Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

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Review

Covid-19 and the impact on the physical activity level of elderly people: A systematic review

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ABSTRACT

Introduction: Social isolation and lifestyle changes provoked by the COVID-19 pandemic have negatively affected the level of physical activity of the elderly people.
Objective: To evaluate the available evidence related to the level of physical activity (PA) of elderly people during the COVID-19 pandemic.
Methods: This is a systematic review, registered on *PROSPERO* (CRD42021241116), which included cross-sectional and cohort studies. Embase, Pubmed, Cochrane, Web of Science and Scopus databases were used to search for the studies. Finally, the New Castle-Ottawa Quality Assessment scale was used to measure the quality of the studies.
Results: 25 studies were found, being 14 cross-sectional and 11 cohort studies. The studies showed that the elderly population was highly affected in relation to the level of physical activity and lifestyle during restrictions, quarantine and lockdowns caused by the COVID-19. There was a significant reduction in physical activity levels, leading to declines in physical fitness and increased sedentary lifestyle, factors directly related to the increase in frailty in this population.
Conclusion: The level of physical activity in the elderly population decreased during the quarantine period of COVID-19 worldwide. Strategies to maintain physical condition must be encouraged with physical exercises that meets the needs of the elderly in the current pandemic scenario, in order to maintain and improve the health of this population.

1. Introduction

The SARS-CoV-2 virus, originated in China in December 2019, spread around the world causing a catastrophic pandemic, which led to the collapse of the healthcare systems in several countries and caused millions of deaths (Johns Hopkins University, 2021; World Health Organization Report, 2020). Because it has a high potential for transmission between humans, mainly by aerosols (WHO, 2020a), several government restrictions involving social distancing were created around the world, as a strategy to contain the COVID-19 outbreak (Centers for Disease Control and Prevention (CDC), 2020).

The positive results of these measures leave no doubt that social distancing reduces the transmission of the virus (Matrajt and Leung, 2020; Wang et al., 2020a). However, it is equally undeniable that such restrictions have harmed the quality of life and reduced the levels of physical activity (PA) of the global population (Martinez et al., 2020; Stockwell et al., 2021), leading to concerns secondary to the pandemic (Hall et al., 2021).

The World Health Organization defines PA as "any bodily movement produced by skeletal muscles that required energy expenditure", and determines the quantity of PA that must be performed by age groups (WHO, 2020b). For elderly people, it is recommended to do at least 150–300 min of moderate-intensity aerobic PA or at least 75–150 min or vigorous-intensity aerobic PA throughout the week (WHO, 2020b).

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The need for social distancing during the COVID-19 pandemic has resulted in drastic changes in lifestyle and social behavior (Hall et al., 2021). This leads to abrupt physical inactivity, which is associated not only with a reduction in skeletal muscle mass, but also with a loss of strength, which is an independent risk factor for mortality (Newman et al., 2006).

In an observational study including a total of 117 elderly people, conducted to investigate the influence of six weeks of lockdown on PA levels, perceived physical function, and mood of people aged ≥70 years, Richardson et al. (2021) found a significant increase in the time of sedentary behavior during the period of restrictions, which is related to negative impacts on health.

In addition to that, the increase in sedentary behavior during the pandemic is expected to lead to significant reductions in musculoskeletal strength and endurance and in cardiorespiratory capacity. Also concerning is the loss of lean mass, muscle function and motor control, that can lead to sarcopenia, cardiometabolic disorders and the emergence and/or worsening of other comorbidities, with more significant impacts on the elderly (Pelicioni and Lord, 2020; Rodrigues et al., 2020; Roschel et al., 2020). All of these factors lead to functional decline, which culminates in limitations in daily life and increased risk of falls, which can lead to serious trauma (Pérez-Ros et al., 2019), increasing morbidity and mortality rates (Rodrigues et al., 2020), especially in the elderly population (19 e 22).

Given the above, it is undeniable that social distance policies and changes in lifestyle during the COVID-19 pandemic have negatively affected the physical health of the elderly. Such losses bring concerns to the post-pandemic period, as the current scenario shows an increase in sedentary behavior and in the body mass index (Ekelund et al., 2019), which is associated with several diseases such as high blood pressure, diabetes, cardiovascular and respiratory diseases, among others (Lin et al., 2019; Powell-Wiley et al., 2021; Ten Hacken, 2009; Ahima, 2009).

In this sense, with a focus on elucidating the current evidence on this topic, the aim of this systematic review was to assess the available evidence related to the level of PA of the elderly people during the COVID-19 pandemic. We hypothesized that the elderly population was severely affected in relation to the level of PA during restrictions, quarantines and lockdowns caused by the COVID-19 pandemic.

2. Methods

2.1. Study design and ethical approval

This systematic review was performed based on *Preferred Reporting Items for Systematic Reviews and Meta-Analysis* (PRISMA) (Page et al., 2020; Page et al., 2021) guidelines, specific for observational studies. The review was prospectively registered on *PROSPERO* (registration number: CRD42021241116).

2.2. Inclusion and exclusion criteria

The following inclusion criteria were considered in this review: [1] observational studies that assessed the level of [2] PA in [3] elderly (60 years and over) during the [4] COVID-19 pandemic (December 2019 to October of 2021). Studies carried out beyond the stipulated period (December 2019 to October 2021) and studies with mixed populations (under 60 years) were not included.

The exclusion criteria consisted of [1] studies that retrieved information on PA levels based on ad hoc questionnaires or other questionnaires that have not been previously validated for elderly people, [2] comments, letters to the editor or studies not published in journals or [3] studies published in journals without peer review.

2.3. Search strategy

The search for studies was systematically performed in October 2021, at the following databases, via Capes Periodicals (https://www.periodicos.capes.gov.br/): 1) Embase; 2) PubMed; 3) Cochrane; 4) Web of Science; and 5) Scopus. The English terms used in the search were based on the literature corresponding to the purpose of the systematic review and on the encyclopedia of Medical Subject Headings (MeSH) terms. The primary descriptor "physical exercise" and its similar descriptors (e.g., "physical activity"; "sedentary behavior") was crossed with the secondary descriptors "elderly" and its similar ones (e.g. "older adults"; "aged") and "COVID-19".

The search only restricted the following factors: "publication period", defined from December 2019, when the first cases of COVID-19 appeared in China, until the day the search was carried out (October 2021); and "study type", including only complete observational studies. Other factors such as language and type of access (free or paid) were not restricted.

The manual search was performed based on the reference lists of the selected articles and on the simple search on the databases mentioned above.

2.4. Study selection

Two reviewers (IPS and VMK) independently performed the selection of the studies based on titles, abstracts and descriptors/keywords of all studies identified by the search strategy, according to the PRISMA guidelines (Page et al., 2020; Page et al., 2021). In case of disagreement, a third reviewer (e.g., MRO) was included as a tiebreaker (screening phase).

Subsequently, two reviewers (IPS and VMK) fully read all the preselected studies according to the eligibility criteria, where the same tiebreaker strategy was adopted as described in the previous phase (eligibility phase). The software *State of the Art Through Systematic Reviews* (StArt) (Luís et al., 2016) was used to conduct the study selection process.

2.5. Extract data and bias assessment

Finally, the data extraction was performed by two reviewers (IPS and VMK) independently regarding the characteristics of the studies and participants, assessment method of PA levels and main outcomes (inclusion phase).

The assessment of methodological quality was performed by two reviewers (IPS and VMK), following the *New Castle - Ottawa Quality Assessment Scale for Cohort Studies and adapted for Cross-Sectional Studies*, that contemplates three categories (Selection, Comparability and Outcomes) (Wells et al., n.d.). Studies with Newcastle-Ottawa form scores (Stang, 2010) of ≥7 were considered as high-quality, 5–6 as moderate quality and 0–4 as low-quality studies.

3. Results

3.1. Selection of the studies

A total of 1328 studies were found by searching the following databases: PubMed (165), Scopus (199), Web of Science (349), Cochrane library (47) and Embase (568). After excluding duplicate articles (442) and studies not meeting the inclusion criteria based on titles and abstracts (794), 92 studies showed potential relevance for full analysis. However, only 25 studies met the predefined eligibility criteria (14 cross-sectional and 11 cohort studies) (Figure 1).

3.2. Study characteristics

The characteristics of the studies included in this systematic review are described in Table 1. Regarding the nationality of the studies found, a prevalence of Japan, Spain and Italy was observed. Because the studies evaluated PA levels during the COVID-19 pandemic, all articles are

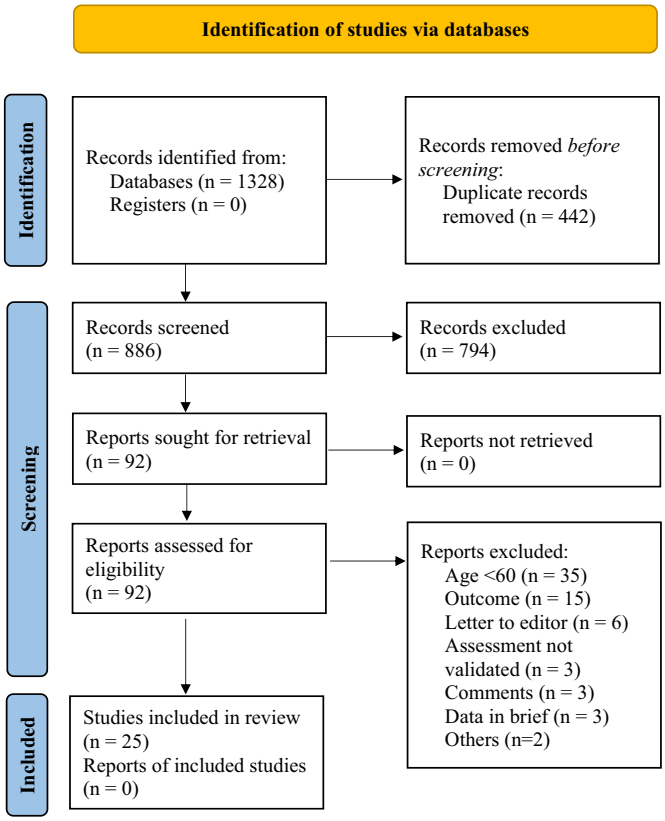

Fig. 1. Study flowchart.

recently published (from 2020 to 2021). The total number of individuals evaluated, including samples of all studies, was 15,964 elderly subjects. In most studies, the female gender was predominant. Few studies addressed comorbidities, with arterial hypertension, Parkinson's disease and diabetes mellitus being the most prevalent.

3.3. Main results of the studies

The methods for assessing the PA level and the main results of the studies are described in Table 2. The studies found aimed to evaluate and compare the levels of PA during the COVID-19 pandemic and lockdowns and to demonstrate the clinical impact of this period on the health of the elderly population.

Regarding the instruments used in the studies to assess the PA level, the International Physical Activity Questionnaire (IPAQ) predominated, either in its full, short (IPAQ-SF), or Environment Module (IPAQ-E) form. In addition, studies also used the Physical Activity Scale for the Elderly (PASE) questionnaire and the accelerometer.

From the application of such instruments, the authors found that quarantine and restrictions to prevent the spread of COVID-19 induced a significant reduction in PA levels in both sexes and changes in lifestyle. The main causes of the reduction in the level of PA, mentioned by the studies, in this period were the increase in sitting time, reduction in equivalent metabolic tasks (METs) and decrease in the number of steps. In addition, there was a reduction in exercise frequency and duration.

3.4. Quality of studies

Tables 3 and 4 show the quality of the 25 studies included, classified based on the Newcastle-Ottawa Quality Assessment Scale for cohort studies and the adapted scale for cross sectional studies (Wells et al., n. d.).

In Table 3, of the 14 cross-sectional studies, 5 were classified as "high-quality" (7 stars), 8 as "moderate quality" (4 to 6 stars) and 1 as "low-quality" ($\leq$ 3 stars). In Table 4, all 11 cohort studies were classified as "low-quality" ($\leq$ 5 stars).

4. Discussion

The studies included in this systematic review confirmed the hypothesis that the elderly population had the PA levels affected during restrictions, quarantines and lockdowns due to the COVID-19 pandemic, regardless of the country of origin of the study, given that each country followed its sanitary rules. The studies showed that there was a reduction in PA levels in the elderly due to the increase in sitting time, reduction in METs and decrease of the number of steps, which can lead to a decline in physical fitness and an increase in sedentary lifestyle.

Maugeri et al. (2020) showed a significant reduction in the total energy for weekly PA of the elderly in Italy. Pérez et al. (2021) in Spain, Meyer et al. (2020) in USA, Qin et al. (2020) in China and Yamada et al. (2020, 2021) in Japan found similar data, each one in their countries. Such data point to a PA reduction at a global level, reinforcing the need to develop strategies to change this condition, regardless of the country of origin. However, although the studies in this systematic review showed that the elderly people had PA levels affected by the pandemic independently in the country of origin of the study, it is important to emphasize that majority of the studies included in this systematic review were conducted in Europe and Asia (21 of 25 studies).

Both continents (Europe and Asia) suffered drastically with the COVID-19 pandemic and had high infection rates in 2020. Not coincidentally, countries in these continents had more severe social distancing and quarantine policies (China's aggressive measures have slowed the coronavirus, 2020; Woskie et al., 2021), which surely affected the lifestyle of these populations. This can be observed by the infection and mortality rates worldwide. Currently, the American continent leads the ranking of infections and mortality by COVID-19 (COVID-19 ranking, n. d.), which reflects the most flexible social distancing policies in these countries, especially in the United States and Brazil. Asia and Europe adopted early and aggressive social distancing policies to contain the outbreak (China's aggressive measures have slowed the coronavirus, 2020; Woskie et al., 2021), and despite there is no clear evidence comparing the impact of these policies between countries worldwide on PA levels, this leads us to the understanding that these measures had a greater impact on mobility and lifestyle of the European and Asian population when comparing to other continents.

In an accelerometer-based analysis on the PA level of 35 hypertensive elderly adults before and after the COVID-19 pandemic, Browne et al. (2020) showed that the pandemic significantly reduced steps/day ($\beta = -886$ steps/day, SE = 361, $p = 0.018$), moderate-vigorous PA ($\beta = -2.8$ min/day, SE = 2.4, p = 0.018), and a trend in light PA ($\beta = -26.6$ min/day, SE = 13.4, $p = 0.053$) of elderly. The authors also showed that sedentary behavior increased during the pandemic outbreak ($\beta = 29.6$ min/day, SE = 13.4, $p = 0.032$) in this population.

It is noteworthy that during the period when the study of Browne et al. (2020) was carried out, Brazil was experiencing a partial blockage of outdoor activities in many regions of the country, and the fact that this study assessed elderly people, allows us to clarify the results found. As the mortality rate was high in elderly and considering the daily disclosure by the media in relation to the number of deaths as well as the "stay at home" recommendations, this population may have had an even more severe impact on the reduction of the level of physical activity in relation to other age groups, favoring an increase in sedentary behavior, corroborating the findings of the Browne et al. (2020) study. In addition, in the study by Miyahara et al. (2021), carried out in Japan, in which they used accelerometers to objectively measure physical activity, the government officials imposed strict rules for the lockdown, affecting the level of physical activity, as shown by the results. On the other hand, in Sweden study, it is known that the impact of lockdowns and government-imposed blocks was smaller, with no impact on the level of

Table 1
Sample characteristics and sociodemographic data.

Author (Year)	Study design	Country	Sample size (n)	Male (%)	Age (years)	Main comorbidities
Maugeri et al. (2020)	Cross-Sectional	Italy	296	NM	Over 60	NM
Sasaki et al. (2021)	Cross-Sectional	Japan	999	462 (46)	74.5 ± 6.3	NM
Visser et al. (2020)	Cohort	The Netherlands	1119	528 (47.2)	74 ± 7.0	NM
Song et al. (2020)	Cohort	Korea	100	54 (54)	70 (62.3–76.0)	PD
Balci et al. (2021)	Cross-Sectional	Turkish	88	54 (61)	PD: 67 (60.0–73.5); Healthy: 66 (58.0–71.0)	PD
Pérez et al. (2021)	Cross-Sectional	Spain	98	33 (34)	82.4 ± 6.1	NM
Browne et al. (2020)	Cohort	Brazil	35	12 (34.3)	65.6 ± 3.8	HT; Db; Dl; Ow; Ob.
Meyer et al. (2020)	Cross-Sectional	USA	1062[a]	NM[a]	≥65[a]	NM
Richardson et al. (2021)	Cross-Sectional	UK	117	52 (44.4)	75 ± 4	NM
Di Santo et al. (2020)	Cross-Sectional	Italy	126	24 (19)	74.29 ± 6.51	Ob; Db; Ht; Hl; CVd; Mskd; Thd; Aid; Respd.
Wang et al. (2020b)	Cohort	China	621[a]	383 (16.5)	≥60[a]	NM
Suzuki et al. (2020)	Cohort	Japan	165	50 (30.7)	78.6 ± 8.0	Ht; Hl; Db; CVd; Mskd; Thd; Aid; Respd.
Ruiz-Roso et al. (2020)	Cohort	Spain	37[a]	NM[a]	68.2[a]	Db
Qin et al. (2020)	Cross-sectional	China	184[a]	93 (50.54)	≥60	NM
Yamada et al. (2020)	Cross-sectional	Japan	1600	800 (50)	74 ± 5.6	NM
de Matos et al. (2020)	Cross-sectional	Brazil	47	32 (69)	66.3 ± 5.07	NM
Chambonniere et al. (2021)	Cross-sectional	France	1178	568 (48.2)	69.7 ± 4.2	NM
Miyahara et al. (2021)	Cohort	Japan	13	2 (15,4)	77,5 ± 3,5	Ht; D1
Yamada et al. (2021)	Cohort	Japan	937	479 (51.1)	73.5	NM
Carvalho et al. (2021)	Cross-sectional	Portugal	68	40 (59)	74.24	NM
Lage et al. (2021)	Cross-sectional	Brazil	1123	101 (9)	67.6	Dp
Nascimento et al. (2021)	Cohort	Brazil	72	13 (18)	67.2	NM
García-Esquinas et al. (2021)	Cohort	Spain	829[b]	330 (39.8)	81.5	NM
Leavy et al. (2021)	Cross-sectional	Sweden	89	48 (54)	71	PD
Salman et al. (2021)	Cohort	UK	4961	2208 (44.5)	>65	NM

Legend: Not mentioned (NM); United Kingdom (UK); Hypertension (Ht); Diabetes (Db); Parkinson's disease (PD); Dyslipidemia (Dl); Overweight (Ow); Obesity (Ob); United States of America (USA); Hyperlipidemia (Hl); Cardiovascular Diseases (CVd); Musculoskeletal Disorder (Mskd); Thyroid Dysfunction (Thd); Autoimmune Disease (Aid); Pré-existing respiratory illness (Respd); Depression (Dp).

[a] When the sample was mixed, only the population ≥60 years was considered.

[b] When the sample was mixed, only the population of validated assessment was considered.

physical activity of the elderly, as shown in the study by Leavy et al. (2021).

In addition to the reduction in PA level, studies also associated this with other factors, such as frailty, pointed out by Shinohara et al. (2021). The worse self-perception of health reported by the elderly indicated a greater frailty, and those who were aware of a decrease in their lower limb muscle strength were significantly more fragile (Shinohara et al., 2021). Makizako et al. (2021) also underscore this decline in health perception and associate lower rates of exercise with a decline in cognitive function during a state of emergency.

Therefore, the pandemic not only caused a reduction in the level of PA in this population, but also the self-perception of health, muscle strength and cognitive function, which may result in irreversible consequences in this critical period. It is still not possible to state the reasons why this level of PA has decreased, requiring studies with better methodological quality and validated assessments. These studies should consider personal, environmental and other factors that may influence the level of PA and should be better studied as potential preventive aspects and intervention targets.

It is known the importance of physical exercise in the elderly. Cunningham et al. (2020) and McPhee et al. (2016) identified that physically active elderly people have a reduced risk of cardiovascular mortality, breast and prostate cancer, fractures, limitations in activities of daily living (ADLs), functional limitations, risk of falls, cognitive declines and depression. In addition, the active elderly also experiences healthier aging trajectories and better quality of life. The authors also emphasize that starting with small increases in PA can encourage this population to progressively incorporate more activities into their daily routine (Cunningham et al., 2020; McPhee et al., 2016). Oliveira et al. (2020) corroborate that there is an association between PA and prevention of frailty and sarcopenia. Thus, encouraging physical exercise and PA in the elderly in this pandemic period becomes essential.

Hammami et al. (2020) complemented that for optimal health, dietary guidelines must be combined with a physically active lifestyle and that during the prolonged "stay at home" policies, regular activity hours were changed, leading to an increase in sedentary behavior. The study also suggests that, currently, exercise is crucial, as PA is capable of improving sleep quality, mood and attenuating the manifestations of stress and anxiety, increased by social isolation. In addition, exercising at an appropriate intensity is associated with better immune system responses against viral respiratory infections (Hammami et al., 2020). Chen et al. (2021) propose that the immunological hypothesis for the vulnerability of COVID-19 in the elderly involves an age-related impairment of the immune defense (immunosenescence) and consequently an increased risk of immunopathology.

Curiously, despite the fact that the elderly population is more susceptible to suffer from COVID-19, being a high-risk population for the disease, there is evidence that higher ages may not turn the elderly more likely to isolate, when compared to people with 50 to 60 years old (Daoust, 2020). However, it is important to mention that the minimum social isolation may have greater impact in elderly people, especially when it comes to decreases in PA and functional capacity, since it is already known that muscle mass decreases 3 to 8% per decade after the age of 30 and it comes even worse after de age of 60 (Volpi et al., 2004).

Regarding the methodological quality of the studies, most of the cross-sectional studies were classified as "moderate quality", whereas for the cohort studies, "low quality" methodologies were prevalent, mainly because the studies did not perform the selection and comparability recommendations as suggested by the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) (Von Elm

Table 2
PA level during the COVID-19 pandemic.

Author (Year) (n = 25)	Activity level assessment method	Cut-off points for PA level	Main outcomes
Maugeri et al. (2020)	IPAQ-SF.	- Low active (<600 MET–minutes/ week); - Moderate active (>600 MET–minutes/ week); - High active (>3000 MET–minutes/ week).	- Statistically significant difference between before and during COVID-19 pandemic (Mean: 2429 vs. 1577 MET–min/wk.; $p < 0.0001$) - Low active individuals increased up to 39.62% - ↓ of total weekly PA energy
Sasaki et al. (2021)	IPAQ-SF.	- Walking (3.3 METs) - Moderate-intensity activity (4.0 METs) - Vigorous-intensity activity (8.0 METs)	- PA was reduced by approximately 5–10% for moderate-intensity activity, walking, and total PA. After the restrictions, there was an increase in sitting time (5% increase for men,10% increase for women).
Visser et al. (2020)	LAPAQ.	- <150 versus ≥150 min/week	- Negative impact on PA behaviors (48.3–54.3% of the sample); - Half of the sample reported to be always (8%) or sometimes (41.3%) less physically active than normal.
Song et al. (2020)	PASE.	NM	- Significant decrease in the amount of exercise (duration and frequency and number of patients who do not exercise at all increased).
Balci et al. (2021)	PASE.	- Higher scores indicate greater physical activity.	- PA level was reduced in healthy and PD groups.
Pérez et al. (2021)	BPAAT.	- Insufficiently active (score 0–3 points); - Sufficiently active (score 4–8 points).	- A general decrease in PA level during the lockdown (BPAAT total score: −1.1/8 (95 CI% 0.6; 1.5) points; $p < 0.001$).
Browne et al. (2020)	Accelerometer.	- Sedentary behavior (≤0 99 cpm); - Light PA (100–1951 cpm); - Moderate-vigorous (≥1952 cpm).	- Increase in sedentary behavior ($p = 0.032$) and decrease in steps/ day ($p = 0.018$).
Meyer et al. (2020)	IPAQ-SF.	- Inactive (0 min); - Insufficiently active (1–150 min/ day); - Sufficiently active (150–300 min/ day); - Highly active (>300 min/day).	- 42.6% reported sitting for more than 8 h per day; - 72.5% reported being either sufficiently or highly active.
Richardson et al. (2021)	IPAQ-E; LLFDI.	- High, moderate, or low PA (according to IPAQ-SV scoring protocol - http ://www.ipaq.ki. se/)	- Both males and females maintained their PA levels but also increased their sedentary time.
Di Santo et al. (2020)	IPAQ-SF.	- 600 MET/week roughly corresponding to 150 min of moderate intensity activity;	- 46 participants declared having decreased their PA; - 69.60% reported an increase in the time spent sitting or lying down; - 5 of the 25 respondents who, before the lockdown did not reach the recommended threshold of 600 MET/week, increased their PA levels during quarantine.
Wang et al. (2020b)	Daily step counts collected through a smartphone linked to a social network platform (WeChat).	- Low daily step (≤1500 steps/day) - Frequent low daily steps (≥14 days of low daily step counts over a 30-day period)	- Daily steps dropped rapidly (by 2678 steps) and substantially and was more pronounced among females. - The prevalence of frequent low daily steps increased to 7.4% (196/2655) during the COVID-19 epidemic period, after physical distancing measures were implemented.
Suzuki et al. (2020)	PAQ-EJ	- Light housework (2.0 METs) - Moderate or somewhat heavy housework (2.5 METs) - Labor (2.8 METs) - Transportation (2.8 METs) - Light exercise/ sports (3.0 METs) - Resistance exercise/sports (3.0 METs) - Moderate or somewhat strenuous exercise/ sports (4.3 METs)	- 47.3% of the participants were less active and decreased their PA per week. - The light and moderate or strenuous exercise/sports and housework categories were the most affected.
Ruiz-Roso et al. (2020)	IPAQ	- Moderate-intensity activities (>3 and <6 METs); - Vigorous-intensity activities (≥6 METs).	- Increase in sitting without doing any PA; - Decrease in average minutes per week spent walking; - Patients with DM with a BMI > 30

(continued on next page)

Table 2 (*continued*)

Author (Year) ($n = 25$)	Activity level assessment method	Cut-off points for PA level	Main outcomes
			kg/m2 showed a significant increment in the hours they spent sitting; - Patients with DM with a BMI between 25 and 30 kg/m2 did not increase hours they spent sitting.
Qin et al. (2020)	IPAQ	- High, moderate, or low PA (according to IPAQ-SV scoring protocol - http://www.ipaq.ki.se/)	- 41.3% of insufficient PA was found during home quarantine induced by COVID-19. - The prevalence of insufficient PA more than doubled during the initial stage of COVID-19 epidemic in China (global: 27.5% vs. China in epidemic stage: 57.5%, 2, $p < 0.0001$)
Yamada et al. (2020)	IPAQ	- Moderate-intensity activities (>3 and <6 METs); - Vigorous-intensity activities (≥6 METs).	- Significant decrease in total PA time in April 2020 (median [IQR], 180 [0 to 420]) when compared to January 2020 (median [IQR], 245 [90 to 480]) ($P < 0.001$).
de Matos et al. (2020)	IPAQ	- Inactive - <600 MET-min/week; - Insufficiently active - ≥600 and <3000 met-min/week; - Active - ≥3000 MET-min/week.	- In the pandemic period, 84% of the sample was considered inactive, 13% moderate active, and 3% high active; - In relation to the periods before and during the pandemic, it was observed that: in elderly ($p < 0.0001$) the weekly energy expenditure reduced significantly.
Chambonniere et al. (2021)	IPAQ; ONAPS-PAQ	- Inactive (≤ 2 h and 30 min per week of moderate to vigorous PA).	- 39.2% decreased PA during the confinement; - PA decreased among 43.4% of old people who lived in urban areas; - PA decreased 32.4% ($p = 0.001$) of old people who lived in rural areas;
Miyahara et al. (2021)	Accelerometer	- Light-intensity PA (1.5–2.9 METs); - Moderate-intensity PA (≥3 METs);	- The PA level of daily activity decreased by 32.6%; - Light-intensity PA decreased by 18.2%; - Walking activity decreased by 17.0%; - The average daily number of steps decreased by 38.9%. - In the High-PA group, the number of steps, activity time, moderate-intensity PA, light-intensity PA, and total PA decreased after self-restraint ($p > 0.02$)
Yamada et al. (2021)	IPAQ-SF.	- Moderate-intensity activities (>3 and <6 METs); - Vigorous-intensity activities (≥6 METs).	- Significant decrease in total PA time in April 2020, August 2020 and January 2021 than in January 2020 ($P < 0.001$).
Carvalho et al. (2021)	IPAQ-SF.	- High, moderate, or low PA (according to IPAQ-SV scoring protocol - http://www.ipaq.ki.se/)	- 90% of older adults self-reported a decrease in overall PA levels; - 64.7% increased daily sitting time during the home confinement.
Lage et al. (2021)	IPAQ-SF	- <150 min per week" or ">150 min per week" of moderate to vigorous PA.	- 83.80% self-reported a decrease in daily PA levels ($p < 0.001$); - 73.90% increased sitting time ($p < 0.001$).
Nascimento et al. (2021)	IPAQ-SF	- Low PA level (0 to <600 MET·min weekly); - Medium PA level (600 to <1200 MET·min weekly); - High PA level (≥1200 MET·min weekly).	- At the beginning of the study, 56.8% of the older adults were classified as active, and after the first month, 18.5% reported changes in this condition; - Changes in MET'S, which presented lower values when compared with April and August ($p < 0.01$, for both); - There was an increase in sitting time compared with April independent of the measure period (week and weekend, $p < 0.01$ for both).
García-Esquinas et al. (2021)	PASE	NM	- Mean reduction in the PASE score of 16.66 points
Leavy et al. (2021)	Accelerometer	- Sedentary behavior (<100	- No statistically significant

(*continued on next page*)

Table 2 (*continued*)

Author (Year) ($n = 25$)	Activity level assessment method	Cut-off points for PA level	Main outcomes
		counts per minute) - Light-intensity PA (100–1040 counts per minute); - Moderate to vigorous intensity PA (≥1041 counts per minute).	difference in overall PA level (steps per day) was seen between prepandemic and postpandemic measures ($P = 0.429$).
Salman et al. (2021)	IPAQ-SF	- Low active (<600 MET–minutes/ week); - Moderate active (>600 MET–minutes/ week); - High active (>3000 MET–minutes/ week).	- Mean PA was significantly lower following the introduction of lockdown from 3519 to 3185 MET min/week ($p < 0.001$)

Legend: Physical Activity (PA); International Physical Activity Questionnaire-Short form (IPAQ-SF); Longitudinal Aging Study Amsterdam Physical Activity Questionnaire (LAPAQ); Parkinson's disease (PD); Physical Activity Scale for the Elderly (PASE); Brief Physical Activity Assessment Tool (BPAAT); Late-Life Function and Disability Instrument (LLFDI); Metabolic Equivalent Task (MET); International Physical Activity Questionnaire Environment Module (IPAQ-E); Physical Activity Questionnaire for Elderly Japanese (PQA-EJ); Body Mass Index (BMI); World Health Organization (WHO); Not mentioned (NM); Interquartile range (IQR).

et al., 2007). However, since COVID-19 is a new disease, which still needs further studies for its better understanding, this preliminary evidence was able to provide important information to direct strategies for the development of exercise protocols focused on the elderly population, which lack scientific support at the current time.

There are limitations in our systematic review that must be considered. Among them, there is a bias in the subjectivity of the responses to the questionnaires in relation to the level of PA and referred symptoms applied in the included studies, as these are often self-reported. In addition, the heterogeneity of the measures of the studies found can be mentioned, which limits the use of more robust methods for the synthesis of results. Also, due to the fact that this review includes observational studies (cross-sectional and cohort), we cannot confirm these data, as they do not prove cause and effect. However, it is important to highlight that we seek the best evidence, with validated assessments and that COVID-19 is a new disease and we still have many gaps that only time will allow scientists and researchers to answer. As it is a recent and relevant topic at the moment, the results of the present study may provide important contribution to clinical practice, given the scarcity of data to guide health professionals.

Furthermore, we must consider that the included studies did not classify individuals according to their PA level before and after the pandemic, however, few studies used gold standard measures to objectively measure physical activity (i.e. accelerometers). Finally, the most of studies did not report the severity of the lockdown imposed in each region in which the study was developed in order to consider the impact of lockdown in the active behavior and if some physical approaches were made to attenuate these changes. Therefore, we recommend that future studies consider the points above mentioned so that more consistent analyzes can confirm the findings of active behavior impairment caused by the COVID-19 pandemic.

4.1. Clinical implications

Since the end of 2019 the general population and mainly the elderly have been suffering from the loss of public spaces, such as gyms, physiotherapy clinics, outdoor leisure areas and social exercise groups. As a consequence, the present systematic review showed the reduction in the PA levels, with studies consistently showing this reduction mainly from the IPAQ (increase in sitting time and reduction in the amount of METs)

Table 3
Quality assessments for cross-sectional studies included (NEWCASTLE - OTTAWA QUALITY ASSESSMENT SCALE).

Cross-sectional studies ($n = 14$)	Selection				Comparability	Outcome		Total Score
	Representativeness of the sample	Sample size	Non-respondents	Ascertainment of the exposure (risk factor)	The subjects in different outcome groups are comparable	Assessment of the outcome	Statistical test	
Balci et al. (2021)	–	–	☆	☆☆	☆☆	☆	☆	☆☆☆☆☆☆☆ (7)
Pérez et al. (2021)	–	☆	☆	☆☆	☆	☆	☆	☆☆☆☆☆☆☆ (7)
Maugeri et al. (2020)	–	–	–	–	–	☆	☆	☆☆ (2)
Sasaki et al. (2021)	☆	☆	–	☆☆	–	☆	☆	☆☆☆☆☆☆ (6)
Qin et al. (2020)	–	☆	–	☆☆	☆	☆	☆	☆☆☆☆☆☆ (6)
Yamada et al. (2020)	–	☆	–	☆☆	☆	☆	☆	☆☆☆☆☆☆ (6)
de Matos et al. (2020)	–	–	–	☆	☆☆	☆	☆	☆☆☆☆☆ (5)
Meyer et al. (2020)	–	☆	☆	☆☆	–	☆	–	☆☆☆☆☆☆ (6)
Richardson et al. (2021)	–	☆	☆	☆☆	☆	☆	☆	☆☆☆☆☆☆☆ (7)
Di Santo et al. (2020)	–	☆	☆	☆☆	☆	☆	☆	☆☆☆☆☆☆☆ (7)
Ruiz-Roso et al. (2020)	–	–	☆	☆☆	☆	☆	☆	☆☆☆☆☆☆ (6)
Carvalho et al. (2021)	–	–	–	☆☆	☆	☆	☆	☆☆☆☆☆ (5)
Lage et al. (2021)	☆	☆	–	☆☆	☆	☆	☆	☆☆☆☆☆ ☆☆ (7)
Leavy et al. (2021)	–	–	–	☆☆	☆	☆	☆	☆☆☆☆☆ (5)

Table 4
Quality assessments for cohort studies included (NEWCASTLE-OTTAWA QUALITY ASSESSMENT SCALE).

Cohort studies ($n = 11$)	Selection				Comparability	Outcome			Total Score
	Representativeness of the exposed cohort	Selection of the non-exposed cohort	Ascertainment of exposure	Demonstration that outcome of interest was not present at start of study	Comparability of cohorts on the basis of the design or analysis	Assessment of outcome	Was follow-up long enough for outcomes to occur	Adequacy of follow up of cohorts	
Song et al. (2020)	–	–	☆	☆	☆	–	☆	☆	☆☆☆☆☆ (5)
Visser et al. (2020)	–	–	–	–	☆	–	☆	☆	☆☆☆ (3)
Browne et al. (2020)	–	–	☆	☆	–	☆	☆	☆	☆☆☆☆☆ (5)
Wang et al. (2020b)	☆	–	–	☆	☆	–	–	☆	☆☆☆☆ (4)
Suzuki et al. (2020)	–	–	–	☆	☆☆	–	–	☆	☆☆☆☆ (4)
Chambonniere et al. (2021)	☆	–	–	–	☆	☆	–	☆	☆☆☆☆ (4)
Miyahara et al. (2021)	–	–	–	☆	☆☆	–	☆	☆	☆☆☆☆☆ (5)
Yamada et al. (2021)	☆	–	–	☆	☆	–	☆	☆	☆☆☆☆☆ (5)
Nascimento et al. (2021)	–	–	–	☆	☆	–	☆	☆	☆☆☆☆ (4)
García-Esquinas et al. (2021)	☆	–	–	☆	☆	–	☆	☆	☆☆☆☆☆ (5)
Salman et al. (2021)	☆	–	–	☆	☆	–	☆	☆	☆☆☆☆☆ (5)

and accelerometry (reduction in the number of steps). This is an important factor for the loss of muscle strength, mobility, balance, cardiorespiratory endurance, functional independence, increased depression index and, consequently, increased frailty syndrome in the elderly (Battaglia et al., 2014; Bellafiore et al., 2011; Cesari et al., 2015; O'Connor et al., 1993). All these consequences are related to an increased risk of mortality.

As an alternative, in times of PA restriction due to the pandemic, home and outdoor exercises can maintain and improve the health and fitness of the elderly, given the decrease in PA levels observed in this population, as seen in this systematic review. Finally, Chen et al. (2021) suggest that exercise supervision, whether through weekly visits or telephone calls, is recommended to improve the effects of exercise at home and reduce the risk of falls.

Thus, this review provides data to guide health professionals, such as geriatricians, physiotherapists, physical educators, nutritionists and health assistants, to focus on the need to implement/maintain exercise promotion, reducing functional losses during the pandemic of COVID-19 and to encourage the continuity of activities and physical exercise safely, in order to maintain their healthy lifestyle and, consequently, improve their autonomy and quality of life.

5. Conclusion

The level of PA in the elderly population decreased during the quarantine period of COVID-19 worldwide. The increase in sitting time, reduction in the amount of METs and the decrease in the number of steps were important factors for the reduction of PA levels. However, most studies presented a low to moderate methodological quality and assessed the level of PA through questionnaires, which may underestimate the findings. Therefore, more accurate methods to assess PA levels in the elderly and clinical studies to find the cause and effect of symptoms are needed in future studies.

In addition, strategies to maintain physical condition must be developed with exercise protocols and interventions that match the needs of the elderly in the current pandemic scenario, in order to maintain/improve the health, muscle strength, cognitive function and, consequently, quality of life of the elderly population.

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Declaration of competing interest

No potential conflict of interest was reported by the authors.

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