



Review Paper

Analysing features of home-based workout during COVID-19 pandemic: a systematic review



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ABSTRACT

Objective: Since the beginning of the COVID-19 pandemic, a decrease in physical activity (PA) related to home confinement has been reported worldwide. However, some individuals were able to engage in physical activities at home. Thus, in a perspective of public health, it may be useful to analyse the available evidence regarding PA adopted during home restrictions, in order to identify possible strategies to help people stay active even during emergency situations. The aim of this review was to analyse how healthy individuals spontaneously exercised at home in the course of the pandemic, in order to detect possible factors associated with this behaviour.

Study design: A systematic review was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.

Methods: The protocol was registered in PROSPERO, an international prospective register of systematic reviews, with the registration number CRD42023394673. A literature search was conducted in PubMed, Scopus, and Web of Science. Cross-sectional studies published in English from the inception of each database to February 06th 2023 and focused on healthy individuals practicing spontaneous PA/exercise at home during the pandemic were considered eligible. The quality assessment was performed using the adapted Newcastle–Ottawa Quality Assessment Scale. Bibliographic information, sample size, study participant/population with age, gender, ethnicity, socioeconomic status, education, smart workers or not, anthropometric parameters, characteristics of at home exercises, athletic status and sedentariness, associated health-related effects, and main findings were synthesised.

Results: From 504 articles, 19 were included. Notwithstanding the differences in the studies examined, the majority of them reported that previous PA level was associated with exercise in such challenging conditions. Furthermore, technologies aimed at supporting exercise were shown to be a useful resource. **Conclusions:** Being habitually active and using digital supports may be associated with a positive attitude towards exercise at home during isolation. This suggests that in emergency situations, exercise should be promoted, also through digital media, especially among those groups who are usually less engaged in PA. Further analyses of longitudinal studies are needed to confirm these findings.

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Introduction

Since the beginning of the COVID-19 pandemic in 2019, the disease has continued to be an important global public health concern, especially for its negative consequences on physical,

psychological, and social aspects related to people's health.^{1–3} Several studies reported changes in daily lifestyles during the COVID-19 pandemic, including disrupted sleep patterns, altered dietary habits, and reduced physical activity (PA) levels, consequent to the changed life conditions.^{4–7} In particular, many surveys evidenced a significant decline in participants' PA^{5,8,9} and an increase in sedentary behaviours, in conjunction with the movement-restriction measures.^{10–15} Indeed, the implementation of physical distancing and isolation strategies during the outbreak limited PA opportunities related to work and leisure time for individuals.¹⁵

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Runacres et al. investigated the impact of COVID-19 pandemic in children and adults, showing an increased sedentary time both in males and females, especially in children. In particular, they reported that daily screen time was the major sedentary behaviour, accounting for 57.2% and 46.8% of total sedentary time, for adults and children, respectively.¹⁶ In some studies, the lower PA levels have been assessed in association with changes in diet quality, revealing a lower quality and an increased overeating during lockdown. These changes certainly lead to a less favourable weight-management behaviour and possible threats for mental/physical health and for interpersonal negative outcomes.¹⁷

Interestingly, along with the general reduction in PA levels observed worldwide in the last four years, literature also shows that social isolation has been experienced by some individuals as an opportunity to stay or become active, practicing at-home workouts or in the surroundings.^{18,19} Besides, Mata et al. reported an initial reduction of active participants at the beginning of lockdown, followed by a major increase in the successive months.²⁰ It has been evidenced that the occasion to stay active depends on several factors such as age, gender, education, income, employment status, and health.²¹ Also, Schottl et al. demonstrated that the private access to a garden/terrace/balcony was a further variable that has contributed to increase the levels of PA during COVID-19.¹⁵ Thus, evidence on changes in PA during the COVID-19 pandemic are heterogeneous. However, a substantial percentage of studies in this field showed persistent physical inactivity or decreasing PA. This is a public health concern because it has been well-demonstrated how sedentary behaviours may lead to adverse changes in individuals' psychophysical well-being, leading to loss of muscle strength, reduced endurance, and increased risk of developing overweight and chronic conditions.²² At the same time, the positive effects of exercise on health, especially in the course of the pandemic, have been widely shown.²³ Considering the importance of PA for people's well-being, since the first months of the pandemic health, authorities published advices and recommendations on how to maintain or improve PA during home restriction.^{24,25} For instance, the World Health Organization designed a guidance in which it recommends 150 min of moderate-intensity or 75 min of vigorous-intensity PA per week, or a combination of both, achievable at home, with no special equipment and with limited space. Besides, the World Health Organization suggested some tips on how to stay active and reduce sedentary behaviour at home during the self-quarantine and showed some examples of home-based exercises.²⁴ Reducing the time spent in sedentary behaviours and the consequences of social isolation on psychological and physical health, PA carried out in the home setting was recommended as an effective measure to maintain or improve physical fitness and psychophysical well-being in all age groups.^{26–31}

In the course of the pandemic, the supervised or unsupervised online tutorials and classes for exercising at home increased markedly as well as the use of home-workout equipment and activity trackers.^{27,32} For example, many studies have assessed exergames as a potential tool in case of quarantine, defining exercise at home as a new gym and showing excellent results in terms of both physical and mental health.²⁷ Home-based exercise, even supported by technology, has contributed to maintain the regular practice of PA, improving physical and cognitive abilities.³³

Considering these evidence, it may be useful for stakeholders and health professionals interested in PA promotion to analyse the available evidence regarding PA/exercise adopted during home restrictions, in order to identify common elements that should be enhanced to help people stay active.

Therefore, this systematic review was aimed to analyse the available literature regarding how healthy individuals have

faced the challenge posed by the restriction measures during the COVID-19 pandemic to perform exercise at home, trying to detect possible factors associated with this behaviour.

Methods

Protocol and registration

The systematic review was conducted according to Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.³⁴ The protocol was registered in PROSPERO (reference number CRD42023394673).

Research question

Studies about possible patterns of spontaneous home-based PA and exercise during COVID-19 pandemic in healthy individuals were selected based on the “PICOS” (P – Patient, problem or population; I – Intervention; C – Comparison, control or comparator; O – Outcome(s); S – Study type) (PRISMA-P 2016) technique: 1. P (Population): all genders healthy individuals; 2. I (Intervention): at-home exercise; 3. C (Comparison): age-, gender-, and condition-matched control group (if present); 4. O (Outcome): assessment of at-home exercise during the COVID-19 pandemic and characterisation of its determinants and possible effects on individuals' wellbeing; and 5. S (Study design): cross-sectional studies. Based on the definition of the *Textbook of Pharmaceutical Medicine* (7th edition; 2013), we considered a healthy individual as “an individual who is in good general health, not having any mental or physical disorder requiring regular or frequent medication”.

Type of Outcome Measure

Primary Outcomes

We evaluated the practice of home-based exercise, possible patterns, and the related positive or negative effects on health during the COVID-19 pandemic.

Data sources

Three electronic databases (PubMed, Scopus, and Web of Science) were interrogated; full search strategy is reported in [supplementary material](#).

Eligibility criteria

Inclusion criteria

Articles were considered eligible if they presented data about spontaneous at-home exercise during pandemic performed by healthy individuals, independently by their gender and age. We included only articles published in English language, from the inception of each database to February 06th 2023.

Exclusion criteria

Studies including unhealthy individuals or regarding exercise and PA considered as part of a plan or a therapy or rehabilitation, or whether involuntary were excluded. We also excluded studies reporting only the outdoor and not indoor exercise and PA or considering periods other than the pandemic. Clinical trials, experimental studies, reviews, meta-analysis, case studies, proceedings, qualitative studies, editorials, commentary studies, and any other types were excluded. Reviews and meta-analyses were examined to identify further articles in their references.

Study selection

Titles and abstracts acquired from the three databases were transferred to the reference software Zotero systematic review manager for the relevance-assessment process. The next step was screening by title and abstract, the potentially eligible studies by five authors (F.G., C.P., F.V., A.D.G., E.M.) independently. Then, full-texts were read independently by the same five authors with a later discussion about their inclusion in the review. Disagreements were settled by consensus among the authors.

Data extraction

The extracted data were arranged into table reporting bibliographic information such as author, year, country, study design, sample size, study participant/population with age, gender, ethnicity, socioeconomic status, education, smart workers or not, anthropometric parameters, characteristics of at-home exercises, sports features such as athletic status and sedentariness, associated health-related effects, and main findings.

Quality assessment

The quality assessment was performed by the use of the tool Newcastle–Ottawa Quality Assessment Scale adapted from cohort and case–control studies to perform a quality assessment for cross-sectional studies. Calculation of overall rating is explained in depth previously.³⁵ Five authors (F.G., C.P., F.V., A.D.G., E.M.) independently assigned a score to each study, and disagreements were

settled by consensus among all the authors. The final rating for each article was the average taken from the five authors.

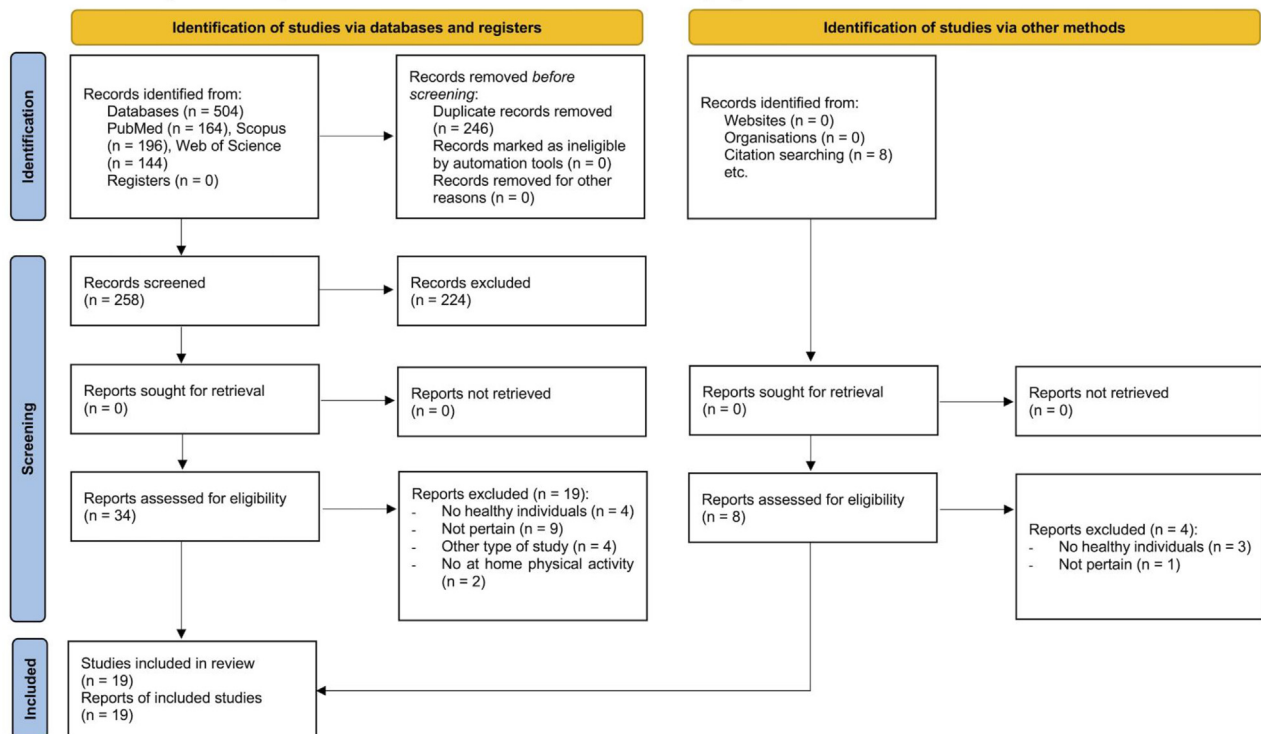
Results

A total of 504 studies were retrieved from the following databases: PubMed, Web of Science, and Scopus (Fig. 1).

After removing the duplicates, 258 articles were left for the following steps. Out of the remaining studies, 224 were deleted after analysing the title and abstract. Then, the full texts of 34 articles were evaluated considering inclusion/exclusion criteria. After the evaluation, 9 articles were excluded because they did not pertain to our question, 4 because the individuals were not healthy, 4 were a different type of study, and 2 because they did not include at-home PA. Finally, we included 15 articles that met the inclusion criteria and 4 articles found through citation searching.^{14,36–53}

The included articles regarded 19 cross-sectional studies published in 2020–2022, involving a total of 61,986 individuals. Eleven studies were performed in Europe,^{14,39–44,48–50,52} 4 in Asia,^{36,37,51,53} 3 in the America,^{38,44–46} and 1 in Australia.⁴² All the studies included both females and males. As for participants' age, 12 studies analysed samples composed of young adult individuals,^{14,36,38,39,44,45,47–53} whereas the others included also older individuals or adolescents.^{37,40–43,46} Participants' ethnicity was reported only in 3 studies,^{40,41,45} showing a higher prevalence of Caucasian. Besides, the studies performed among primary-to-high school,³⁷ college,^{45,47} and university students,^{36,47} other 8 studies^{39–41,46,50–53} reported the participants' educational level, reporting great proportion of highly educated individuals. Only 3 articles reported participants' income,^{39,40,53} which was medium to high across the studies.

PRISMA 2020 flow diagram for new systematic reviews which included searches of databases, registers and other sources



From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ* 2021;372:n71. doi: 10.1136/bmj.n71. For more information, visit: <http://www.prisma-statement.org/>

Fig. 1. PRISMA flowchart for search strategy.

As for the employment status, one study⁴⁶ reported that the 52.6% of the adult participants and the 25.8% of the adolescents were employed, whereas 21.7% of the adults and 64.6% of the adolescents were students. In the sample examined by Symons et al.,⁵⁰ 40.7% of participants worked full-time, 28.1% were students, and 14.3% did not work. In the study by Kass et al.,⁴⁰ the sample was composed by individuals working mainly from home.

The mean body mass index of the sample was reported in 4 articles,^{39,50,51,53} with highest prevalence of normal-weight individuals.

In 4 studies, the sample was composed by athletes,^{38,39,47,48} whereas 6 studies involved active and inactive people.^{14,36,40,42–45,48,50,52} The remaining articles did not specify the participants' PA habits before the pandemic. As for exercise practiced during the pandemic, participants from 11 studies reported self-created home training,^{14,37–42,45,47–49} whereas guided at-home or outside exercise was reported in 11 studies.^{14,40–49} A great variability in the type and intensity level of exercises was found.

Table 1 shows the main characteristics and findings of the studies included.

In summary, a reduction in time, volume or intensity of PA or exercise was reported in nine studies.^{36,37,40,42,47,48,50–52} However, 18 out of 19 studies reported maintained engagement in PA or exercise during the pandemic, and ten studies^{14,38,40,41,43–45,48–51} reported even an increase in some PA domain.

In the majority of those studies which showed equal or increased PA trajectories, females,^{43,52} younger,^{14,43,47,52} and previously active individuals^{36,39,43,50} or users of digital resources^{14,43–46,48–50} were more likely to report higher engagement in PA or exercise during the pandemic.

Discussion

This study aimed to detect possible factors associated with spontaneous home workout adopted to face movement restrictions imposed by governments to control COVID-19 spread.

Literature from the last three years shows that COVID-19 pandemic and related control measures have determined a global reduction of people's PA. At the same time, however, non-negligible proportions of several populations worldwide have been able to maintain or increase their PA level even during the home confinement periods. Therefore, in order to detect those factors that can be related with the ability to react positively to the imposed restrictions, it is important to analyse the way and the resources these individuals used during the isolation. In the perspective of public health, this represents an intriguing field to explore since what happened during this pandemic may help not only to deal with any future emergency situation but also to reduce sedentary behaviours and the rate of related diseases, in line with the third goal of the United Nations Sustainable Development Agenda.⁵⁴

Then, this review observed that different categories of individuals adopted different ways to exercise during the social restrictions related to the COVID-19 pandemic. Although the characteristics of the samples and the assessment methods were different among the selected studies, some key points emerged.

First, even though a general reduction in PA components during the pandemic with reference to the prepandemic period was reported in the selected articles, equal or increased levels of PA were showed by at least a part of each sample examined in each study. This finding is in line with other evidence concerning PA during the COVID-19 pandemic,^{55,56} although results from the studies performed worldwide are not consistent,⁵⁷ possibly as a consequence of the different methodologies adopted to define physical activity.²⁵ These results highlight the ability to quickly adapt to the constraints imposed by social distancing for some people and to use

them as an opportunity to start or increase exercise for others. The definition of which factors can represent barriers or facilitators for these behaviours can help to address movement-promotion initiatives. With regard to this, the studies examined in this review highlighted that the previous PA levels played a role in determining exercise engagement during the pandemic,^{14,38,39,47,49,50} in accordance with other studies.^{51,58} As for the athletes' category, in particular, both the runners observed by DeJong et al.³⁸ and the football athletes involved in the Schüttler's study⁴⁸ were able to maintain and also increase some domain of their usual training. It should be noted, however, that the sample of student athletes observed by Purc-Stephenson et al.⁴⁷ reported a reduction of training load and intensity. On the other hand, some included studies reported an increased engagement even among previously inactive or less active individuals.^{14,40–42,44,45,50,51} This suggests that previous lifestyle cannot be the only determinant for continuing exercise during challenging situations.

In four of the included studies, exercising during the lockdown was associated with younger age^{14,43,47,52} and in two with the female gender.^{43,52} Furthermore, the study by Mutz et al.⁴³ and the one by Parker et al.⁴⁶ showed a higher engagement in digitally guided PA, which was related with the achievement of recommended PA levels, among younger adults and females than in their counterparts. These findings agree with other studies which analysed the differences in PA engagement between genders and age groups, both in adults and children/adolescents.^{59,60} However, other evidence related to the COVID-19 pandemic does not confirm these results.^{18,19,57,60,61}

Above all, eight of the selected studies showed that the use of digital resources such as activity trackers, fitness apps, and online tutorials or lessons was related with exercising during social isolation.^{14,43–46,48–50} This evidence highlights the role of digital devices and media as resources to maintain or increase exercise, in line with previous evidence.^{62,63} Moreover, our results suggest that those who can benefit more from these resources were females and younger individuals, in agreement with other studies.^{64,65} This result should be taken in consideration by further research, since these same categories show also a high risk of excessively use online media to face isolation.⁶⁶

These findings bring some unavoidable consideration for public health policies. First, while many people were able to replace their daily activity with home workout, an increase in sedentary time was observed during the lockdown, with PA technology use having no impact.⁴⁴ Therefore, the increased sedentary time, which can lead to a number of serious health concerns, still remains an unsolved issue.

Moreover, the increased use of PA technology observed during the current pandemic suggests that a pressing need for further digital resources to doing exercise is likely to occur in the next few years. Activity tracking can help people to move, stay aware of their activity levels, establish goals, and reach some intensity level. The use of online tutorials/classes and fitness apps allows individuals to both exercise and stay connected with communities, even during social isolation. However, it should be considered that staying active at home may be unsafe. Some of the studies examined reported sports-related injuries due to the sudden change in activity levels/type.^{34,40} This could be related to a lack of information regarding how to exercise safely and even to an unsupervised use of technologies, which can push to overcome physical limits.

Finally, some of the studies included in this review analysed the possible predictors of PA during social constraints. First, in the study by Purc-Stephenson et al.,⁴⁷ besides younger age, "higher intrinsic and introjected motivation", "having access to fitness resources", "maintaining a steady training schedule", "having fewer

Table 1
Characteristics of the included studies.

| Author Year Country | Sample characteristics | Sport/PA and inactivity before and during the pandemic | Type of exercise during the pandemic | Frequency/intensity of exercise during the pandemic | Associated health- related effects | Main findings | Quality Assessment (NOS) |
|--|---|---|--|--|---|--|-----------------------------|
| Al-Mhanna et al. 2022 Malaysia ³⁶ | N: 509 dental students; gender: 53 males (54.1%) 45, females (45.9%) prepandemic; 216 males (52.5%), 195 females (47.4%) during the pandemic; age: 16–40 years | Prepandemic: 26 (27%) inactive, 72 (73%) active; during the pandemic: 313 (76%) inactive, 98 (24%) active | Jogging, games, yoga, gym, indoor, outdoor, and both | 27.5% of the inactive students became “less active”, whereas 12.2% of active students became “less active”; 8.3% and 11.8% of the total inactive students (n = 313) became “much more” and “more” inactive, respectively, whereas 0.0% and 26.5% of the total active students (n = 98) became “much more” and “more active”, respectively | – | The results from this study revealed a significant rise in the level of inactivity between the two groups, “inactive” and “active” groups, most inactive and active students participated in PA both outdoors and indoors, and the active students spent significantly more days/ week and min/each day than the inactive students performing PA. The COVID-19 pandemic–affected students' PA and well- being, particularly the psychosocial and boredom-induced stress that resulted from reduced PA | Poor (4) |
| 104 Bagherian et al. 2022 Iran ³⁷ | N: 43660 primary, secondary and high school students; gender: 28128 females (64%), 15532 males (36%); age: 8–17 years; weight: 18–144 kg; height: 75–198 cm | – | Flexibility exercises, as well as walking or running (27%), bicycling (16%), weight training (6%); 72% reported PA at home, whereas 28% outside the house, including the gym (4%) and sports halls (5%) | 32% of students less than 1 h per day, 28% reported 1–2 h, 15% reported 2–3 h and 19% 3 h, 6% did not exercise at all | 51% of participants reported not becoming overweight while taking virtual classes during the pandemic; 49% reported very little (35%), relatively high (10%), and large (4%) changes in body weight becoming overweight during the pandemic | During the COVID-19 pandemic, half of the students became overweight; the majority of school-aged students (41%) reported undertaking very little or no PA during the pandemic, and 32% of students reported doing less than an hour of exercise each day | Good (7) |
| DeJong et al. 2021 Brazil ³⁸ | N: 1147; gender: 757 females (66%), 390 males (34%); age: median 35 years | Active runners before and during the pandemic | Running indoor and outdoor | Total runs per week before (4.27 ± 1.93) and during the pandemic (4.56 ± 1.92) | 410 participants (35.7%) reported 634 running-related injuries in the year prior to the pandemic, whereas 144 (12.6%) reported a total of 219 during the 3-month social isolation period of the pandemic period. The COVID-19 pandemic influenced runners' behaviours with increased training volume and decreased intensity, motivation and well-being in general | The COVID-19 pandemic influenced runners' behaviours and resulted in increased training volume with decreased training intensity. Runners' motivations for running overall declined and shifted from competition and socialization towards fitness, stress relief, and occupying time. Running-related injury risk was overall higher during the pandemic for lower extremity overuse injuries than during the year before | Fair (5) |

| | | | | | | | |
|--|---|--|---|---|---|---|----------|
| Gjestvang et al. 2022 Norway ³⁹ | N: 233; gender: 193 females (82.8%), 40 males (17.2%); mean age: 39.62 ± 13.67 years; employment: full-time 138 ± 84.1; income: high household (>100,000\$/year) 97 ± 41.6; educational level: high (≥4 years) 94 ± 40.3; mean BMI 24.98 ± 3.80 kg/m ² | Athletes in a gym club; low-exercise attendees tended to work out shorter during the lockdown than high-exercise attendees; high-exercise attendees reported longer exercise durations than low-exercise attendees during lockdown; none of low-exercise attendees reported to work out >90 min | Home-based exercise, walking, cycling | High-exercise attendees (66.5%) had a mean exercise frequency of 4.81 ± 1.15 days/week during prelockdown and 4.75 ± 1.30 days/week during lockdown; low-exercise attendees reported a decreased exercise frequency from prelockdown to during lockdown (1.81 ± 1.33 days/week, mean change 1.24 days/week) | Exercise frequency was lower in those with a BMI ≥25 than in those having a BMI <25 prelockdown, but this was not observed during lockdown; more participants with a BMI ≥25 reported exercise dropouts than participants with a BMI <25 | Home-based exercise, walking, and cycling were most frequently reported during lockdown. Participants reported a small decrease in exercise duration and frequency compared to that during prelockdown. Closure of fitness clubs impacted low-exercise attendees more than high-exercise attendees | Fair (5) |
| Kass et al. 2021 UK ⁴⁰ | N: 818; gender: 641 females (78.4%), 177 males (21.6%); mean age: 47 ± 13 years; ethnicity: 754 white, 26 Asian, 6 black, 3 Chinese, 12 mixed, 10 other/prefer not to say; educational level: 3 no schooling, 82 GCSE or equivalent, 203 A level or BTEC or apprenticeship or equivalent, 279 Bachelor's degree, 160 Master's degree, 91 Doctorate; income: 3 <£5200; 28 £5200 to £15,999; 49 £15,600 to £25,999; 83 £26,000 to £36,399; 147 £36,400 to £51,999; 192 £52,000 to £77,999; 217 £78,000 and above; employment: 483 working from home, 98 working outside, 83 unemployed; mean BMI 26 ± 5 kg/m ² | 300 participants never cycled or ran before or during lockdown, 242 never used gym or exercise classes before lockdown; 307 participants classified as inactive before lockdown decreased to 267 during lockdown (13% reduction); the number of participants reporting to exercise more than twice a week increased (147 to 203), and those who exercised less than once a month from before to during lockdown decreased (559 to 478) | Home-based workout, exercise class (including online or virtual class), gym, walking, cycling | Never exercising at the gym or undertaking an exercise class (online or live), increased by 50.8% during lockdown, with 53.5% changing from exercising frequently to never exercising; outdoor running and cycling >2 times/week increased by 38% during lockdown; walking at least 30 min continuously on >2 occasions/week increased by 70% during lockdown with minimum 10-min walks on 7 days per week increasing by 23%; sitting time (>8 h a day) increased by 43.6% on weekdays and 121% at weekends; sitting <4 h/day decreased during lockdown (46.5% and 25.6% for weekdays and weekends, respectively) | Self-reported body mass change showed that in 32.2% of participants body mass increased, with 39.1% reporting an increase in food intake; those citing tiredness or lack of time as a barrier to exercise reduced by 16% and 60%, respectively, from prelockdown to during lockdown | During lockdown, time spent walking, running, and cycling increased; however, the majority of people still did not meet the Government guidelines for PA. Less people cited lack of time and feelings of tiredness as barriers to PA during lockdown. Sitting time increased both during weekdays and weekend days along with food intake during lockdown | Fair (5) |
| Martin et al. 2021 UK ⁴¹ | N: 1213; gender: 670 females (55.2%), 543 males (44.8%); mean age 49.41 ± 17.16 years; ethnicity: white or Caucasian: 1183 (97.5%), Asian: 12 (1%), black or African American: 5 (0.4%), mixed race: 8 (0.7%), other: 5 (0.4%) | Participants exercised on an average of 4 days per week before the lockdown and 5 days during the lockdown | online workouts, fitness applications and home-gym set ups | 3.6% of participants exercised 0 days per week during the lockdown, yet 21.2% (up from 10.4%) exercised on all 7 days | Most of the respondents took part in PA during home isolation and at the same time, had good health values, were not bored with home isolation, and still maintained a subjective sense of well-being and life satisfaction with their lives | PA during home isolation had a positive association on residents' well-being and health values | Poor (4) |

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Table 1 (continued)

| Author Year Country | Sample characteristics | Sport/PA and inactivity before and during the pandemic | Type of exercise during the pandemic | Frequency/intensity of exercise during the pandemic | Associated health- related effects | Main findings | Quality Assessment (NOS) |
|---|---|---|--|--|---|--|-----------------------------|
| Maugeri et al. 2020 Italy ⁴² | N: 2524; gender: 1426 females (56.4%), 1098 males (43.6%); age: young: (<21 years) 346, young adult: (21–40 years) 1178, adults: (41–60 years) 704, over 60 years: 296; normal weight: 1707 (67.63%), overweight: 483 (19.14%), underweight: 334 (13.23%); mean BMI: 22.26 ± 3.52 kg/m ² | Before COVID-19, 41.76% were high active (≥ 3000 MET–minutes/week), 35.18% were moderate active (≥ 600 MET–minutes/week), and 23.06% of participants were low active (<600 MET–minutes/week); during quarantine, low-active individuals increased up to 39.62%, whereas moderately-active and highly-active individuals decreased to 29.75% and 30.63%, respectively. | Heavy lifting, performing intense aerobic exercises, using bike or treadmill, carrying light loads and bicycling at a regular pace carry, work out in the garden, walking activities | Total PA decreased during quarantine: 2429 vs. 1577 mean MET–min/week (vigorous PA pre-pandemic 1109 vs. quarantine 766.6 mean MET–min/week; moderate activity 574 vs. 523.3 mean MET–min/week; walking (746 vs. 287.6 mean METS–min/week; low-active individuals significantly increased total weekly PA energy expenditure during quarantine (408.1 vs 755.3 mean MET–min/week). | There was a positive correlation between the variation of PA and mental well-being: the reduction of total PA had a profoundly negative impact on psychological health and well-being of population | The quarantine in Italy has led a significant reduction of total weekly PA energy expenditure in all age groups and especially in men. However, individuals classified before COVID-19 as low active significantly increased total weekly PA energy expenditure during quarantine. This unexpected result could be due to the greater housework activities carried out by these individuals forced to stay at homes, compared to before quarantine | Good (7) |
| Mutz et al. 2021 Germany ⁴³ | N: 1508; gender: 770 females (51%), 738 males (49%); mean age: 48.8 ± 18.6 years; educational level: lower: 27%, medium: 32%, upper secondary degree: 41% | The mean pre-pandemic level of sporting activity is significantly higher in the active group with digital sports activities than in the active group with offline activities only, as well as the inactive group | General fitness workout, strength and weight training, body and mind practices, (functional) gymnastics, dance, endurance training; 23% reported using digital media for sports activities at least once during the COVID-19 pandemic, whereas only 12% during the pre-pandemic period | The group of individuals who used digital sports activities during the pandemic stands out with an above-average pre-pandemic, sports-activity level (176 min/week, SE = 10); those solely engaged in offline sports during the pandemic had a significantly lower pre-pandemic activity level (137 min/week, SE = 7); those inactive during the pandemic reported a very low activity level in the time before the COVID-19 outbreak (19 min/week, SE = 10) | – | Data on the pre-pandemic level of sports activity of active digital sports users show that this group was already more active before the COVID-19 crisis. Individuals engaged in digital sports achieved 30 min/week more sports activity during the pandemic than individuals solely involved in offline sports. Digital sports practitioners are younger, better educated, and financially better off. Females are overrepresented | Fair (6) |
| Mutz and Gerke 2021 Germany ¹⁴ | N: 1001; age: ≥ 14 years | Pre-pandemic: 39.4% inactive; 41.6% active. During pandemic: 59.5% inactive; 23.7% active. Based on physical activity before and during pandemic, 4 groups were identified: (a) inactive individuals; and those who (b) | 18% of participants refer to light physical activities (e.g., going for walks), and 9% indicate outdoor endurance sports (running, cycling, skating, Nordic walking); 14% referred to home-based individual exercise (gymnastics, yoga, | Pre-pandemic: 17% engaged in sport and exercise for 2 h per week; 13.5% for 3–4 h; 7% for 5–6 h; 4.1% for more than 6 h. During pandemic: 10.3% for 2 h per week; 6.8% for 3–4 h; 4.4% for 5–6 h; and 2.2% for more than 6 h | – | The study shows a significant decline in leisure time, sport, and exercise (LTSE) in the population. Overall, 31% of Germans reduced their LTSE, whereas 27% maintained and 6% increased their LTSE level. A 36% stake was | Fair (6) |

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| | | reduced, (c) maintained or (d) increased the time spent in exercise and sport | stretching, Pilates, weight- and cardio-training with ergometers, treadmills, cross-trainers or training with dumbbells or similar equipment; 2% tried out online- and DVD-based fitness programs; 6% indicate more physical activity relating to housework and gardening | | | not engaged in LTSE, either before or at the start of the lockdown. Younger age groups were more likely to maintain LTSE levels than older ones, whereas gender and education level did not affect physical activity. The “maintainers/intensifiers” group (6%) increased their home workouts and outdoor endurance sports, whereas the “reducers” found no adequate substitutes for their sports routines | |
| Newbold et al. 2021 UK ⁴⁴ | N (first survey): 390; gender: 297 females (76%), 82 males (24%), 4 nonbinary, and 7 preferred not to self-describe; mean age: 36 ± 12; n (follow-up): 126; gender: 101 females (80%), 20 males (20%), 1 nonbinary, and 4 preferred not to self-describe; mean age: 36 ± 11 years | Participants experienced a decrease in time spent on moderate work activity and travel during the lockdown, and an increase in time spent on moderate and vigorous sport and sitting time | running, training, yoga | Before the lockdown: vigorous sport activity 175 ± 274 min/week, moderate sport activity 192 ± 361 min/week, sitting 3388 ± 1343 min/week; during the lockdown: vigorous sport activity 223 ± 423 min/week, moderate sport activity 254 ± 445 min/week, sitting 3908 ± 1632 min/week) | Mental health was a big motivator for a lot of people, with increased stress due to lockdown and the pandemic, overall. While mental health had been a motivator for some before, it had become more of a primary concern for all, and PA was seen as a key part of looking after one's mental well-being | There was an increase in activity-tracking use associated with an increase in vigorous sports activity in response to the lockdown, a significant increase in people using online classes and video tutorials, changes in people's motivation and a general increase in awareness of the importance of staying active due to the physical and mental health benefits. However, some people also experienced difficulties in staying active including reduced motivation and even injury. Additionally, while people were able to maintain a high level of vigorous activity, sedentary time was not impacted by technology use | Poor (4) |
| Olfert et al. 2022 USA ⁴⁵ | N: 2018; gender: females: 1416 (70.7%), males: 553 (27.6%); mean age: 24.9 ± 5.54 years; ethnicity: white: 1665 (83.1%), multiple: 112 (5.6%), Asian: 85 (4.2%), black or African American: 52 (2.6%), | There was an increase in moderate PA, but the amount of respondents with low PA significantly increased, and the amount of respondents with high PA significantly decreased | There was a significant decrease in the use of gyms, the student recreation centre, outdoor activities, and running outside and inside. There was a significant increase in the use of self-created and guided at-home | Moderate PA increased from 12.8% to 14.7%, low PA significantly increased from 27.8% to 51.9%, high PA significantly decreased from 59.5% to 34.0% | | The number of students engaging in low PA increased, the number of students engaging in high PA decreased, and many switched to the use of at-home workouts. There was a significant increase in the use of self-created | Good (7) |

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Table 1 (continued)

| Author Year Country | Sample characteristics | Sport/PA and inactivity before and during the pandemic | Type of exercise during the pandemic | Frequency/intensity of exercise during the pandemic | Associated health- related effects | Main findings | Quality Assessment (NOS) |
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| | other: 50 (2.5%), American Indian or Alaska native: 3 (0.1%), native Hawaiian or Pacific Islander: 2 (0.1%). educational level (class standing): Graduate/ Professional School: 773 (29.3%), Senior: 557 (21.1%), Junior: 482 (18.3%), Sophomore: 425 (16.1%), Freshman: 399 (15.1%) | | workouts, as well as the use of workout apps | | | and guided at-home workouts | |
| Parker et al., 2021 Australia ⁴⁶ | N: 1188 adults; mean age: 37.4 years (SD: 15.1), 980 females (82.5%) and 208 males (17.5%). 963 adolescents, mean age: 16.2 years (SD: 1.2), 685 females (71.1%) and 278 males (28.9%) Employment status: (working) 625 (52.6%) of adults and 248 (25.8%) of adolescents; Student status (yes) 258 (21.7%) of adults and 622 (64.6%) of adolescents | – | Moderate- to vigorous- intensity physical activity and muscle strengthening exercise; instructor-led activities such as yoga, Pilates, and dance | Days per week during a usual week over the past month (none, from 1 day/week to 7 days/ week) for 30 min (adults aged ≥ 18 years) or 60 min (adolescents aged 13–17 years). Adult responses were 5 or more days per week and ≥ 150 min/week, adolescent responses were 7 days per week and ≥ 60 min/day. Median frequency was 4 times per week, and the median duration was 120 min per week | – | Digital platform users were more likely than nonusers to meet moderate- to vigorous- intensity physical activity and muscle strengthening exercise guidelines during the COVID-19 stay-at- home restrictions. Digital platforms play a critical role in helping to support physical activity engagement when access to facilities or opportunities for physical activity outside the home are restricted | Fair (5) |
| Purc-Stephenson et al. 2022 Canada ⁴⁷ | N: 424; gender: 299 females (70.52%), 125 males (29.48%); mean age: 19.77 \pm 1.82 years | Students athletes of a sports team significantly reduced their training load and intensity, with approximately 25% exercising two or fewer days a week | Home-based exercise; 75% of participants had resistance bands, free weights, or sports- specific equipment to train at home, and 60% had a cardio machine at home | 0–2 days a week (5.90% pre and 24.76% during), 3–4 (43.16% pre and 39.39% during), 5+ (50.94% pre and 35.85% during) | Compared to male athletes, female athletes reported poorer mental health and more emotional distractions that impacted their training | Results showed that athletes significantly reduced their training load and intensity. Barriers to training included limited access to fitness resources and equipment, having inconsistent training schedules, and experiencing emotional distractions, with some of these barriers more common among female athletes than in male athletes. Being male, being younger, having higher levels of intrinsic and introjected motivation, having access to fitness resources, maintaining a steady training | Poor (4) |

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| Schneider et al. 2021 Austria ⁴⁸ | N: 1305; gender: 705 females (54%), 600 males (46%); mean age: 30.5 ± 11.7 years | Before the pandemic 844 (68.5%) were athletes, of which 46 (4.5%) practiced professional sports, and 11.4% indicated no regular sports activity; during confinement, 15.7% could perform their main sport unrestricted | Home-based activities, online training, recreational sports, and competitive and professional sports; 385 (40.1%) stated that they switched to other sports during the lockdown period; most commonly, outdoor and home-based activities | 43.5% stated a reduced amount of time spent on sporting activities; 46.4% reported a reduced intensity level; conversely, 21.3% declared an increased extent, 17.8% increased intensity levels during confinement conditions. | — | schedule, having fewer emotional distractions, and lower mood disturbance were significant predictors to being motivated to train during the pandemic Higher age and usually training in a club setting are statistically associated with reduced PA (both reduced extent and intensity levels) during the confinement period, whereas the availability of online training was linked to both increased extent and intensity levels | Fair (6) |
| Schuttler et al. 2022 Germany ⁴⁹ | N: 101; gender: 40 females (39.6%), 61 males (60.4%); mean age: 22.8 ± 4.4 years; mean height: 176 ± 9.3 cm, mean weight: 70.4 ± 10.4 kg | Both professional and amateur football athletes increased the weekly amount of training time | Running, cycling, workout (core, legs, arms, abdominals), and video training moved from soccer fields and gymnasiums to the home and outdoors | Mean time per week of cycling increased from 37.5 to 187.5 min/week in professionals and from 0 to 37.5 min/week in amateurs; running time increased from 112.5 to 187.5 min/week in professionals and from 93.75 to 112.5 min/week in amateurs; video training at home increased from 0 to 112.5 min/week in professionals and remained unchanged in amateurs (from 0 to 15 min/week) | — | The weekly amount of training time for resistance exercise (cycling) increased in both professionals and amateur gamers during the COVID-19 lockdown. Time spent on different muscle-strengthening workouts was significantly elevated in both cohorts. Video-guided training was intensified in both groups. The position has moved from soccer fields and gymnasiums to the home and outdoors. COVID-19 lockdown profoundly changed training methods in both amateur and elite football players from one day to another | Fair (5) |
| Symons et al. 2021 Belgium ⁵⁰ | N: 427; gender: 73 females (17.1%), 354 males (82.9%); mean age: 34 ± 14.1 years; educational level: elementary: 7 (1.6%), secondary: 48 (11.2%), Bachelor's degree: 182 (42.6%), Master's degree: 149 (34.9%), PhD: 41 (9.6%); employment: full-time: 174 (40.7%), more | Respondents significantly increased their level of light and moderate intensity PA | — | People spent 205.86 ± 176.71 min per week in light PA, 125.95 ± 127.10 min in moderate PA, and 82.10 ± 106.78 min in vigorous PA; respondents scored significantly higher on light PA (114.57 ± 49.47) and moderate PA | — | Individuals who participated in this study generally exercised more before the lockdown, especially in light-intensity and moderate-intensity exercise. When a distinction in our sample was made between individuals | Poor (4) |

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Table 1 (continued)

| Author Year Country | Sample characteristics | Sport/PA and inactivity before and during the pandemic | Type of exercise during the pandemic | Frequency/intensity of exercise during the pandemic | Associated health- related effects | Main findings | Quality Assessment (NOS) |
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| | than part-time: (>50%) 47 (11.0%), part-time: (=50%) 15 (3.5%), less than part-time: (<50%) 10 (2.3%), not employed: 61 (14.3%), student: 120 (28.1%) | | | (111.05 ± 52.36) than on the neutral value of 100 (no change in comparison with before the lockdown) | | who were sufficiently active and insufficiently active before the lockdown, it was found that sufficiently active individuals engaged even more in PA, whereas insufficiently active individuals exercised equally (i.e., not enough) or even less compared to before the lockdown | |
| Wang et al. 2020 China ⁵¹ | N: 2289; gender: 1113 females (48.6%), 1176 males (51.4%); mean age: 27.8 ± 12 years; educational level: under college: 251 (11%), university: 1717 (75%), postgraduates and above: 321 (14%); mean height: 169.6 ± 9.1 cm, weight: 64.3 ± 13.4 kg, mean BMI: 22.3 ± 3.6 kg/m ² | 52% of the participants reported reduced levels of PA, whereas 17% increased their amount of exercise, 44% of the participants reduced their daily PA, and 19% increased their daily PA | Vigorous PA (e.g., rope jumping and weight training), moderate PA (e.g., jogging, Tai Chi, and dancing), and light PA (e.g. yoga, Chinese traditional stretch exercise, and Baduanjin) | 40% did not perform moderate-intensity PA, 55% vigorous moderate-intensity PA, and 18% light-intensity PA; few people reported performing vigorous PA with a short duration; approximately 10% of adults did not perform any light PA, and approximately 26% did not perform vigorous PA | PA was positively associated with the quality of life in both men and women | PA participation during containment measures was associated with better quality of life, the substantially reduced amount of moderate to vigorous PA warrants the identification of ways to enable and encourage people to engage in PA at home with limited space | Fair (6) |
| Zaworski et al. 2020 UK ⁵² | n: 688; gender: 491 females (71.0%), 197 males (29.0%); mean age: 28.61 ± 9.5 (18–58) years; educational level: 373 (55%) higher, 288 (42%) secondary, 12 (2%) basic, 1 (1%) vocational | Oldest people not practicing any PA before the pandemic increased from 1.7% to 19.5% | Jogging, flexibility exercises/yoga, strength exercises, fitness/pilates/aerobic, general improvement exercises, marching, walks, nordic walking, cycling/roller skating | Statistically significant decrease in the frequency of PA was noted in men and in the age group of 39–58 y; there was no statistically significant decrease in the frequency of PA in women and persons aged 18–28 y and 29–38 y; there was a statistically significant increase in the frequency women undertaking flexibility exercises, e.g., yoga, as well as a decrease in marching and walks; men significantly less frequently did strength exercises | Both women and men indicated mental health significantly more frequently and staying fit and maintaining a good figure less frequently; all the sample groups, in terms of gender and age, were more likely to expect that PA during the pandemic would contribute to alleviate lockdown-related isolation fatigue | The analysis of the duration of PA before and during the pandemic has shown a statistically significant reduction in the workout time among both men and women and across all age groups | Fair (6) |

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| <p>Zuo et al. 2021 China⁵³</p> | <p>n: 543; gender: females 302 (55.6%), 241 males (44.4%); age: 63.2% under 29 years; educational level: college degree and below: 28.5%, undergraduate: 48.7%, postgraduate and above: 23.0%; income: below 100,000: 35.6%; 100,000–200,000: 46.9%; over 200,000: 17.4%; employment: employed: 69.7%; BMI too thin (<18.5) kg/m²: 14.3%, standard (18.5–23.9): 71.1%, overweight (>24.0): 14.7%</p> | <p>fitness and leisure activities (69.8%), recreation games and leisure activities (24.4%); healthcare activities (19.8%); other PA (15.1%)</p> | <p>small activity (volume less than 19): 28.3%, moderate activity (20–42): 34.5%, high activity (greater than 42): 37.2%</p> | <p>most of the respondents took part in physical activity during home isolation, and at the same time had good health values, were not bored with home isolation, and still maintained a subjective sense of well-being and life satisfaction with their lives at that time</p> | <p>This study shows that physical activity during home isolation had a positive association on resident well-being and a positive association on resident health scores. Furthermore, this study shows the importance of residents' physical activities in home isolation. Moderate exercise at home and regular PA benefit our physical and mental health, especially in terms of improving overall well-being</p> | <p>Poor (4)</p> |
|---|---|---|--|---|---|-----------------|

PA: physical activity; NOS: Newtown–Ottawa Scale; BMI: body mass index; SD: standard deviation; BTEC: Business and Technology Education Council; GCSE: General Certificate of Secondary Education; MET: metabolic equivalent task.

emotional distractions”, and “lower mood disturbance” were identified as significant predictors of being motivated to train. Moreover, Symons et al.⁵⁰ described five predictors of being more active: “relying on an application in combination with a tracker or wearable as support”, “not focusing on physical performance goals”, “better time allocation”, “not experiencing physical activities as a physical effort”, and “watching online videos during the lockdown”.

From this variegated overview, it can be concluded that several individual, social, and environmental factors can have played a role in determining exercise-related behaviours at home in the course of the pandemic. Beyond the possible effect of age and gender, it seems that a previous active lifestyle and the availability of resources, especially digital resources, were the main facilitator for PA engagement in the home setting during social constraints.

These findings are in contrast with other reviews aimed at evaluating the changes occurred in PA during the COVID-19 lockdowns and after. In the review performed by Zaccagni et al.,⁶⁷ on the studies regarding the Italian population only two studies out of 20 reported an increase in PA during the lockdown with respect to the prepandemic period. In the review by Stockwell et al.,¹³ the majority of the studies examined reported decreases in PA during their lockdowns across several populations, and people who were more active before the lockdown were more likely to show larger decreases in PA. The systematic review and meta-analysis by Wilke et al.,⁶⁸ aimed at assessing changes in PA levels occurred during lockdowns and their possible predictors, registered a general decrease in PA components worldwide but in Australia; nor sociodemographic neither previous lifestyle were found to be related with PA-related behaviours assumed during the lockdowns.

It should be considered, however, that the variability showed by the literature on this issue can explain the disagreement with our findings. As assumed in the review by Wunsch et al.,⁵⁷ in fact, sociodemographic characteristics of the samples, PA-assessment methods and times across the pandemic, and country-related measures adopted to control the coronavirus spread may have affected the outcomes of the investigations. Therefore, our findings should be contextualised only to the inclusion criteria used in this review, namely spontaneous exercise performed at home or in the surroundings by healthy individuals during social constraints.

As for the use of digital media as a support for PA/exercise during social isolation, Harangi-Rákos et al.,⁶⁹ in their review, highlighted how the current availability of information–communication technologies can reduce the burden of health problems related with a pandemic. Gaming applications and also exergames may increase the pleasure of PA experiences. Coaches and instructors of physical education can keep in touch with their clients, athletes, and students and customise PA according to their health and fitness characteristics. With the help of telecommunication apps and software, people can also exercise together, and the results achieved with practice can be shared through social media platforms, strengthening motivation to exercise. This is in accordance with the findings of our review and opens new perspectives in PA promotion.

Our review has some limitations that should be taken in account when considering these findings. First, since the characteristics of exercise performed during the pandemic were not reported in all the studies concerning PA performed during the pandemic, it is possible that the selected studies offer only a part of the real picture regarding this issue. Furthermore, the variability of the selected studies limits the comparison of their findings and the definition of consistent results, especially regarding the type of exercise performed at home. With regards to this, in particular, it should be noted that the phase of the COVID-19 pandemic at which the

studies were performed may have notably affected the results. A review of longitudinal studies investigating home workout across the pandemic, since the first nationwide lockdowns to the subsequent phases of individual quarantines, could be clarifying in this direction.

However, the strength of this review was the specific focus on spontaneous workout during pandemic-related home confinement, which to the Authors' knowledge was not specifically addressed in previous reviews. Our main findings highlight some aspects that could act as determinant of healthy behaviours during critical situations such as the COVID-19 pandemic and that deserve attention in future research.

Conclusions

The literature regarding spontaneous home workout performed by healthy individuals during the COVID-19 pandemic highlights some aspects that could be helpful to enhance PA promotion in challenging conditions and beyond.

First, in such an emergency situation, previous PA engagement seems to be a predictor of exercise at home in the changed conditions.

Furthermore, technologies aimed at supporting PA and exercise may represent a useful resource, especially for young and female individuals.

Even though the variability among the examined studies limits the acceptance of these findings, they suggest that digital resources may support health policies in increasing the PA levels of individuals, especially those who are less used to engage in exercise, when material resources are unavailable.

The analysis of longitudinal, comparable studies performed on this issue along the COVID-19 pandemic may confirm these findings.

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Competing interests

The authors declare that they have no conflicts of interest.

Author contributions

Conceptualisation, C.P., F.G. and F.V.; methodology, A.D.G and E.M.; software, A.D.G and E.M.; validation, F.G., C.Pandemic and F.V.; formal analysis, A.D.G and E.M.; investigation, F.G., A.D.G, and E.M.; data curation, F.G., C.P. and F.V.; writing—original draft preparation, F.G., C.P., A.D.G. and E.M. writing—review and editing, G.L., V.R.S., M.V. All authors have read and agreed to the published version of the manuscript.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.puhe.2023.06.040>.

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