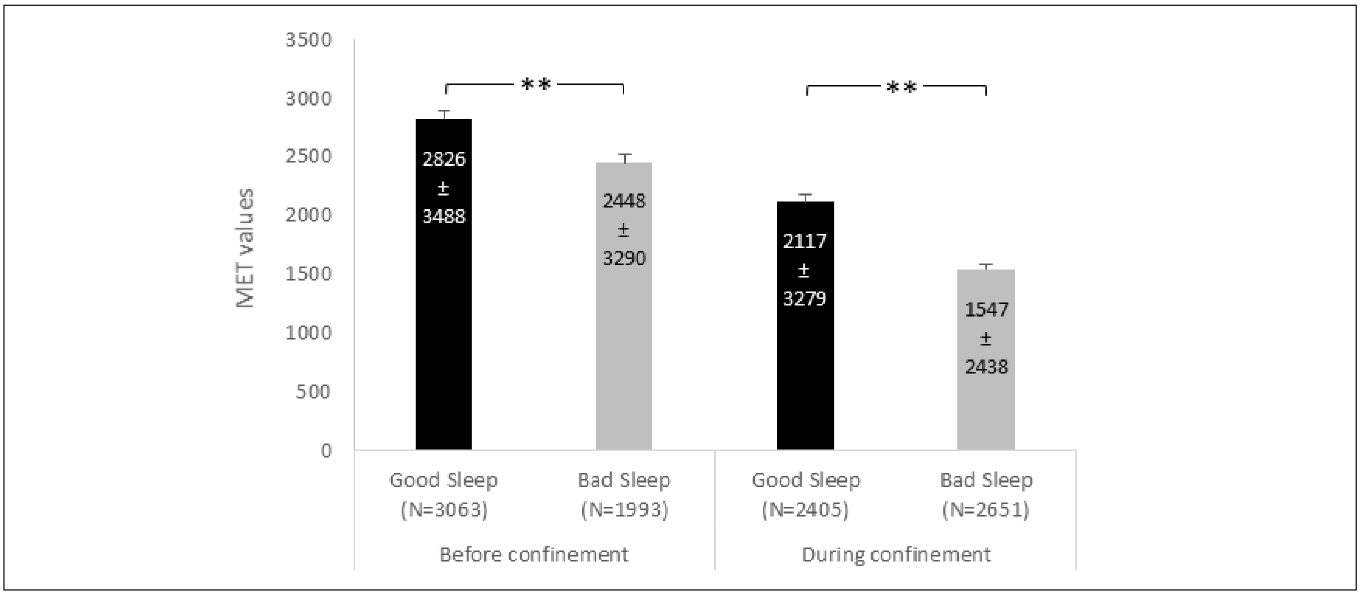

FIG. 3. Total physical-activity energy expenditure in individual experiencing good and bad sleep before and during home confinement. Data were mean ± SD. MET: Metabolic equivalent of task; ** significant difference at p < 0.001

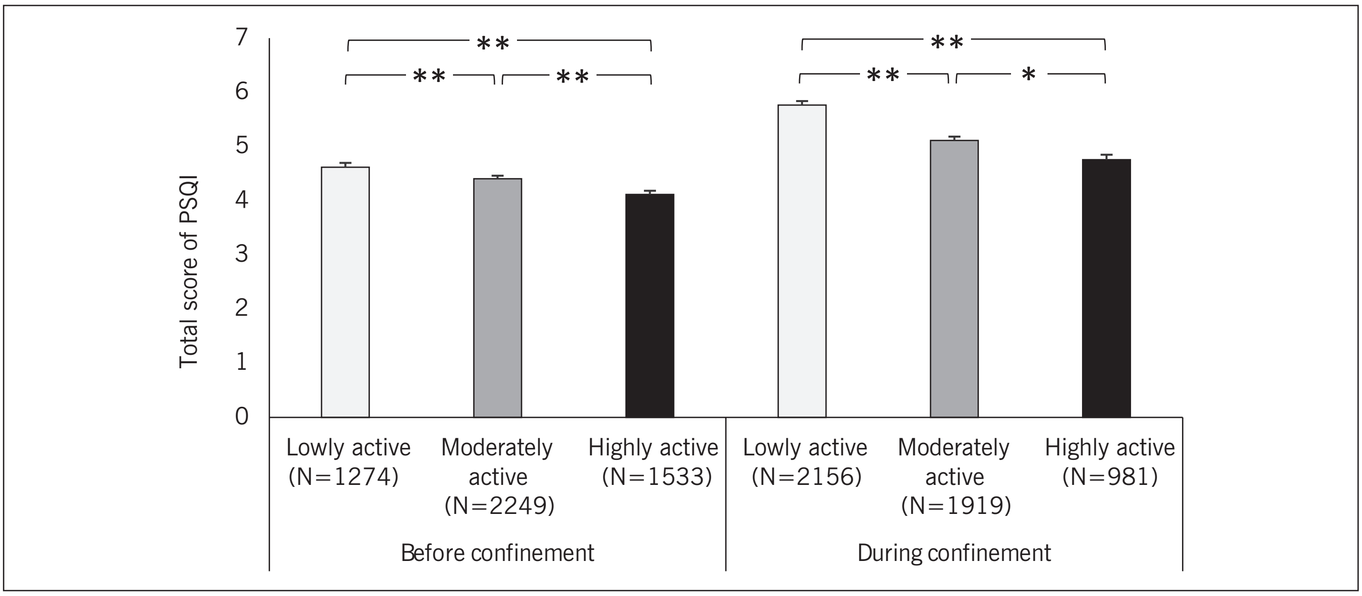

FIG. 4. Total score of Pittsburgh Sleep Quality Index (PSQI) in low, moderate and high active participants before and during home confinement. Data were mean ± SD. ** significant difference at p < 0.001, * significant difference at p < 0.01

higher either before ($Z = 4.524$, $p < 0.001$, $ES = 0.064$) or during ($Z = 8.899$, $p < 0.001$, $ES = 0.125$) home confinement.

The total PSQI score in low, moderate and high active participants before and during home confinement is shown in Figure 4.

The Kruskal-Wallis test showed a significant main effect of PA levels on PSQI total score in either before ($H_{(2, N = 5056)} = 28.99$, $p < 0.001$, $ES = 0.15$) and during ($H_{(2, N = 5056)} = 77.24$, $p < 0.001$, $ES = 2.5$) home confinement period with lower PSQI score for high active compared to moderate ($p < 0.001$ at "before" and $p < 0.01$ at "during") and low ($p < 0.001$ in both periods) active participants as well as lower score in moderate compared to low active participants ($p < 0.001$ in both periods).

DISCUSSION

The present study reports final results from 5056 participants (59.4% female) who responded to our ECLB-COVID-19 multilingual online survey. Results showed (i) a poor sleep quality during COVID-19 home confinement as a result of increases in sleep disturbances, daytime dysfunction, sleep latency, and the use of sleep medications and (ii) a negative effect of COVID-19 home confinement on self-reported PA levels. Additionally, an association between PA levels and sleep quality was found with higher PA energy expenditure in individual experiencing good compared to bad sleep and better total PSQI score in more active participants.

A major finding in this study was the increase of the global PSQI score during vs. before home confinement. Additionally, global PSQI score recorded during the home confinement period was higher than the cut-off for poor sleep quality, suggesting that quarantined individuals suffered from poor overall sleep quality despite the longer sleep duration. It is worth noting that poor sleep quality has been associated with increased negative emotions and reduced quality of life in healthy subjects [16, 45], increased severity of symptoms in some psychiatric disorders (e.g., pain, mood disorders), and physical illness [46–49].

Previous studies on the effects of home confinement on sleep patterns revealed higher global PSQI values than those reported in our study. For example, PSQI scores as high as 8.48 [13] and 8.58 [14] have been reported in general dwelling populations and medical staff from China who treated patients with COVID-19 infection, respectively. We speculate that higher PSQI scores recorded in China, Hubei province, could be attributed to the high level of stress and anxiety caused by the COVID-19 pandemics in Chinese people compared to those of other countries. In addition, the studied population in Xiao et al. [14] consisted of medical staff who treated patients with COVID-19, and increased workload and the stress associated with the risk of getting infected could explain, at least in part, the higher PSQI scores compared to those reported in our studied population.

Some components of the PSQI questionnaire increased significantly during vs. before home confinement. The increase in the sleep onset latency or sleep latency, defined as the time elapsed between getting into bed or 'lights out' to sleep onset [50], could be explained by the potential worried pre-sleep thoughts (e.g., worries about the situation and its unknown upcoming duration, potential negative health effects of the virus if one gets infected, conflicting messages from authorities, job continuity issues, financial security, among others) leading to anxiety and stress [12]. Additionally, it was recently documented that eating more than usual with unhealthy eating habits such as ad libitum eating close to bedtime are common during confinement [4, 5]. These unhealthy diet behaviors could be in the origin of the increased time taken to fall asleep [51,52] during confinement. Related to psychological and dietary factors, quarantined people could be exposed to less daylight than usual, particularly those living in homes with small windows and without an outside area [12], leading to difficulties in commencing sleep [53]. As a consequence, participants increased their intake of sleep medication, as demonstrated in the present findings, to assist falling asleep during COVID-19 home confinement [54].

Sleep disturbances, another component of the PSQI questionnaire, increased significantly during vs. before confinement. A stressful situation complementing the points mentioned above, e.g., COVID-19 pandemic risks/consequences, could explain the latter finding [55, 56]. As a consequence of sleep disturbances, higher daytime dysfunctions were reported during home confinement, which can potentially induce more negative emotions and frustration [16].

Recent published recommendations advised individuals to stay physically active at home during COVID-19 home confinement [5, 23, 28, 29, 57]. However, in accordance with recent published studies showing alteration in the levels of PA [5, 33, 58], the present findings identified a marked reduction of all PA intensity levels (i.e., vigorous, moderate, walking) during COVID-19 home confinement. These results could be explained by the restriction imposed by the lockdowns and causing the closure of sports halls and gymnasiums, as well as the decrease of recreational or incidental daily PA (e.g., walking, bicycling, because of obviously less spaces availability). Moreover, participants did not meet the recommendations of the WHO neither before nor during home confinement [59, 60]. Moreover, the percentage of low active individuals increased during COVID-19 home confinement, which could be explained by the radical change in everyday schedules and habits. For example, people staying at home during lockdowns spent much more time engaged in low-intensity activities, such as housework (e.g., washing dishes, cooking, gardening when applicable). Additionally, the greater female presence in the present study might also have mediated this finding.

Regarding sedentary behaviour, daily sitting time significantly increased from 5 to 7 hours per day (large ES = 0.590). Increases in daily sitting time during lockdowns have been reported in previous studies [5, 33]; however, the reported mean values in the current report indicate an alarming situation, where the daily participants' sitting time during the COVID-19 home confinement resides in the threshold area (i.e., 6–8 hours), which Patterson et al. [61] suggested may cause an increase in disease and mortality risks.

In accordance with the results of recent cohort study [4], the present results showed that Δ total score of PSQI was negatively correlated with Δ global PA score. Additionally, concordant with the result of the correlational analysis, we found that individuals with higher total PA energy expenditure experienced good sleep quality. Nevertheless, the weak correlation between Δ total score of PSQI and Δ global PA scores indicates that increases in PA will not necessarily lead to sleep improvements during COVID-19 home confinement.

Strengths and limitations

The use of a multicenter anonymous cross-disciplinary online survey, recently recommended as an exciting and flexible qualitative research tool [34], with the calculated large sample size and the rapidly collected data during the restrictions are the main strength of this study. However, there are some limitations that need to be considered. First, we did not use any objective measurement for the evaluation of sleep quality and PA levels. Previous report suggest that self-reported PA tends to be overestimated compared to objective measure [40] but, up to now, IPAQ-SF is considered as potentially useful tool for assessing PA and it has been well validated across different age groups and in various countries [62]. Likewise, sleep quality could be considered as a subjective perception, with still no consensus on what good sleep, in fact, implies [63]. Second, daily naps, known for their beneficial effect for health [64], are not assessed by the PSQI questionnaire. Thus, future surveys assessing daily naps duration in addition to main sleep are warranted. Third, our survey was advertised online; therefore, it may be subject to volunteer bias (i.e. people particularly interested in lifestyle behaviours during COVID-19 home confinement could be more prone to participate and to perceive differences between before and during COVID-19 home confinement). Finally, the sample was relatively heterogeneous (e.g. from different countries and cultural backgrounds), which could compromise internal validity; for example, no criteria-based subsample analysis and the majority of respondents are 'highly educated' and young/middle aged adults. Therefore, the present findings need to be interpreted with caution. Interestingly, however, our online survey allowed us to reach a geographically diverse sample, potentially ensuring robust external validity.

CONCLUSIONS

COVID-19-related home confinement significantly and deleteriously altered sleep quality and PA levels in a large global sample of people. To maintain health during the COVID-19 pandemic, PA promotion and sleep hygiene education and support are needed.

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Competing interest statement

All authors declare: no support from any organisation for the submitted work; no financial relationships with any organisations that might have an interest in the submitted work in the previous three years, no other relationships or activities that could appear to have influenced the submitted work.

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REFERENCES

1. Guan WJ, Ni ZY, Hu Y, Liang WH, Ou CQ, He JX et al. Clinical Characteristics of Coronavirus Disease 2019 in China. N Engl J Med 2020;382:1708–1720
2. ECDC. Situation update worldwide, as of October 4, 2020. https://www.ecdc.europa.eu/en/geographical-distribution-2019-ncov-cases. (Retrieved December 5, 2020)
3. Rubin GJ, Wessely S. The psychological effects of quarantining a city. BMJ 2020;368:m313.
4. Ammar A, Trabelsi K, Brach M, Chtourou H, Boukhris O, Masmoudi L, et al. on behalf of the ECLB-COVID19 Consortium. Effects of home confinement on mental health and lifestyle behaviours during the COVID-19 outbreak: Insight from the ECLB-COVID19 multicenter study. Biol Sport. 2021;38(1):9–21. doi:10.5114/biolsport.2020.96857.
5. Ammar A, Brach M, Trabelsi K, Chtourou H, Boukhris O, Masmoudi L, et al. on behalf of the ECLB-COVID19 Consortium. Effects of COVID-19 Home Confinement on Eating Behaviour and Physical Activity: Results of the ECLB-COVID19 International Online Survey. Nutrients. 2020;12:1583. doi:https://doi.org/10.3390/nu12061583
6. Ammar A, Chtourou H, Boukhris O, Trabelsi K, Masmoudi L, Brach M, et al. Covid-19 home confinement negatively impacts social participation and life satisfaction: A worldwide multicenter study. Int J Environ Res Public Health. 2020;17(17):6237. https://doi.org/10.3390/ijerph17176237.
7. Ammar A, Mueller P, Trabelsi K, et al. on behalf of the ECLB-COVID19 Consortium. Psychological consequences of COVID-19 home confinement: The ECLB-COVID19 multicenter study. PLOS one 2020;doi:10.1371/journal.pone.0240204.
8. Brooks SK, Webster RK, Smith LE, Woodland L, Wessely S, Greenberg N, Rubin GJ. The psychological impact of quarantine and how to reduce it: rapid review of the evidence. The Lancet. 2020;395:912–920.
9. Qiu J, Shen B, Zhao M, Wang Z, Xie B, Xu Y. A nationwide survey of psychological distress among Chinese people in the COVID-19 epidemic: implications and policy recommendations. Gen Psychiatr. 2020;33(2).
10. Jiang Hj, Nan J, Lv Zy, Yang J. Psychological impacts of the COVID-19 epidemic on Chinese people: Exposure, post-traumatic stress symptom, and emotion regulation. Asian Pac J Trop Med 2020;13:252–9.

11. Pfefferbaum B, North CS. Mental Health and the Covid-19 Pandemic. N Engl J Med. 2020;383:510–512
12. Altena E, Baglioni C, Espie CA, Ellis J, Gavriloff D, Holzinger B, et al. Dealing with sleep problems during home confinement due to the COVID-19 outbreak: practical recommendations from a task force of the European CBT-I Academy. J Sleep Res. 2020;https://doi.org/10.1111/jsr.13052
13. Xiao H, Zhang Y, Kong D, Li S, Yang N. Social Capital and Sleep Quality in Individuals Who Self-Isolated for 14 Days During the Coronavirus Disease 2019 (COVID-19) Outbreak in January 2020 in China. Med Sci Monit. 2020; 26:e923921-1–e923921-8.
14. Xiao H, Zhang Y, Kong D, Li S, Yang N. The effects of social support on sleep quality of medical staff treating patients with coronavirus disease 2019 (COVID-19) in January and February 2020 in China. Med Sci Monit. 2020;26:e923549-1–e923549-8.
15. Zisapel N. Sleep and sleep disturbances: biological basis and clinical implications. Cell Mol Life Sci. 2007;64(10):1174.
16. Bower B, Bylsma LM, Morris BH, Rottenberg J. Poor reported sleep quality predicts low positive affect in daily life among healthy and mood-disordered persons. J Sleep Res. 2010;19:323–332.
17. Spira AP, Chen-Edinboro LP, Wu MN, Yaffe K. Impact of sleep on the risk of cognitive decline and dementia. Curr Opin Psychiatry. 2014;27(6):478.
18. Mullington JM, Haack M, Toth M, Serrador JM, Meier-Ewert HK. Cardiovascular, inflammatory, and metabolic consequences of sleep deprivation. Prog Cardiovasc Dis2009;51(4):294–302.
19. Nagai M, Hoshide S, Kario K. Sleep duration as a risk factor for cardiovascular disease—a review of the recent literature. Curr Cardiol Rev. 2010;6:54–61.
20. Irwin M. Effects of sleep and sleep loss on immunity and cytokines. Brain Behav Immun. 2002;16(5):503–12
21. Faraut B, Touchette E, Gamble H, Royant-Parola S, Safar ME, Varsat B, et al. Short sleep duration and increased risk of hypertension: a primary care medicine investigation. J Hypertens. 2012;30:1354–63
22. Bryant PA, Trinder J, Curtis N. Sick and tired: does sleep have a vital role in the immune system? Nat Rev Immunol. 2004;4(6):457–67.
23. Yousfi N, Bragazzi NL, Briki W, Zmijewski P, Chamari K. The COVID-19 pandemic: how to maintain a healthy immune system during the lockdown – a multidisciplinary approach with special focus on athletes. Biol Sport. 2020;37(3):211–216. doi:10.5114/biolsport.2020.95125
24. National Heart, Lung, and Blood Institute. COVID and Sleep: Better Slumber During the Pandemic May Help Protect Your Health, as of September 1, 2020. https://www.nhlbi.nih.gov/news/2020/covid-and-sleep-better-slumber-during-pandemic-may-help-protect-your-health (Retrieved October 21, 2020).
25. Müller P, Ammar A, Zou L, Apfelbacher, C, Erickson KI, Müller NG. COVID-19, physical (in-)activity, and dementia prevention. Alzheimer's Dement. 2020;1–3. Doi: https://doi.org/10.1002/trc2.12091
26. Young DR, Hivert MF, Alhassan S, Camhi SM, Ferguson JF, Katzmarzyk PT, Lewis CE, Owen N, Perry CK, Siddique J, et al. Sedentary Behavior and Cardiovascular Morbidity and Mortality: A Science Advisory from the American Heart Association. Circulation. 2016; 134 E262–E279.
27. Müller P, Achraf A, Zou L, Apfelbacher C, Erickson KI, Müller NG. COVID-19, physical (in-) activity, and dementia prevention. Alzheimers Dement (N Y). 2020;6(1):e12091.
28. Chtourou H, Trabelsi K, Hmida C, Boukhris O, Brach M, Bentlage E, Glenn JM, Bott N, Shephard EJ. Ammar A, Bragazzi NL. Staying physically active during the quarantine and self-isolation period for controlling and mitigating the COVID-19 pandemics: A systematic overview of the literature. Front Psychol. 2020;DOI:10.3389/fpsyg.2020.01708.
29. Bentlage E, Ammar A, How D, Ahmed M, Trabelsi K, Chtourou H, Brach M. Practical recommendations for maintaining active lifestyle during the COVID-19 pandemic:A systematic literature review. Int J Environ Res Public Health. 2020;17(17):6265. doi:10.3390/ijerph17176265.
30. Sallis JF, Adlakha D, Oyeyemi A, Salvo D. An international physical activity and public health research agenda to inform COVID-19 policies and practices. J Sport Health Sci. 2020;9(4):328–334.
31. Bisciotti GN, Eirale C, Corsini A, Baudot C, Saillant G, Chalabi H. Return to football training and competition after lockdown caused by the COVID-19 pandemic: medical recommendations. Biol Sport. 2020;37(3):313–319. doi: 10.5114/biolsport.2020.96652
32. Potter GDM, Skene DJ, Arendt J, Cade JE, Grant PJ, Hardie LJ. Circadian Rhythm and Sleep Disruption: Causes, Metabolic Consequences, and Countermeasures. Endocr. Rev. 2016;37:584–608.
33. Sañudo B, Fennell C, Sánchez-Oliver AJ. Objectively-Assessed Physical Activity, Sedentary Behavior, Smartphone Use, and Sleep Patterns Pre- and during-COVID-19 Quarantine in Young Adults from Spain. Sustainability. 2020;12:5890.
34. Braun V, Clarke V, Boulton E, Davey L, McEvoy C. The online survey as a qualitative research tool. Int J Soc Res Methodol. 2020. DOI:10.1080/13645579.2020.1805550
35. Ammar A, Bouaziz B, Trabelsi K, Glenn J, Zmijewski P, Müller P, et al. Applying digital technology to promote active and healthy confinement lifestyle during pandemics in the elderly. Biol Sport. 2021;38(3):391–396. DOI: https://doi.org/10.5114/biolsport.2021.100149
36. Whitley E, Ball J. Statistics Review 4: Sample Size Calculations. Crit. Care. 2002;6:335–341. doi: 10.1186/cc1521.
37. Buysse DJ, Reynolds CF, Monk TH, Berman SR, Kupfer DJ. The Pittsburgh Sleep Quality Index: A new instrument for psychiatric practice and research. Psychiatry Res. 1989;28:193–213.
38. Moghaddam JF, Nakhaee N, Sheibani V, Garrusi B, Amirkafi A. Reliability and validity of the Persian version of the Pittsburgh Sleep Quality Index (PSQI-P). Sleep Breath. 2012;16(1):79–82.
39. Graig CL, Marshall AL, Sjöström M, Bauman AE, Booth ML, Ainsworth BE, Pratt M, Ekelund ULF, Yngve A, Sallis JF, et al. International Physical Activity Questionnaire: 12-Contry Reliability and Validity. Med Sci Sports Exerc. 2003;35:1381–1395.
40. Lee PH, Macfarlane DJ, Lam TH, Stewart SM. Validity of the international physical activity questionnaire short from (PAQ-SF): A systematic review. Int J Behav Nutr Phys Act. 2011;8:115.
41. Stewart AI, Mills KM, King AC, Haskell WL, Gillis DAWN, Ritter PL. Champs physical activity questionnaire for older adults: Outcomes for interventions. Med Sci Sports Exerc. 2001;33:1126–1141.
42. Yasunaga A, Park H, Watanabe E, Togo F, Park S, Shephard RJ, Aoyagi Y. Development and evaluation of the physical activity questionnaire for elderly Japanese: The Nakanojo study. J Aging Phys Act. 2007;15:398–411.
43. Rosenthal R, Cooper H, Hedges L. Parametric measures of effect size. The handbook of research synthesis. New York: Russell Sage Foundation, 1994. p.231–244.
44. Hinkle D, Wiersma W, Jurs S. Applied statistics for the behavioral sciences. Boston: Houghton Mifflin, 2003.
45. Choi EPH, Wan EYF, Kwok JYY, Chin WY, Lam CLK. The mediating role of sleep quality in the association between nocturia and health-related quality of life. Health Qual Life Outcomes. 2019;17:181.

46. Zhang P, Lou P, Chang G, Chen P, Zhang L, Li T, Qiao C. Combined effects of sleep quality and depression on quality of life in patients with type 2 diabetes. BMC Fam Pract. 2016;17:40.
47. Becker NB, Jesus SN, Joao KA, Viseu JN, Martins RI. Depression and sleep quality in older adults: a meta-analysis. Psychol Health Med. 2017;22:889–895.
48. Lee SWH, Ng KY, Chin WK. The impact of sleep amount and sleep quality on glycemic control in type 2 diabetes: A systematic review and meta-analysis. Sleep Med Rev. 2017;31:91–101.
49. Castro-Marrero J, Zaragozá MC, González-Garcia S, Aliste L, Sáez-Francàs N, Romero O, Ferré A, Fernández de Sevilla T, Alegre J. Poor self-reported sleep quality and health-related quality of life in patients with chronic fatigue syndrome/myalgic encephalomyelitis. J Sleep Res. 2018;27:e12703.
50. Gupta L, Morgan K, Gilchrist S. Does elite sport degrade sleep quality? A systematic review. Sports Med. 2017;47(7):1317–1333.
51. Araiza AM, Lobel M. Stress and eating: Definitions, findings, explanations, and implications. Soc Personal Psychol Compass. 2018;12(4):e12378.
52. Crispim CA, Zimberg IZ, dos Reis BG, Diniz RM, Tufik S, de Mello MT. Relationship between food intake and sleep pattern in healthy individuals. J Clin Sleep Med. 2011;7(6):659–664.
53. Monk TH, Buysse DJ, Billy BD, Kennedy KS, Kupfer DJ. The effects on human sleep and circadian rhythms of 17 days of continuous bed rest in the absence of daylight. Sleep 1997;20:858–864.
54. Alnofaiey YH, Alshehri HA, Alosaimi MM, Alswat SH, Alswat RH, Alhulayfi RM, et al. Sleep disturbances among physicians during COVID-19 pandemic. BMC Res Notes. 2020;13:493.
55. Lee SJ, Zhang J, Choi AM, Kim HP. Mitochondrial dysfunction induces formation of lipid droplets as a generalized response to stress. Oxid Med Cell Longev. 2013;2013:327167.
56. Gouin JP, Wenzel K, Boucetta S, O'Byrne J, Salimi A, Dang-Vu TT. High-frequency heart rate variability during worry predicts stress-related increases in sleep disturbances. Sleep Med. 2015;16(5):659–664.
57. Dwyer MJ, Pasini M, De Dominicis S, Righi E. Physical activity: Benefits and challenges during the COVID-19 pandemic. Scand J Med Sci Sports. 2020;30(7):1291.
58. Maugeri G, Castrogiovanni P, Battaglia G, Pippi R, D'Agata V, Palma A, et al. The impact of physical activity on psychological health during Covid-19 pandemic in Italy. Heliyon. 2020;6(6):e04315.
59. World Health Organization. 2018. Available online at: https://www.who.int/news-room/fact-sheets/detail/physicalactivity#:$\sim$:text = Adults%20aged%2018%E2%80%9364%20years,%2D%20and%20vigorous%2Dintensity %20activity
60. World Health Organization. 2020. Available online at: https://www.who.int/dietphysicalactivity/factsheet_adults/en/
61. Patterson R, McNamara E, Tainio M, de Sá TH, Smith AD, Sharp SJ, Edwards P, Woodcock J, Brage S, Wijndaele K. Sedentary behaviour and risk of all-cause, cardiovascular and cancer mortality, and incident type 2 diabetes: A systematic review and dose response meta-analysis. Eur J Epidemiol. 2018;33:811–829,
62. Rääsk T, Mäestu J, Lätt E, Jürimäe J, Jürimäe T, Vainik U, Konstabel K. Comparison of IPAQ-SF and two other physical activity questionnaires with accelerometer in adolescent boys. PloS One. 2017;12(1):e0169527.
63. Åkerstedt T, et al. Sleep and recovery. In: Current Perspectives on Job-Stress Recovery. Vol 7. Res. Occup. Stress Well Being. Bingley, UK: Emerald Group Publishing Limited;2009;205–247. http://www.emeraldinsight.com/doi/abs/10.1108/S1479-3555%282009%290000007009. Accessed January 3, 2017.
64. Milner CE, Cote KA. Benefits of napping in healthy adults: impact of nap length, time of day, age, and experience with napping. J Sleep Res. 2009;18(2):272–281.