




Review

Changes in Workers' Physical Activity and Sedentary Behavior during the COVID-19 Pandemic

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Abstract: Background: COVID-19 has changed the world and strongly affected the health of the people and the quality of their life. These changes might impact employees' physical activity (PA) and sedentary behavior (SB). This study aimed to summarize the literature focusing on the COVID-19-caused changes in physical activity and sedentary behavior among the adult working population. Methods: Literature searches were conducted in June 2021 using multiple electronic databases. The following keywords and synonyms were used during the searching process: physical activity, sedentary behavior, COVID-19, employee. After the data cleaning process (duplicates, inclusion criteria), the title and the abstract of all manuscripts from the searches were screened independently by two reviewers. Results: Thirty-nine manuscripts were selected as a result of the searching process. Of these, 5 were SB related, 15 were PA related and 19 addressed both PA and SB. There were longitudinal (10), cross-sectional (28) and a case study (1) in the selected manuscripts. The majority of studies were conducted in the USA (6) and Europe (18), and four studies examined the PA and/or SB in multiple countries. The majority (34 studies) of the studies used subjective, self-reported, but mostly before-validated questionnaires. Objective measures were less common and used only 12.8% of the examined studies. Moreover, 76.4% of the studies described an overall decrease in the amount of PA during the COVID-19 pandemic. In three cases, researchers observed an increase in PA among the workers. Five studies reported no significant changes in the amount of PA during the pandemic. As far as SB is concerned, 18 out of 24 of the studies reported an overall increase in the amount of SB between the two periods. Four manuscripts reported no significant change in the amount of SB, and there was only one manuscript in the examined studies that reported an overall decrease in the SB time before and during the COVID-19 pandemic. Discussion: There is no doubt that the COVID-19 pandemic, including lockdown and work from home (WFH) policies, impaired the PA and SB level of the populations. This period has delivered an important message for the adult working population as well. They should be as active as possible and avoid high levels of SB and uninterrupted sitting time. Therefore, organizations, policies and public health bodies should motivate workers, especially office workers, to be more active and interventions must be developed to mitigate the negative effects of the COVID-19 on PA and SB.

Keywords: physical activity; sedentary behavior; workers; COVID-19; working from home

1. Introduction

People's lifestyles have changed significantly in recent years, with an increasing number of people living a sedentary lifestyle, mainly in developed countries. According to

Tremblay et al. [1], sedentary behavior can be defined as any waking behavior characterized by an energy expenditure ≤ 1.5 metabolic equivalents (METs), put simply as any time people are sitting or lying down. Due to the significant increase in SB levels in most developed countries over the past century, occupational SB has appeared as a substantial public health issue. The main contributor to the daily sedentary time for workers is the substantial sitting time at the workplace [2]. People may spend three-quarters of the workday in SB [3], and according to Kazi et al., if people spend more time sitting during the workday, they will spend more time sitting during their leisure time [4]. SB should separate from the lack of physical activity because people can be sufficiently active according to the PA guidelines while sitting too much [5,6]. High sedentary times (for example, during work time) have been associated with harmful health effects independent of PA [7], including premature all-cause mortality [8], overweight, obesity, cancer and chronic illnesses such as cardiovascular diseases, metabolic syndrome, type 2 diabetes and low back pain [9–11].

Insufficient PA is also a key risk factor for the above-mentioned non-communicable diseases (NCDs) and is currently one of the leading risk factors for mortality worldwide [12–14]. According to Lee et al., the inactive lifestyle contribution to global premature deaths is approximately 9% [12]. Therefore, it is indisputable that being regularly physically active is an important determinant of health and plays a crucial role in people's health and quality of life; consequently, it is an essential issue in public health recommendations. The World Health Organization (WHO) recommends 150 min of moderate-intensity or at least 75 min of vigorous-intensity aerobic physical activity, or an equivalent combination of moderate- and vigorous-intensity activity, throughout the week for substantial health benefits [15]. However, worldwide, approximately 27.5% of adults and 81% of adolescents do not meet the recommendations for aerobic exercise, and therefore, there is an urgent need to increase physical activity and reduce sedentary time [16].

Due to the rapid technological development nowadays, more and more jobs have become sedentary, and more adults are employed in low activity occupations where they could accumulate the time of SB, which may contribute to the risk of NCDs [17–20].

Furthermore, the COVID-19 pandemic has changed the world and strongly affected the health of the people and the quality of their life (more than 190 million people with COVID-19, causing more than 4.1 million deaths worldwide) [21]. As suggested by the WHO, national containment strategies (e.g., social distancing) were implemented worldwide by national authorities to mitigate the spread of the COVID-19 virus. These national restrictions have interrupted normal daily activities such as PA. This new virus has significantly altered employment as well: businesses had to close for a while or constantly, and many workers (especially office workers) were required to shift to a remote working environment (working for home—WFH) to stay safe [22]. The conventional concept of WFH has been reconsidered by the COVID-19, and WFH has become a policy priority for most governments and presumably, after the pandemic, it will become more common among businesses [23]. The increase in WFH during the pandemic may have negative impacts on working conditions, and workers may have adapted unhealthy lifestyles. This may result in an increase in SB and a decrease in PA [24].

Since the initial lockdown restrictions were implemented, the number of studies related to PA and SB during the COVID-19 pandemic has been growing. Previous literature on PA or SB and the present pandemic has mainly focused on the general population [25–32], the older population [33–35], people with different chronic illnesses [36–38], health care professionals [39] or athletes [40,41]. Employees, and especially office workers, are underrepresented. Nevertheless, they are often included in the participants of these studies. However, no study, to the best of our knowledge, has yet synthesized the literature in connection with the COVID-19 pandemic and the changes of the employees' PA and SB. In this paper, we try to conduct a systematic review on the COVID-19-caused changes in the level of PA and SB among employees. The main purposes of this study were, on the one hand, to collect studies which directly or indirectly investigate the employees' PA and SB overall changes during the COVID-19 pandemic and, on the other hand, to identify the home office effects on the level of PA and SB.

2. Materials and Methods

In June 2021, a literature search was performed, and the scientific journal articles were retrieved from ScienceDirect, PubMed and Scopus. We used these sources since all of them provide immediate access to the relevant studies. Manuscripts were selected according to the following inclusion and exclusion criteria:

Inclusion criteria:

- Study populations involving healthy adult employees (in any country);
- Study outcomes investigating any form of PA and/or SB changes before and during the COVID-19 lockdown;
- Manuscripts written in English language;
- No restriction used in connection with study design;
- Publication type involving research papers.

Exclusion criteria:

- Study population involving children, adolescents, older or retired people or with a specific disease condition;
- Study outcomes not investigating the change of the PA and/or SB before and during the COVID-19 lockdown;
- Study not examining the employees' subgroup;
- Publication type involving letters to editor, comments, editorials, reviews and recommendations.

At the end of the journal database search and selection process, an additional academic search was conducted, which was not restricted to only journal articles. Dissertations, master theses and project works were examined in connection with the topic. The same inclusion and exclusion criteria were applied.

To cover the relevant studies, literature searches will only include papers published since November 2019. All articles whose topics were related to the present study were taken into consideration. During the search, Boolean operators (such as AND or OR) and the following keywords were used (Table 1).

COVID-19, novel coronavirus, physical activity, sedentary, physical inactivity, sitting, worker, working from home, employment, employee, occupation.

Duplicates were removed with the use of Zotero reference management software. The title and the abstract of all manuscripts from the searches were screened independently by two reviewers (G.R., É.B.B.), who determined the acceptability of the studies according to the inclusion and exclusion criteria. If disagreements aroused between the reviewers during the selection process, a third reviewer (K.R.-Ó.) was consulted; this was necessary on five occasions. Selected full-text manuscripts were then examined by G.R. and reviewed by É.B.B., K.R.-Ó., K.K., Z.B., I.F. and P.L. In order to identify other sources, the reference lists of the selected full-text manuscripts were further manually searched.

Reviewers picked out the following data from the selected studies: author (year of publication), the title of the manuscript, country, sample size, PA or SB assessment, study design, working population of the sample, change direction in SB, key findings related to SB, change direction in PA, key findings related to PA, main outcomes and types of outcomes.

Table 1. Search strategy: databases and searching terms.

Database	Searching Terms
PubMed	((((COVID-19 [Title/ Abstract] OR “Novel Coronavirus” [Title/ Abstract] AND (“Physical activity” [Title/ Abstract] OR “Physical inactivity” [Title/ Abstract] OR “Sedentary behavior” [Title/ Abstract] OR Sitting[Title/ Abstract]) AND (Worker [Title/ Abstract] OR “Working from home” [Title/ Abstract] OR Employment [Title/ Abstract] OR Employee [Title/ Abstract] OR Occupation [Title/ Abstract]))))
Scopus	(TITLE-ABS-KEY (COVID-19 OR “Novel Coronavirus” AND TITLE-ABS-KEY (“Physical activity” OR “Physical inactivity” OR “Sedentary behavior” OR Sitting) AND TITLE-ABS-KEY (Worker OR “Working from home” OR Employment OR Employee OR Occupation))
ScienceDirect	COVID-19 OR Coronavirus AND physical activity OR sedentary OR physical inactivity OR sitting AND worker OR working from home OR employment OR employee OR occupation.

3. Results

Our search identified a total of 982 records. When duplicates were removed, studies were limited to English and human samples, and inappropriate manuscript types were excluded: a total of 508 records were retained. After title and abstract screening, we located 80 full-text articles. The citations of these papers were then screened. An additional nine eligible papers were identified and one of these was retained after full-text review. At the end of the selection process, additional sources were screened to find other relevant studies, and finally, four studies were added to the selection. Due to the actuality of the research topic, we have found several early-stage studies, and three of them were selected, for which the publications are currently in the peer-review process phase [42–44]. In two cases, we selected a high-quality master’s thesis or project work [45,46].

The flowchart of the search and selection process is shown in Figure 1.

3.1. Main Characteristics of the Studies

Table 2 contains a summary of the characteristics of the studies reviewed. Thirty-nine manuscripts were selected as a result of the searching process. Five manuscripts were SB related, 15 manuscripts were PA related and 19 manuscripts addressed both PA and SB. There were longitudinal studies (10), cross-sectional studies (28) and a case study (1) in the selected manuscripts. The majority of the studies were conducted in Europe (18) and the USA (6), and four studies examined the PA and/or SB in multiple countries.

Of the studies, 20 out of 39 had focused on only the employees, and 16 manuscripts had studied the general population but directly investigated the employment status. An average 56.35% of the examined population was employed and investigated directly of these studies. In three cases [47–49], there was no information about the ratio of employees in the examined population, but the daily occupational PA was determined, and we considered this information. The total of 39 included manuscripts yielded a total of 118,022 participants with a range of job types. Twelve studies especially examined office workers [23,46,50–59], and 11 studies [22,23,42,44–46,52,60–63] examined WFH or remote working.

3.2. Measurement Types and Outcomes of the Studies

Objective measures were less common and were used in only 12.8% of the examined studies. Different smart technologies were used to identify PA patterns; two times activity trackers [50,51] and accelerometers [52,53] were used, one time a mobile application was used [64] and one time a mixed methodology was used (next to the objective measurement self-report measure International Physical Activity Questionnaire—short form also employed to collect additional information) [65]. The majority (35 studies) of the studies used subjective, self-reported but generally before-validated questionnaires (e.g., International Physical Activity Questionnaire, Global Physical Activity Questionnaire, Occupational Sitting and Physical Activity Questionnaire).

A range of outcomes was used to categorize PA and SB changes in the form of time (e.g., METs/min/week, step counts/day or different types of PA levels in minutes or hours/day or week) and as a percentage of the population.

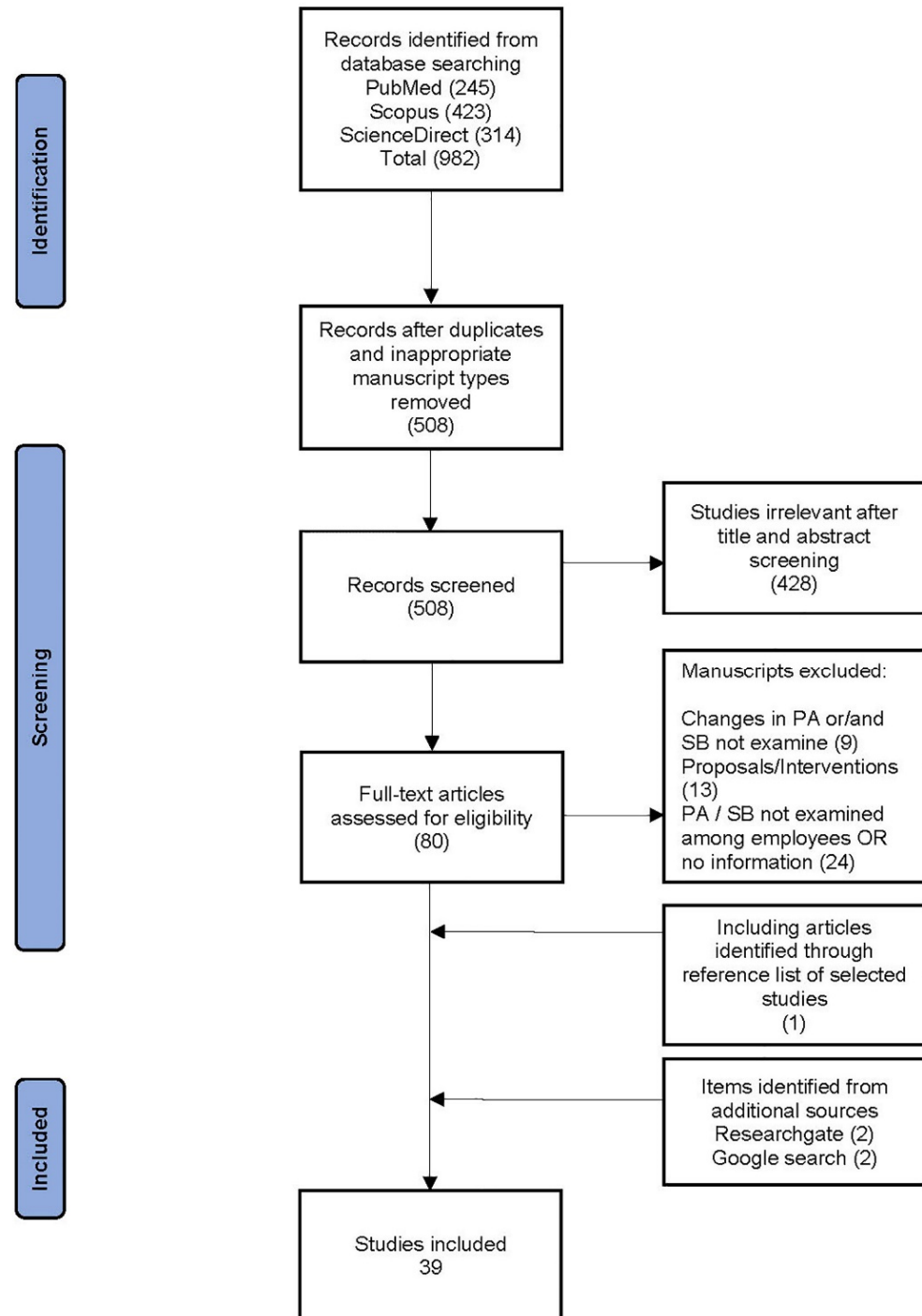


Figure 1. Study selection process.

Table 2. Characteristics of included studies.

Author (Year of Publication)	Title of the Manuscript	Country	Sample Size	PA or SB Assessment	Study Design	Working Population of the Sample	Employment Status	Change Direction in SB	Key Findings Related to SB	Change Direction in PA	Key Findings Related to PA	Main Outcomes	Outcomes Category
Adamkis (2021) [50]	Physical activity, sleep and weight management in the COVID-19 era: a case report	IRE	1	Activity tracker (Garmin Vivofit 4)	case study—8 weeks	Workers	Office worker	NI		▼	During COVID-19, there was a significant decrease in daily steps taken.	step count/day	
Aegerter et al. (2021) [55]	No Evidence for a Decrease in Physical Activity Among Swiss Office Workers During COVID-19: A Longitudinal Study	SUI	76	self-reported (IPAQ-SF)	longitudinal study	Workers	Office worker	NI		—	The total PA did not decline during the COVID-19 lockdown. There was no evidence of a decline in any of the three types of PA (walking, moderate-intensity activity and vigorous-intensity activity). Across the three categories “high,” “moderate” and “low” PA, 17% of the participants became less active during the lockdown while 29% became more active.	MET minutes/week	Walking, moderate-intensity activity, vigorous-intensity activity.
Argus—Pääsuke (2021) [56]	Effects of the COVID-19 lockdown on musculoskeletal pain, physical activity, and work environment in Estonian office workers transitioning to working from home	EST	161	self-reported (BPAQ)	cross-sectional data	Workers	Office worker	▼	In text: A significantly lower sedentary time was detected. No significant difference in the duration of continuous work was found.	▼	During COVID-19, a decline has been detected in self-reported PA levels (sport, leisure). However, an increase can be observed in work-related PA level.	Baecke Physical Activity Index	Work-related PA, sport-related PA and leisure-time PA.

Table 2. Cont.

Author (Year of Publication)	Title of the Manuscript	Country	Sample Size	PA or SB Assessment	Study Design	Working Population of the Sample	Employment Status	Change Direction in SB	Key Findings Related to SB	Change Direction in PA	Key Findings Related to PA	Main Outcomes	Outcomes Category
Blom et al. (2021) [57]	Lifestyle Habits and Mental Health in Light of the Two COVID-19 Pandemic Waves in Sweden, 2020	SWE	5599	self-reported	cross-sectional data	Workers	Blue-collar workers/White-collar workers	—	Small perceived changes in sitting time. The majority of respondents reported no change due to the first pandemic wave (66.1%) and second wave (78.5%) in sitting time. White-collar workers had higher odds of decreasing sedentary time compared to blue-collar workers.	—	Small perceived negative changes in PA. The majority of respondents reported no change due to the pandemic in daily PA (first wave: 62.5%; second wave: 72.2%) and exercise (first wave: 59.4%; second wave: 71.0%). White-collar workers had higher odds of increasing daily PA and exercise than blue-collar workers.	min/day, percentage of the respondents	Perceived change in sitting time, daily activity, exercise.
Bourdas—Zacharakis (2020) [47]	Impact of COVID-19 Lockdown on Physical Activity in a Sample of Greek Adults	GRE	8495	self reported (Active-Q)	cross-sectional data	No information	No information, just reference to occupational PA	NI		▼	During COVID-19, a large decline has been detected in daily occupational PA level.	MET minutes/week	Daily occupation, transportation to and from daily occupation, leisure time activities and regular sporting activities.
Bourdas—Zacharakis (2020) [48]	Evolution of changes in physical activity over lockdown time: Physical activity datasets of four independent adult sample groups corresponding to each of the last four of the six COVID-19 lockdown weeks in Greece	GRE	5206	self reported (Active-Q)	cross-sectional data	No information	No information, just reference to occupational PA	NI		▼	During COVID-19, a large decline has been detected in daily occupational PA level.	MET minutes/week	Daily occupation, transportation to and from daily occupation, leisure time activities and regular sporting activities

Table 2. Cont.

Author (Year of Publication)	Title of the Manuscript	Country	Sample Size	PA or SB Assessment	Study Design	Working Population of the Sample	Employment Status	Change Direction in SB	Key Findings Related to SB	Change Direction in PA	Key Findings Related to PA	Main Outcomes	Outcomes Category
Brusaca et al. (2021) [53]	Physical Behaviours in Brazilian Office Workers Working from Home during the COVID-19 Pandemic, Compared to before the Pandemic: A Compositional Data Analysis	BRA	11	accelerometer (Axivity AX3) + self-reported diary	longitudinal study (5 days (weekend))	Workers	Office worker	—	Office workers spent much time in SB, but no significant change was observed during the COVID-19.	▼	During COVID-19, workers spent less time in different PA levels.	min/day	Sedentary behaviour: lying and sitting, standing.; light PA: moving and slow walking; moderate-to-vigorous PA: fast walking, stair climbing, running and cycling, time-in-bed.
Buoite Stella et al. (2020) [65]	Smart technology for physical activity and health assessment during COVID-19 lockdown	ITA	400 (continued working as usual: 69 person can identify as a worker)	self-reported (IPAQ-SF; step data)	cross-sectional data	Workers—50.5% of the respondents—17.25% investigated directly	Employee/ Manager/ Freelancer/ Health professional	NI		▼	During COVID-19, a large decline has been detected in daily step count and MET value (IPAQ-SF) among those who continued working as usual during the lockdown.	MET minutes/week; step count/day	
Castañeda—Babarro et al. (2020) [43]	Impact of COVID-19 confinement on the time and intensity of physical activity in the Spanish population	ESP	3800	self-reported (IPAQ-SF)	cross-sectional data	Workers—78% of the respondents; Study work—10% of the respondents	Workers	▲	SB were negatively affected during the COVID-19 outbreak. Significant increase can be observed.	▼	PA were negatively affected during the COVID-19 outbreak. Significantly decreased VPA, walking can be observed, MPA did not change	MET minutes/week	Walking, moderate-intensity PA and vigorous-intensity PA, sitting.

Table 2. Cont.

Author (Year of Publication)	Title of the Manuscript	Country	Sample Size	PA or SB Assessment	Study Design	Working Population of the Sample	Employment Status	Change Direction in SB	Key Findings Related to SB	Change Direction in PA	Key Findings Related to PA	Main Outcomes	Outcomes Category
Da Silva et al. (2021) [60]	Changes in the prevalence of physical inactivity and sedentary behavior during COVID-19 pandemic: a survey with 39,693 Brazilian adults	BRA	39,693	self-reported (ConVid—Behavior Survey)	cross-sectional data	Workers—25.9% WFH and 20.7% work with normal routine of the respondents	WFH/Normal routine/No work	▲	Prevalence of ≥ 4 h/day of TV-viewing and ≥ 4 h/day of computer/tablet significantly increased during the COVID-19 pandemic in the working population.	▼	Prevalence of physical inactivity (<150 min/week) increased, therefore PA declined during the COVID-19 pandemic in the working population.	percentage of the respondents	<150 min/week of PA; ≥ 4 h/day of TV viewing; ≥ 4 h/day of computer/tablet.
Ding et al. (2021) [64]	How COVID-19 lockdown and reopening affected daily steps: evidence based on 164,630 person-days of prospectively collected data from Shanghai, China	CHI	815	Smartphone application (WeRun—step data)	longitudinal study	Workers	Workers	NI		▼	Sharp decline in daily steps has been detected, and it was followed by a slow but steady increase. This increasing trend continued into the reopening phase. By the end of the study (3.5 month into the reopening), total step counts were still slightly below the baseline level.	step count/day	
Fearnbach et al. (2021) [61]	Factors Protecting against a Decline in Physical Activity during the COVID-19 Pandemic	USA	4376	self-reported (Pennington Biomedical COVID-19 Health Behaviors Survey)	cross-sectional data	Workers—72.9% of the respondents. (WFH—32.2%; Not WFH—37.4%; Already WFH—3.3%;—Not working—27.1%)	WFH/Not WFH/Already WFM/No work	NA		▼	During COVID-19, those who transitioned to working from home saw a minimal increase in PA, whereas all others (not working from home, already working from home before COVID-19 and not working before COVID-19) experienced a decline.	MET minutes/week, percentage of the respondents	Perceived change in PA.

Table 2. Cont.

Author (Year of Publication)	Title of the Manuscript	Country	Sample Size	PA or SB Assessment	Study Design	Working Population of the Sample	Employment Status	Change Direction in SB	Key Findings Related to SB	Change Direction in PA	Key Findings Related to PA	Main Outcomes	Outcomes Category
Franco et al. (2021) [54]	Physical activity and adherence to the mediterranean diet among Spanish employees in a health-promotion program before and during the COVID-19 pandemic: The sanitas-healthy cities challenge	ESP	297	self-reported (IPAQ-SF)	cross-sectional data	Workers	Office worker	▲	Despite of employees have been participating in a health promotion program, SB were negatively affected during the COVID-19 outbreak. The ratio of sedentary participants significantly increased during the pandemic.	▲	Due to participants having been participating in a health promotion program during the COVID-19 pandemic, a significant increase has been detected in the moderate and total activity and a non-significant increase in vigorous activity and non-significant decrease in walking reported.	MET minutes/week, percentage of the respondents	Walking, moderate-intensity PA, vigorous-intensity PA, sedentarism.
Gibbs et al. (2021) [58]	COVID-19 shelter-at-home and work, lifestyle and well-being in desk workers	USA	112	self-reported (SBQ; PPAQ)	longitudinal study	Workers	Desk workers (sales or services; Clerical/administrative support; Professional/managerial/technical; Other)	▲	SB was negatively affected during the COVID-19 outbreak. Increased sitting and screen time can be observed, especially on non-workdays.	—	PA was no affected during the COVID-19 outbreak.	hours/day, minutes/week	SB, moderate-intensity activity, vigorous-intensity activity, moderate to vigorous intensity activity.
Hallman (2020) [52]	Working from home during the COVID-19 outbreak in Sweden: effects on 24-h time-use in office workers	SWE	27	accelerometer (Axivity AX3),	longitudinal study (7 day (weekend))	Workers	Office worker	—	Sedentary, standing and moving behaviours did not change markedly during days WFH compared to days WAO. A total sedentary time of this size, which is consistent with other studies of office workers.	NI	Standing and moving behaviors did not change markedly during days WFH compared to days WAO.	minutes/day	Sitting/lying, standing, moving.

Table 2. Cont.

Author (Year of Publication)	Title of the Manuscript	Country	Sample Size	PA or SB Assessment	Study Design	Working Population of the Sample	Employment Status	Change Direction in SB	Key Findings Related to SB	Change Direction in PA	Key Findings Related to PA	Main Outcomes	Outcomes Category
Hernandez et al. (2021) [42]	Influence of the COVID-19 lockdown on remote workers' physical and psychosocial wellbeing and work productivity	GBR	184	self-reported (IPAQ)	cross-sectional data	Workers	Remote worker/not remote worker	▲	The majority of respondents (70%) reported spending a greater amount of time sitting during the COVID-19 lockdown.	▲	During COVID-19, more respondents managed to increase the investigated PA levels (VPA, MVPA, walking).	MET minutes/week	Walking, moderate-intensity activity, vigorous-intensity activity, sitting.
Huntley, DG (2021) [45]	Effects of Working at Home During COVID-19 on Sedentary Behavior, Use of Strategies to Decrease Sedentary Behavior, and Perceived Work Performance	USA	194	self-reported (OSPAQ)	cross-sectional data	Workers	WFH	▲	Increased time spent in SB. However, sitting time decreased but no significant difference was found between the pre-COVID-19 and during COVID-19 times.	▼	During COVID-19, a decline has been detected in all investigated non-sedentary levels (walking, standing, heavy labour).	Minutes/day	Sitting, Standing, Walking, Heavy Labour.
Karaca et al. (2020) [66]	Sedentary Screen Time in Working Adults Before and During COVID-19 Pandemic	TUR	602	self-reported (PAAQ)	cross-sectional data	Workers	Employed	▲	Sedentary screen time (SST) at work decreased during COVID-19 compared to before COVID-19, while recreational SST increased. Work related sedentary screen time (SST) at home increased.	NI		Hours/week	Work-related SST at work, Work-related SST at home.
Katewongsa et al. (2020) [67]	The effects of the COVID-19 pandemic on the physical activity of the Thai population: Evidence from Thailand's Surveillance on Physical Activity 2020	THA	4460 (2019) 4482 (2020)	self-reported (GPAQ)	cross-sectional data	Workers—80.2% (2019) 83.6% (2020) of the respondents	Formal sector/ Informal sector/ Private enterprise/ Agriculture/ Unemployed	NI		▼	Huge decline can be observed in the percentage of Thai adult workers with sufficient MVPA in all types of occupation.	MVPA minutes/week, percentage of the respondents	Work-related, transportation and recreational.

Table 2. Cont.

Author (Year of Publication)	Title of the Manuscript	Country	Sample Size	PA or SB Assessment	Study Design	Working Population of the Sample	Employment Status	Change Direction in SB	Key Findings Related to SB	Change Direction in PA	Key Findings Related to PA	Main Outcomes	Outcomes Category
Katewongsa et al. (2020) [68]	The effect of containment measures during the COVID-19 pandemic to sedentary behavior of Thai adults: Evidence from Thailand's surveillance on physical activity 2019–2020	THA	5379 (2019) 6531 (2020)	self-reported (GPAQ v.2)	cross-sectional data	Workers—79.2% (2019) 84.2% (2020) of the respondents	Formal sector/ Informal sector/ Private enterprise/ Agriculture/ Unemployed	▲	During the COVID-19 pandemic, SB increased. Higher levels of SB were most frequent among employees in the private enterprises. Slight decrease can be observed in SB in the formal sector.	NI		SB minutes/day, percentage of the respondents	Work-related, transportation, and recreational.
Kooshari et al. (2021) [17]	Changes in Workers' Sedentary and Physical Activity Behaviors in Response to the COVID-19 Pandemic and Their Relationships With Fatigue: Longitudinal Online Study	JAP	2466	self-reported (GPAQ)	longitudinal study	Workers	Workers	▲	SB were negatively affected during the COVID-19 outbreak. The total SB level significantly increased during the pandemic (The work related and the PC use sitting time).	▼	PA were negatively affected during the COVID-19 outbreak. The total PA level significantly decreased during the pandemic (All domain specific PA decreased).	Hours/day	Work-related vigorous PA, Work-related moderate PA, Transport-related PA, Leisure-related vigorous PA, Leisure-related moderate PA, Sitting time in different domain.
Lopez—Bueno et al. (2020) [69]	Immediate Impact of the COVID-19 Confinement on Physical Activity Levels in Spanish Adults	ESP	2042	self-reported (PAVS-SF)	cross-sectional data	Workers—63% of the respondents	Employed/ Unemployed	NI		▼	The total PA declined during the COVID-19 lockdown among employees. Unemployed group showed greater PA levels decline than those employed.	Minutes/week	PA, MVPA (WHO)
Majumdar et al. (2020) [59]	COVID-19 pandemic and lockdown: cause of sleep disruption, depression, somatic pain, and increased screen exposure of office workers and students of India	IND	558	self-reported (MCTQ;CES-D;NQ)	cross-sectional data	Workers—36.4% of the respondents	Office worker/ Students	▲	Increased time spent at the workstation. Office workers spent greater duration of time on their cell phone, desktop/laptop computers during the lockdown.	NI		Hours/day	Cellphone usage, Desktop/laptop usage, Television usage.

Table 2. Cont.

Author (Year of Publication)	Title of the Manuscript	Country	Sample Size	PA or SB Assessment	Study Design	Working Population of the Sample	Employment Status	Change Direction in SB	Key Findings Related to SB	Change Direction in PA	Key Findings Related to PA	Main Outcomes	Outcomes Category
Mata et al. (2020) [44]	Health behaviors and mental health before and during the COVID-19 pandemic: A longitudinal population-based survey.	GER	3500	self-reported	longitudinal study	Workers—14.4% (remote workers) of the respondents investigated directly	Working at the workplace/Remote work/Part-time work, furloughed, unemployed/Retired/Not working	▲	People working remotely spent more time in front of the screen during the COVID-19 lockdown.	▼	People working remotely less active during the COVID-19 lockdown.	Percentage of the respondents	
McDowell et al. (2020) [22]	Working From Home and Job Loss; Due to the COVID-19 Pandemic Are Associated With Greater Time in SB	USA	2303	self-reported	cross-sectional data	Workers	No change in work/WFH/Job loss	▲	Greater time spent sitting and viewing screens.	—	PA did not differ by COVID-19 employment changes.	Minutes/day, Share of WHO recommendation	
Ong et al. (2021) [51]	COVID-19-related mobility reduction: heterogeneous effects on sleep and physical activity rhythms.	SIN—INT	1824	Activity tracker (Fitbit Ionic)	longitudinal study	Workers	In text: Most were office worker	NI		▼	Indices of PA (step count and MVPA), declined during COVID-19 lockdown.	Step count/day, moderate to vigorous PA (MVPA) minutes	
Radwan et al. (2021) [62]	Indirect Health Effects of COVID-19: Unhealthy Lifestyle Behaviors during the Lockdown in the United Arab Emirates	UAE	2060	self-reported	cross-sectional data	Workers—74.58% of respondents (WFH 54.8% investigated directly)	WFH/Working/Not working	NI		▼	Decreased physical activity was significantly associated with WFH.	Percentage of the respondents	Decreased PA.
Rodríguez—Nogueira et al. (2021) [70]	Musculoskeletal Pain and Teleworking in Times of the COVID-19: Analysis of the Impact on the Workers at Two Spanish Universities	ESP	472	self-reported (SNQ)	cross-sectional data	Workers	Administrative staff/Teaching and research staff	▲	SB were negatively affected during the COVID-19 outbreak. A significant increase was observed in the number of participants who not doing any exercise.	▼	During COVID-19, a decline has been detected in all investigated PA levels, but the number of women who carry out exercise frequently has increased.	Hours/day	PA (never, seldom, frequently).

Table 2. Cont.

Author (Year of Publication)	Title of the Manuscript	Country	Sample Size	PA or SB Assessment	Study Design	Working Population of the Sample	Employment Status	Change Direction in SB	Key Findings Related to SB	Change Direction in PA	Key Findings Related to PA	Main Outcomes	Outcomes Category
Schaap (2020) [46]	Occupational Sedentary Behaviour During COVID-19 Regulations-Related Working From Home	NED	119	self-reported (BQOS)	cross-sectional data	Workers	Office worker (WFH)	▲	Office workers are very much sedentary while working from home during the COVID-19 regulations.	▼	Participants experienced less PA during WFH.	Minutes/day, percentage of the respondents	Sitting, moving, standing.
Schmidt—Pawlowski (2021) [63]	Physical Activity in Crisis: The Impact of COVID-19 on Danes' Physical Activity Behavior	DEN	1802	self-reported	cross-sectional data	Workers—60.2% of the population are employed	Work outside of home/Work at home/Work partly outside partly at home/Not work/Sent home student/Other	NI		▼	The total PA declined during the COVID-19 lockdown in the WFH, partly WFH groups. An increase has been detected among the work outside of home group.	Minutes/week	PA
Taeymans et al. (2021) [71]	Physical Activity, Nutritional Habits, and Sleeping Behavior in Students and Employees of a Swiss University During the COVID-19 Lockdown Period: Questionnaire Survey Study	SUI	821	self-reported (IPAQ-SF)	cross-sectional data	Workers—12.2% of the respondents	BSc students/MSc students/Employees	▲	Employees had a higher median daily sitting time. Prevalence of long sitting time is higher compared to national data.	NI	The employee group showed a lower median summed MET minutes per week.	MET minutes/week, minutes/day	Walking, moderate-intensity PA, and vigorous-intensity PA, sitting.
Wilke et al. (2021) [49]	A pandemic within the pandemic? Physical activity levels substantially decreased in countries affected by COVID-19	INT	13,503	self-reported (NPAQ-S)	cross-sectional data	no information	No information, just reference to occupational PA	NI		▼	During COVID-19, a decline has been detected in all investigated PA levels. Declines in PA were higher for occupational (53%) than for leisure time (34%).	Minutes/week	Moderate-to-vigorous PA, vigorous PA during leisure time, occupational time.

Table 2. Cont.

Author (Year of Publication)	Title of the Manuscript	Country	Sample Size	PA or SB Assessment	Study Design	Working Population of the Sample	Employment Status	Change Direction in SB	Key Findings Related to SB	Change Direction in PA	Key Findings Related to PA	Main Outcomes	Outcomes Category
Xiao et al. (2021) [23]	Impacts of Working From Home During COVID-19 Pandemic on Physical and Mental Well-Being of Office Workstation Users	INT	988	self-reported	cross-sectional data	Workers	Office worker (WFH)	NI	In text: Increased time spent at the workstation.	▼	During COVID-19, a large decline has been detected in daily occupational PA level. Respondents reported decreased overall PA and exercise.	Percentage of the respondents	Overall PA (e.g., standing, step count), Physical exercise (e.g., classes, walking, running, biking).
Yang—Koenigstofer (2020) [72]	Determinants of physical activity maintenance during the COVID-19 pandemic: A focus on fitness apps.	USA	431	self-reported (IPAQ-SF)	longitudinal study	Workers—93% of the respondents	Employed/ Self-employed/ Unemployed	—		▼	During COVID-19 decline has been detected in two PA levels: moderate PA and vigorous PA decreased.	MET minutes/week	Walking, moderate-intensity PA, vigorous-intensity PA, sitting.
Schuch et al. (2021) [73]	Moderate to vigorous physical activity and sedentary behavior changes in self-isolating adults during the COVID-19 pandemic in Brazil: a cross-sectional survey exploring correlates.	BRA	877	self-reported	cross-sectional data	Workers—66.1% of the respondents (self-isolated)	Employed/ Unemployed/ Student/ Military/ Retired	▲	SB were negatively affected during the COVID-19 outbreak. Significant increase was observed in the number of participants who were employed.	▼	During COVID-19, MVPA declined in those with an occupation.	Hours/day, minutes/week	MVPA, SB—persistent inactive, decreased PA, increased PA, persistent active.
Hall-López (2020) [74]	Physical activity levels in physical education teachers before and during school suspension brought by the COVID-19 quarantine	MEX	37	self-reported (IPAQ)	cross-sectional data	Workers	Workers	NI		▼	The level of PA MET-minutes/week of PE teachers decreased during the COVID-19 quarantine.	MET minutes/week	Low, Moderate, High.

Table 2. Cont.

Author (Year of Publication)	Title of the Manuscript	Country	Sample Size	PA or SB Assessment	Study Design	Working Population of the Sample	Employment Status	Change Direction in SB	Key Findings Related to SB	Change Direction in PA	Key Findings Related to PA	Main Outcomes	Outcomes Category
Alfawaz et al. (2021) [75]	Effects of home quarantine during COVID-19 lockdown on physical activity and dietary habits of adults in Saudi Arabia	KSA—INT	1946	self-reported	cross-sectional data	Workers—58.6% of the respondents	Employed/Unemployed/Student/Own business/Farmer	NI		▼	During COVID-19, daily walking and home PA decreased. However, there was a significant percentage of participants who increased their frequency by 3–4 times per week in swimming. Employment status has no effect on this result.	Days/week	Daily walking, Home PA with weights, Swimming.
Barcley et al. (2020) [76]	The Acute Effects of the COVID-19 Pandemic on Physical Activity and Sedentary Behavior in University Students and Employees.	USA	398	self-reported (IPAQ, Godin)	cross-sectional data	Workers—53.7% of the respondents	Undergraduate/Graduate/Faculty/Staff/Administration/Other	▲	Participants significantly increased average weekly sitting during the COVID-19 isolation.	—	Although the overall PA increased among the employees, this is not supported by the statistical analysis.	MET minutes/week, Godin Score	Mild, Moderate, Vigorous, Sedentary.
Greany et al. (2021) [77]	Self-reported changes in physical activity, sedentary behavior, and screen time among informal caregivers during the COVID-19 pandemic.	USA	835	self reported	cross-sectional data	Workers	Workers	▲	More than half of the respondents reported an increase in SB (63%) an ST (weekday: 61%; weekend: 57%).	▲	More than half of respondents (55%) reported an increase in MPA and nearly half of respondents (48%) reported an increase VPA.	Percentage of the respondents	Moderate intensity PA, Vigorous intensity PA, Sedentary Behavior, Screen time.

Notes: Countries abbreviation: IRE = Ireland, BRA = Brazil, USA = United States of America, SUI = Switzerland, SWE = Sweden, MEX = Mexico, DEN = Denmark, INT = International, NED = Nederland, GER = Germany, JAP = Japan, GBR = Great Britain, THA = Thailand, CHI = China, ITA = Italy, GRE = Greece, TUR = Turkey, ESP = Spain, EST = Estonia, UAE = United Arab Emirates, IND = India, KSA = Saudi Arabia, SIN = Singapore. Measurements abbreviation: IPAQ-SF = International Physical Activity Questionnaire—Short Form, Active-Q = Active-Questionnaire, BPAQ = Baecke Physical Activity Questionnaire, SBQ = Sedentary Behavior Questionnaire, PPAQ = Paffenbarger Physical Activity Questionnaire, OSPAQ = Occupational Sedentary and Physical Activity Questionnaire, GPAQ = Global Physical Activity Questionnaire, PAVS-SF = Physical Activity Vital Sign—Short Form, MCTQ = Munich Chrono-Type Questionnaire, CES-D = Epidemiological Studies-Depression Scale, NQ = Nordic Questionnaire, PAAQ = Physical Activity Assessment Questionnaire, NPAQ-S = Nordic Physical Activity Questionnaire—short, BQOS = Brief Questionnaire on Occupational Sitting, SNQ = Standardized Kuorinka Modified Nordic Questionnaire, Godin = Godin Physical Activity Questionnaire; Other abbreviations: MET = Metabolic Equivalent, MPA = Moderate Physical Activity, MVPA = Moderate to Vigorous Physical Activity, VPA = Vigorous Physical Activity, SB = Sedentary Behavior, PA = Physical Activity, SST = Sedentary Screen Time; ▲ = Increase; ▼ = Decrease; — = No change; NI = No investigation; NA = No available information.

3.3. PA in Adult Working Populations

In total, 76.4% of the studies described an overall decrease in the level of PA during the COVID-19 pandemic. In two cases, researchers observed an increase in PA among working adults. In the case of Franco et al. [54], respondents have been participating in health promotion programs during COVID-19 and maybe for this reason an increase has been detected in PA levels. In the other case [42], there were no specific promoting circumstances related to the PA level increase. Five studies [22,55,57,58,76] reported no significant changes in the level of PA between the periods. Studies addressed changes in PA in different forms: time spent on PA, step counts, percentage of the sample, comparison of results with the previous national data.

3.4. SB in Adult Working Populations

As far as SB is concerned, 18 out of 24 of the studies reported an overall increase in the amount of SB between the two periods. Four manuscripts [52,53,57,72] reported no significant change in the amount of SB, and there was only one manuscript in the examined studies that reported an overall decrease in the SB time before and during the COVID-19 pandemic among the working adult population. Studies addressed changes in SB in different forms: time spent on PA, step counts, percentage of the sample, comparison of results with the previous national data.

One paper [71] did not directly examine the changes of the amount of PA or SB pre-COVID-19 versus post-COVID-19 lockdown; however, the possible effect of lockdown can be observed. In Taeymans et al. study [71], the employees had a higher median daily sitting time and lower median summed MET minutes per week than other examined groups and the prevalence of long sitting time is higher compared to national data.

4. Discussion

The present review provides an overview of studies examining the changes in the employment's PA and SB during the COVID-19 pandemic. We identified 39 studies including different types of employments from several countries. Regardless of the applied methodology, a greater part of the investigated studies found that SB level increased and PA level decreased among the employees during the lockdown period.

Three-quarters of the studies reported negative effects on PA during the COVID-19 pandemic. In two cases, researchers observed an increase in PA among the employees, and six studies reported no significant changes in the amount of PA pre-COVID-19 versus post-COVID-19 lockdown among employees. Although [78] examined the impacts of the pandemic on a general population, our results are in line with the findings by this systematic review [78], which revealed that most of the selected studies found that the level of PA declined during the lockdown period. Several other studies examining different population groups found similar effects of the COVID-19 lockdown on participants' PA and sedentary patterns. For example, an online survey that examined the effects of the COVID-19 pandemic on PA among children in the USA reported that the parents perceived a decline in the PA level of the children as compared to before the pandemic [79]. In a mini-review [80], the authors reported a significant reduction of PA levels among university students compared to pre-lockdown values. Moreover, another review study investigating adults with physical disabilities and/or chronic diseases found a decrease in PA during the first wave of COVID-19 in almost every examined study [81].

A variety of methodologies and PA measures were used in the investigated articles (Table 2). Most of the studies had a cross-sectional design and applied mostly validated self-reported questionnaires, and only 12.8% of the research used objective measures. To avoid the limitations of the self-reported questionnaires, using objective measurement (e.g., accelerometer, pedometer) might be a solution [64]. Future research should focus on objective, directly comparable, accelerometer-based data where it is possible. For example, worldwide data from different wearable activity trackers revealed an overall decrease in step counts during the COVID-19 lockdown [82–84]. Tison et al. [85] examined the

changes in step count before and during the COVID-19 lockdown. The study found a decline in smartphone-derived step counts based on aggregated data. Differences can be observed between regions due to the regional variation in COVID-19 timing, enforcement, and behavior change [85].

Another study [64] also examined smartphone-based step counts from 815 Chinese adults before, during and after the lockdown. The study reported a sharp decline in daily step counts due to the abrupt nature of the lockdown, followed by a slow, steady increase, and almost four months after reopening, the total step counts were still slightly below the baseline level [64]. Objective data would be able to highlight the long-term consequences of the pandemic on peoples' PA level changes. The prediction of the long-term health effects of the lower PA level during and after the COVID-19 pandemic is difficult. However, a study from Japan reported a lasting significant decrease in PA level over three years following the 2011 earthquake and tsunami [24,86].

A potential reason for the decline in PA level among working adults might be that, on the one hand, during COVID-19, national governments prohibited several activities such as the majority of outdoor and social activities and most gyms, leisure and sporting facilities closed, therefore, people found it difficult to be active. On the other hand, additional responsibilities (e.g., school-aged children at home) for working adults and especially home-working employees also decreased opportunities to be active.

In contrast with the studies that showed a decline in PA levels among working adults, in two studies from Sweden and two studies from Switzerland, no changes in PA level were reported during the COVID-19 pandemic. These results can be explained by the less strict lockdown measures in the two countries: the stricter the confinement measures, the more likely that PA patterns are affected.

In most cases, people working remotely were less active during the COVID-19 lockdown [44,46,62], and those who continued to work at normal routine usually did not observe such a high level of changes in their PA level [52,58]. Dispersedly mode-specific and subgroup-specific increases can be found in different PA levels. However, the total PA levels decreased [70]. For example, in an Estonian [56] study, office workers reported a significant decrease in self-reported PA levels (sport, leisure), although an increase was reported in work-related PA level. However, the total level of PA decreased.

To slow down the spread of the coronavirus, several countries introduced enforcing social distancing, and the severity of these containment measures varies between countries. Lockdown restrictions, including self-isolation, stay at home, physical distancing, travel limitations, restrictions on public movement and banned sports activities and exercise outdoors are just some examples introduced during the pandemic [87]. This new virus has significantly altered people lives, and employment as well, businesses had to close permanently or constantly and many workers (especially office-based workers) were required to shift to a remote working environment (WFH) to stay safe [22]. For example, in Spain, remote work rose from almost 5% to 34% during quarantine [54]. Another study reported that nearly 50% of the participated organization had more than 80% of their employees working from home during the first wave of the COVID-19 pandemic [88]. The rise of remote working during the COVID-19 pandemic was confirmed in several other studies as well [89–92]. Switching to home offices may have a negative impact on employments' healthy habits. Employees and especially office workers are already at risk for being physically inactive (spending three-quarters of the workday in SB) [93], and it is especially true during the lockdown and the rise of WFH, which was associated with extended sedentary periods and increased screen time [22,52,54,78,94]. Employees who worked from home spent longer uninterrupted SB time during work time than those who never worked at home [95]. Even more alarming, if people spend more time sitting during the workday, they will spend more time sitting during their leisure time [4,96]. Furthermore, additional responsibilities (e.g., school-aged children) for home-working employees also decrease the opportunities to be active. According to a UK survey, 85% of UK employees with school-age children are balancing homeschooling with work [97].

Not surprisingly, 18 studies out of 24 reported an increase in SB time. In contrast with the studies that showed an increase in SB level among working adults, only four studies reported no changes in SB level during the COVID-19 pandemic (two studies from Sweden and two studies from Switzerland) [52,55,57,71]. These different results could be explained by the less strict lockdown measures in the two countries: the stricter the confinement measures, the more likely SB patterns are affected.

Although Stockwell et al. examined the impacts of the pandemic on a general population, our results are in line with the findings by this systematic review [78], which revealed that most of the selected studies found that the level of SB increased during the lockdown period. Moreover, in one study, despite employees have been participating in a health promotion program (10,000 steps/day), SB was negatively affected during the COVID-19 outbreak. The ratio of sedentary participants significantly increased during the pandemic [54].

Another review study investigating adults with physical disabilities and/or chronic diseases found an increase in SB during the first wave of COVID-19 in almost every examined case [81].

According to McDowell et al. switching to WFH due to the COVID-19 pandemic was associated with greater time spent sitting and was associated with more time spent in SB each day [22,45,46]. Fukushima et al. also support the fact that office workers are very much sedentary while working from home during the COVID-19 regulations, as they reported that WFH workers have 111 more minutes of sedentary behavior per day than non-WFH workers [95].

On the other hand, working from home, or in the office is even better than being unemployed during the pandemic as regards PA and SB. Recent research [22,60,63,69], in accordance with previous research [98], reported a lower level of PA and increased level of SB among unemployed people. In line with these results, previously inactive or low active people at baseline had become less physically active during the COVID-19 pandemic [29,57]. It is important to note that activity change during the COVID-19 lockdown depends on the level of lockdown and the habitual PA [64].

Lack of PA and accumulated SB is a known major health risk factor for poor overall health, premature mortality, and NCDs such as obesity, diabetes, and cardiovascular disease [8,9,11,99,100]. Moreover, it is even more important for older people and people with different chronic illnesses to be active in order to avoid the deterioration of their condition [70,101].

Office or desk workers probably have lower PA levels than other workers [102], therefore, it would be important, on the one hand, for organizations to be able to identify and help to preserve their employees' health regardless of whether they work from home or go to the office, and on the other hand, for governments and health professionals to encourage workers to be more active. Public health interventions are needed to break uninterrupted SB for all workers and motivate them to increase their PA, especially those who work from home. Innovative smart technologies may also contribute to prevent employees from a sedentary lifestyle and increase PA. For example, digital health coach technology can play in enhancing people's healthy behavior [103].

A strength of our study was that we conducted a systematic review in connection with the COVID-19 pandemic impacts on a specific population: the employees' PA and SB. Hence, our review may provide initial insight into the effects of the pandemic on the workers' activity behavior, and the results may contribute to the development of public health interventions among the adult working population.

Limitations

Although this is a review, the study has some limitations. First of all, the still ongoing pandemic and the novelty of the topic is one of the main limitations of the manuscript. Reviewers made great efforts in the searching process to find all relevant manuscripts; however, some articles may have been overlooked due to the examined databases and

the selected searching terms. The majority of the studies applied self-reported subjective questionnaires, which were often based on participants' retrospective answers where accuracy and objectivity may be questionable. In several studies, the selected sample did not represent the population at a national level. The different occupations and workplaces included in the selected studies also can be a bias. Different methods of assessing SB and PA in the studies also affect the comparison of the results. Finally, our inclusion criteria could be another bias since the present study investigated only the adult working populations and excluded other parts of the population such as adults with physical disabilities and/or chronic diseases or adolescents and children.

5. Conclusions

Despite the variety of measurement types and study methodologies of the selected studies, the majority of them reported that PA levels have significantly decreased and, at the same time, that SB levels have significantly increased in the adult working population during the COVID-19 pandemic. The stricter the confinement measures, the more likely that PA and SB patterns are affected. People working from home were less active during the COVID-19 lockdown. In contrast, those who continued to work in a normal routine usually did not observe such a high level of changes in their PA level. On the other hand, being unemployed is even worse than WFH, or working from the office, because unemployed people have a lower level of PA and increased level of SB. The lack of PA and accumulated SB is a known major health risk factor for poor overall health, premature mortality and NCDs. The findings of the present review and the well-known health risk factors of the inactive lifestyle illustrate the urgent need to support people, especially sitting-based workers, to increase PA and decrease sedentary time during the pandemic. The workplace is an outstanding opportunity for promoting PA and reducing sedentary time in the working population. Considering that the COVID-19 is an ongoing pandemic, the adult working population should be continuously surveyed, and interventions and strategies should be developed by organizations, governments and health professionals to increase the level of PA and decrease sedentary time among workers, with a special focus on people working from home.

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