sustainability

MDPI

Review

Effectiveness of Physical Activity Interventions in Sedentary People during COVID-19 Lockdown: A Systematic Review of Randomized Controlled Trials

Stefano Ciriminna [1], Nicola Veronese [1], Claudia Cannizzo [1], Alessandro D'Aleo [1], Antonina Ganci [1], Sofia Elena Montana Lampo [1], Federica Bifara [1], Giuseppe Battaglia [2,3], Giuseppe Messina [4,5], Valerio Giustino [2], Antonio Palma [2,3], Mario Barbagallo [1] and Ligia J. Dominguez [1,6,*]

1 Geriatric Unit, Department of Internal Medicine and Geriatrics, University of Palermo, 90133 Palermo, Italy; ste.ciri@gmail.com (S.C.); nicola.veronese@unipa.it (N.V.); claudiacannizzo24@gmail.com (C.C.); alessandro.daleo95@gmail.com (A.D.); ninaganci1994@gmail.com (A.G.); sofiamontana25@gmail.com (S.E.M.L.); federica.bifara@gmail.com (F.B.)
2 Sport and Exercise Sciences Research Unit, Department of Psychology, Educational Science and Human Movement, University of Palermo, 90133 Palermo, Italy; giuseppe.battaglia@unipa.it (G.B.); valerio.giustino@unipa.it (V.G.); antonio.palma@unipa.it (A.P.)
3 Regional Sports School of Italian National Olympic Committee (CONI) Sicilia, 90141 Palermo, Italy
4 Department of Human Sciences and Promotion of the Quality of Life, San Raffaele University, 20132 Rome, Italy; giuseppe.messina@uniroma5.it
5 PLab Research Institute, 90121 Palermo, Italy
6 School of Medicine, Kore University of Enna, 94100 Enna, Italy
* Correspondence: ligia.dominguez@unikore.it

Abstract: Background: The social restriction measures during the COVID-19 pandemic resulted in decreasing physical activity levels. We aimed to evaluate whether the interventions reported in randomized controlled trials (RCTs) assessing the effects of physical activity during the COVID-19 lockdown on people with sedentary behavior were effective. **Methods**: We searched several databases from their inception until 1 April 2023, including RCTs evaluating the effects of any physical activity intervention in increasing the physical activity level in people with sedentary behavior during COVID-19 confinement, based on evidence derived from intervention studies with a control group. Studies were excluded if they (i) did not include humans; (ii) did not include sufficient information regarding the interventions or regarding the outcomes of interest; (iii) did not have a control group. We used the Rayyan systematic review platform for the selection of the studies to include based on the title/abstract information. **Results**: Starting with 2461 records from the original literature search, and after reviewing them according to the latest PRISMA recommendations, 11 RCTs including a total of 1770 participants were available and were included in the systematic review. We found that most of the studies examined (73%) reported the beneficial effects of the proposed interventions on improving the physical activity, reducing the sedentary time, and positively contributing to the psychological well-being of the participants. **Conclusions**: The results of the present systematic review on RCTs of interventions to increase physical activity in sedentary people during the COVID-19 lockdown show the beneficial effects of diverse online-delivered strategies, which can be applied even after the pandemic in conditions in which access to in-person activities is not possible.

Keywords: physical activity; COVID-19; lockdown; tele-coaching; randomized controlled trial

check for updates

Citation: Ciriminna, S.; Veronese, N.; Cannizzo, C.; D'Aleo, A.; Ganci, A.; Montana Lampo, S.E.; Bifara, F.; Battaglia, G.; Messina, G.; Giustino, V.; et al. Effectiveness of Physical Activity Interventions in Sedentary People during COVID-19 Lockdown: A Systematic Review of Randomized Controlled Trials. *Sustainability* **2024**, *16*, 1331. https://doi.org/10.3390/su16031331

Academic Editor: Jesús-Nicasio García-Sánchez

Received: 27 November 2023
Revised: 13 January 2024
Accepted: 24 January 2024
Published: 5 February 2024

1. Introduction

The recent COVID-19 pandemic has changed the lifestyle of practically all populations in the world. In order to stop the contagion, governments imposed public health measures consisting of the restriction of usual activities, such as the closure of businesses and the prohibition of social gatherings and mass events [1]. These measures certainly helped to mitigate the spread of the virus and reduced the burden during the pandemic [2], but they also significantly limited opportunities to engage in physical activity and exercise since parks, gyms, and sports clubs could not be accessed during the restrictions [3]. At the same time, restraint measures encouraged an escalation in sedentary behavior; for example, worldwide, there was an increase in the time spent sitting or in front of a screen, which was already high before the pandemic at all ages [4].

The accrued evidence clearly shows how physical activity and exercise can effectively contribute to health maintenance and the prevention of cardiovascular, metabolic, neurodegenerative, and musculoskeletal diseases, today being considered a measure of paramount public health relevance [5–7]. On the other hand, there is also cumulative evidence of the negative consequences of a sedentary lifestyle [4,8,9]. In fact, it has been reported that physical inactivity leads to an approximately 9% increase in premature mortality [4,8] and a rise in healthcare costs of up to 4.6% [10]. Physical inactivity is a major risk factor for several conditions [4,11]. The 2018 Physical Activity Guidelines Advisory Committee Scientific Report concluded that high amounts of sedentary behavior increase the risk of all-cause and cardiovascular disease mortality, as well as of incident cardiovascular disease and type 2 diabetes, with strong evidence. There was moderate evidence indicating that sedentary behavior is associated with incident endometrial, colon, and lung cancer and limited evidence suggesting that sedentary behavior is associated with cancer mortality and weight status. In addition, there was strong evidence indicating that the hazardous effects of sedentary behavior are even more pronounced in physically inactive people [11]. A recent study including 65,361 adults showed a 34% reduced risk of hospitalization, 41% reduced risk of ICU admission, 45% lower need for mechanical ventilation, and 42% reduced risk of mortality in people with a high level of physical activity when compared to those with low levels [12].

Considering the crucial role that physical activity and exercise play in health status at the population level, various investigations have been performed to evaluate the consequences of the restrictions on public life in terms of people's behavior. A systematic review of 66 studies including a total of 86,981 participants published in 2021 found that the majority of studies reported decreases in physical activity and increases in sedentary behaviors during their respective lockdowns across several populations, including children and patients with a variety of medical conditions [13]. These results were strongly confirmed by a recent quantitative analysis based on a systematic review and meta-analysis of 173 trials with over 320,000 participants [14]. Compared to the pre-pandemic data, total physical activity and walking decreased by 35% and 48%, respectively, taking into account all levels of physical activity from light to vigorous in similar proportions, with a parallel increase in sedentary behavior. There was no influence of sex, age, body mass index, or health status [14].

Consequently, there is no doubt about the foremost importance of identifying strategies to maintain or even improve physical activity during restrictions on social life. A number of methods have been proposed in periods of lockdown, including tele-coaching and other digital techniques, which could be used to promote and advise physical activity without having contact with people.

Based on this background, with the present systematic review, we aimed to evaluate whether the interventions reported in randomized controlled trials (RCTs) were effective in terms of the effects of physical activity (tele-coaching) during the COVID-19 lockdown on people with sedentary behavior.

2. Materials and Methods

This systematic review adhered to the PRISMA statement [15] and followed a pre-planned but unpublished protocol.

2.1. Data Sources and Searches

Six investigators (S.C., C.C., A.D.A., A.G., S.M.L., F.B.) conducted a literature search using PubMed/Medline and Web of Science from database inception until 1 April 2023.

In PubMed, the following search strategy was used: (Sedentary Behavior* OR Sedentary Lifestyle OR Physical Inactivity OR Lack of Physical Activity OR Sedentary Time) AND ("covid 19" [MeSH Terms] OR "covid 19" [All Fields] OR "covid19" [All Fields] OR "covid 19" [All Fields] OR "covid 19" [MeSH Terms] OR "sars cov 2" [All Fields] OR "sars cov 2" [MeSH Terms] OR "severe acute respiratory syndrome coronavirus 2" [All Fields] OR "ncov" [All Fields] OR "2019 ncov" [All Fields] OR "coronavirus" [MeSH Terms] OR "coronavirus" [All Fields] OR "cov" [All Fields])". Any inconsistencies were resolved by consensus with a senior author (L.J.D.).

2.2. Study Selection

We used the following PICO question for the study inclusion: in people with sedentary behavior during the COVID-19 pandemic social restrictions (P), compared with a control group (C), what was the effect of any physical activity intervention (I) in increasing the physical activity level (O) based on the evidence derived from intervention studies with a control group (S)?

Studies were excluded if they (i) did not include humans; (ii) did not have sufficient information regarding interventions or regarding outcomes of interest; (iii) did not have a control group. We used the Rayyan systematic review platform (https://www.rayyan.ai/, 1 April 2023) for the selection of the studies to include based on the title/abstract information.

2.3. Data Extraction

The six independent investigators cited before (S.C., C.C., A.D.A., A.G., S.M.L., F.B.), in couples, extracted key data from the included articles into a standardized Excel spread sheet, with two senior authors (N.V. and M.B.) checking the data. For each article, we extracted data on the author names, year of publication, country, sample size, demographics, setting/population, type of study and type of intervention, and follow-up (weeks). Concerning physical activity, we extracted data regarding the baseline presence of physical inactivity/sedentary behavior, the instruments used for the defining physical activity levels in the studies, and the tools used to increase the physical activity levels.

2.4. Outcomes

The outcome of interest in our systematic review was the physical activity level, defined as any bodily movement produced by skeletal muscles that results in energy expenditure, as defined by the World Health Organization (World Health Organization 2019), after a follow-up period with a specific training intervention compared to a control group not undertaking any specific training. The physical activity level was recorded according to the data originally reported in the studies, i.e., using questionnaires or objective tools, such as accelerometers.

2.5. Quality Assessment

The quality/risk of bias assessment was made using the tool suggested by JBI [16]. This tool is based on 13 different questions regarding the methodological aspects of an intervention study. In detail:

1. Study Design Consideration: JBI provides specific tools tailored to different study designs. For intervention studies, common designs include RCTs, non-randomized controlled trials, and quasi-experimental designs.
2. Structured Criteria: Each tool consists of a set of structured criteria relevant to the specific study design. These criteria guide the appraiser in evaluating various aspects of the study methodology, including the study population, intervention, comparison groups, outcomes, and statistical analysis.

3. Validity and Reliability: The tools assess the validity and reliability of the included studies. This involves examining the appropriateness of the study design for addressing the research question, ensuring the proper randomization and allocation concealment in RCTs, and evaluating the potential for bias.
4. Outcome Measurement: Evaluation of the tools involves scrutinizing the clarity and appropriateness of the outcome measures, whether objective or subjective. It considers whether the outcomes align with the research question and whether they are measured consistently across groups.
5. Data Analysis: The tools assess the statistical methods used in data analysis, including whether appropriate statistical tests were applied, whether the analysis accounts for potential confounding variables, and whether the results are reported clearly.

2.6. Data Synthesis and Analysis

The data are reported descriptively since extremely heterogeneous definitions of physical activity or tools for improving this aspect were used in the studies. We therefore reported the main findings of the studies included, indicating whether the associations reported were statistically significant at a p-value < 0.05.

3. Results

3.1. Literature Search

The search identified 2461 records across three databases. After screening 1954 title/abstracts, we found 21 full texts. Among these full texts, 10 studies were excluded, of which 7 had an incorrect outcome considering our PICO question, and 2 others were excluded because they did not have a control group; thus, 11 intervention studies were finally eligible for our systematic review after the exclusions, as shown in Figure 1.

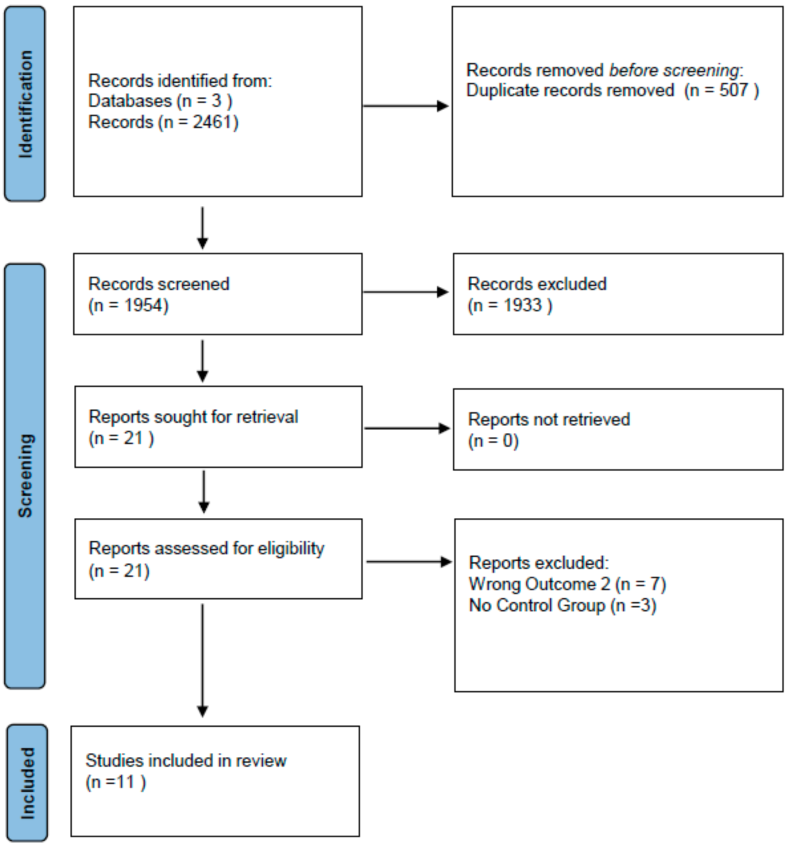

Figure 1. PRISMA flow chart.

3.2. Descriptive Data

Table 1 shows the most important descriptive data of the studies included [17–22]. The 11 studies comprised 898 participants randomized for intervention vs. 872 controls, with a total of 1770 participants. Five studies were carried out in Europe, four in America, and two in Asia or Oceania. The information about ethnicity was reported only in four studies [23–26] with heterogenous data. The vast majority of the studies included were RCTs (8/11) and 3 studies were quasi-experimental with a control group. The mean follow-up period was 38 weeks, with a range between 1.5 and 152 weeks. The mean age of the participants was 39 years, and they were prevalently women (66%) (Table 1). The interventions aiming to increase the physical activity levels are fully described in Table 1. Even if they were mainly based on web tools, the interventions were quite different in terms of their frequency, intensity, and type.

Table 1. Descriptive characteristics of the studies included.

Author, Year	Sample Size Intervention	Sample Size Controls	Total Sample Size	Country	Ethnicity %	Type of Study	Type of Intervention	Follow-Up (Weeks)	Mean Age (Years)	% of Females
Bargı, 2022 [17]	15	16	31	Turkey	NA	RCT	Progressive PAC program based on increasing daily step counts. The PAC consisted of regular outdoor walking, walking inside the home, leisure activities, and/or housework	4	IG: 20 ± 1.07 CG: 19.94 ± 1.24	90
Brazo-Sayavera, 2021 [18]	21	14	35	Spain	NA	quasi experimental study	5 weeks of supervised power training plus 6 weeks of unsupervised home-based power training	11	IG: 74.7 ± 4.5 CG: 73.1 ± 3.9	63
Garcia Perez de Sevilla, 2021 [19]	11	12	23	Spain	NA	RCT	18 sessions of 60 min each, with a frequency of 3 sessions per week, a 10 min warm-up of mobility exercises, training sessions consisting of a 40 min combination of strength training and moderate-intensity aerobic training	156	IG: 42.78 ± 6.88; CG: 40.46 ± 7.77	74
Ferreira Silva, 2023 [20]	59	54	80	Brazil	NA	Quasi experimental study	Educational material focused on activities described in the Physical Activity Guide for the Brazilian Population designed for children and young people from 6 to 17 years of age in the domains of free time, displacement, school, and household chores	4	IG: 16.2 ± 0.94 CG:15.9 ± 1.15	33
Granet, 2022 [21]	38	45	83	Canada	NA	RCT	Web-based PA interventions	12	LG: 70.7 ± 5.2 RG: 69.6 ± 5.1	70
Han, 2022 [22]	66	44	110	China	NA	Quasi experimental study	The family-based PA intervention program for children and parents was designed by pre-school exercise experts and early childhood educators based on SEM theory	8	IG: 4.16 ± 0.55 CG: 4.33 ± 0.43	51
Litt, 2023 [23]	145	146	291	USA	Hispanic 35% CG; 33% GG; Non-Hispanic 65% CG; 67% GG	RCT	Intervention gardening group was provided a standard community garden plot (average size of 10 m^2), seeds, and seedlings, and an introductory gardening course taught through DUG	156	IG: 42 ± 13 CG: 41 ± 14	82

Table 1. *Cont.*

Author, Year	Sample Size Intervention	Sample Size Controls	Total Sample Size	Country	Ethnicity %	Type of Study	Type of Intervention	Follow-Up (Weeks)	Mean Age (Years)	% of Females
Maddison, 2023 [24]	103	97	200	New Zealand	Maori: 16.5% CG, 20.4 IG; Pasifika: 16.5% CG, 15.5 IG; New Zealand European or Other: 67% CG, 64.1 IG	RCT	The 12-week RUFIT-NZ program was a gender-sensitized healthy lifestyle intervention delivered through professional rugby clubs	52	IG: 45.1 ± 8.7 CG: 46.3 ± 8.7	None
McDonough, 2021 [25]	32	32	64	USA	Non-Hispanic Caucasian: 81.25% CG, 75% IG; African American 9.375% CG; 6.25% IG; Asian 9.375% CG, 9.375% IG; Hispanic 0% CG, 9.375% IG	RCT	Weekly aerobic and muscle-strengthening PA videos	12	IG: 22.69 ± 3.06 CG: 22.91 ± 3.68	75
Wilke, 2022 [26]	386	377	763	Germany	Hispanic: 62.2% TOT, 62.5% CG, 61.9% DHE; Caucasian: 28.1% TOT, 27.6% CG, 28.7% DHE; African: 9.6% TOT, 9.8% CG, 9.3% DHE	RCT	Live-streamed multicomponent home exercise (DHE)	8	IG: 32.9 ± 13.1 CG: 32.6 ± 12.1	69
Teuber, 2022 [27]	22	35	57	United Kingdom	NA	RCT	Digital nudging for PA breaks for 10 days	1.5	23.52 ± 2.81	83

CG: control group; DHE: digital home exercise; DUG: Denver Urban Gardens; GG: Garden Group; IG: intervention group; LG: live group; NA: not available; PA: physical activity; PAC: physical activity counselling; RCT: randomized control trial; RG: recorded group; RUFIT-NZ: Rugby Fans In Training, New Zealand; SEM: socioecological model; TOT: total.

3.3. Main Findings

Table 2 summarizes the main results of the studies included. In a Turkish study of 31 young participants, a pedometer installed on smartphones led to a significant increase in physical activity levels. In particular, during a follow-up period of four weeks, the daily (mean difference [MD]: 3999.69 steps/d) and weekly (MD: 35,415.33 steps/week) step counts, total walking (MD: 734.15 MET-min/week), and total physical activity scores (MD: 924.22 MET-min/week) significantly increased in the intervention group compared to the control group. Furthermore, anxiety scores decreased significantly, with no changes in the depression and quality of life scores [17].

In a quasi-experimental study involving 35 older participants with type 2 diabetes, the authors compared a supervised vs. an unsupervised physical activity intervention consisting of a multicomponent training program focusing on muscle power. Both groups reported a significant increase in the time spent walking, while the sitting time increased more in the control group. Thus, the intervention resulted in an important increase in physical activity level [18]. Another pilot study in middle-aged university employees explored the possibility of tele-supervised real-time training sessions, over 156 weeks of follow-up. Among 23 participants completing the training, the authors found that those following the intervention (11 participants) increased their physical activity levels, reducing their daily sitting time by 2.5 h. Moreover, this study reported that the quality of life was greatly improved by this kind of intervention [19].

Table 2. Physical activity characteristics and main findings of the studies included.

Author, Year	Tool Used for Increasing Physical Activity	Definition of Physical Inactivity/Activity	Tool Used for Defining Physical Activity	Main Results
Barğı, 2022 [17]	Pedometer applications installed on smartphones	Inactive (less than 600 MET-min/week), minimally active (at least 600 MET-min/week) or very active (at least 3000 MET-min/week)	Step count (pedometer applications), IPAQ short form	After 4-week PAC, the daily (MD: 3999.69 steps/d) and weekly (MD: 35,415.33 steps/week) step counts, total walking (MD: 734.15 MET-min/week), and total physical activity scores (MD: 924.22 MET-min/week) increased in the PAC group compared with the control group.
Brazo-Sayavera, 2021 [18]	Supervised intervention was carried out at a public sport facility. Unsupervised intervention was carried out in participants' homes	NA	IPAQ-L	Both groups significantly increased their time spent walking and on vigorous physical activity. Both groups showed an increase in the total physical activity level.
Garcia Perez de Sevilla, 2021 [19]	Tele-supervised real-time training sessions	NA	GPAQ	The participants increased their PA levels, reduced their daily sitting time by 2.5 h, and improved their HrQoL in the Physical Component Summary by more than four points, which is of great clinical relevance.
Ferreira Silva, 2023 [20]	WhatsApp messaging application	NA	Questionnaire pre and post intervention (IPAQ)	The intervention was not effective in increasing the practice of physical activity and reducing the time spent on sedentary behavior in adolescent people. Some factors, such as the frequency of sending messages and intervention time, may have impacted the results.
Granet, 2022 [21]	Web-based PA intervention delivered either in a live group or a recorded group	NA	Rapid Assessment of Physical Activity (RAPA)	Web-based PA interventions are feasible, acceptable, and beneficial for improving functional capacities and physical activity levels during periods of lockdown. However, the interactive web live modalities appeared to be more effective in promoting some of these outcomes than the recorded and individual modalities.
Han, 2022 [22]	PA intervention based on a smartphone app	NA	PA was measured using a GENEActiv waveform triaxial accelerometer	The family parent–child PA intervention based on a smartphone app can effectively increase the MVPA of preschool children and their parents, reduce sedentary time, and improve preschool children's physical fitness. Overall, the family parent–child PA intervention model based on a smartphone app for preschool children designed in this study is feasible and effective.
Litt, 2023 [23]	Introductory gardening course taught through DUG	Moderate to vigorous physical activity was defined as a stepping cadence of at least 75 steps per min and sitting time was defined as sitting down for at least 30 min consecutively	activPAL3 accelerometers	Telehealth intervention led to an improvement in moderate to vigorous physical activity during the COVID-19 pandemic.
Maddison, 2023 [24]	Each intervention session included: (1) a 1 h workshop-based education component focused on nutrition, physical activity, sleep, sedentary behavior, and learning evidence-based behavior change strategies for sustaining a healthier lifestyle; and (2) a 1 h group-based but individually tailored exercise training session	NA	Godin Leisure Time Physical Activity Questionnaire	After 52 weeks of intervention, the RUFIT-NZ significantly improved the physical activity levels in the treated compared to the control group.

Table 2. *Cont.*

Author, Year	Tool Used for Increasing Physical Activity	Definition of Physical Inactivity/Activity	Tool Used for Defining Physical Activity	Main Results
McDonough, 2021 [25]	The intervention group received one YouTube video per week	NA	ActiGraph accelerometer, PA readiness questionnaire	Significantly improved young adults' free-living MVPA, muscle-strengthening PA, and sleep efficiency, which was likely a result of the intervention's positive effects on participants' self-determined motivation for PA and decreased perceived barriers to PA.
Wilke, 2022 [26]	Video live streaming	NA	NPAQ (moderate PA), NPAQ (vigorous PA)	Live-streamed DHE is efficacious in consistently enhancing PA and, to a smaller degree, in improving mental well-being, anxiety, sleep quality, and exercise motivation during pandemic-related public life restrictions.
Teuber, 2022 [27]	Nudges sent via MS Teams software	NA	Physical Activity Questionnaire of the European Health Interview Survey (EHIS-PAQ)	The digital nudging intervention did not show any significant effect on the likelihood to participate in PA breaks on a given day. Instead, an individual-level effect revealed that the longer a student studied at home over the course of a day, the more likely they were to take a PA break. Potential strategies for interrupting sedentary behavior and introducing PA breaks should not rely solely on digital nudging. PA breaks integrated into home study lessons via presented videos by the lecturer may be another possibility in terms of digital semesters.

COVID: coronavirus disease; DHE: digital home exercise; DUG: Denver Urban Gardens; GPAQ: Global Physical Activity Questionnaire; HrQoL: health-related quality of life; IPAQ: International Physical Activity Questionnaire; IPAQ-L: International Physical Activity Questionnaire, long version; MD: mean difference; MET: metabolic equivalent; MVPA: moderate to vigorous physical activity; NA: not available; NPAQ: Nordic Physical Activity Questionnaire; PA: physical activity; PAC: physical activity counselling.

Ferreira Silva et al. explored the use of the WhatsApp messaging application three times/week for 4 weeks among 113 young participants, showing that this intervention was not effective in increasing the practice of physical activity nor in reducing the time spent on sedentary behavior (p = 0.556) [20]. Additionally, a web-based intervention in 83 older participants showed that both live group and recorded group sessions were able to increase their physical activity levels, even if the interactive forms resulted in better results compared to the recorded sessions [21].

Han et al. reported that a family parent–child physical activity intervention based on a smartphone app effectively increased the moderate to vigorous physical activity of preschool children and their parents, reducing their sedentary time, and improving the preschool children's physical fitness. The mean performance of different exercise modalities (tennis ball throwing, balance beam walking, and continuous jumping on both feet) were all significantly improved compared to the control group [22]. An interesting study including 291 middle-aged people showed that a gardening course administered using the web led to an improvement in moderate to vigorous physical activity vs. a control group not receiving the intervention (p = 0.012) [23]. Maddison et al. explored the feasibility of a multimodal intervention in 200 adult participants, in which an individually tailored physical exercise session of 1 h was given. They found that physical activity level substantially increased at 12 and 52 weeks compared to a group not doing this kind of physical exercise [24].

The last three studies explored the potential role of web-based physical activity interventions. The study by McDonough et al. reported that following a YouTube video once a week significantly improved young adults' free-living physical activity and muscle strength among 64 participants [25]; similarly, a multicenter RCT including 763 healthy people from nine countries found that a 4-week video live-streamed multicomponent home exercise intervention was effective in significantly enhancing not only physical activity but also mental well-being, by decreasing anxiety and improving sleep quality and exercise motivation, all of which were related to the pandemic [26]. A study by Teuber et al. using nudges sent via Microsoft Teams to 57 young students did not show any significant effect on their likelihood to participate in physical activity breaks on a given day. Instead, an individual-level effect revealed that the longer a student studied at home over the course of a day, the more likely they were to take a physical activity break [27].

3.4. Quality Assessment

Appendix A (Table A1) shows the quality of the studies included. Overall, the studies were of discrete quality. As expected in these kinds of studies, the blindness of the participants or the investigators was not upheld in 10/11 studies (questions 4 and 5 of the JBI) [16].

4. Discussion

In the present systematic review, we aimed to appraise the effects of interventions on physical activity (such as tele-exercise, tele-coaching) among people with sedentary behavior during the COVID-19 lockdown. Starting from over 2400 records in the original literature search and after reviewing them according to the latest PRISMA recommendations, 11 studies with a total of 1770 participants were available and were included in the systematic review. We found that most of the studies examined reported the beneficial effects of the proposed interventions in improving the level of physical activity, reducing the sedentary time, and positively contributing to the psychological well-being of the participants.

Of the 11 RCTs meeting the inclusion criteria and included in the systematic review, 8 (73%) [17–19,22–26] showed strongly positive results even considering that they referred to different age groups, from children to older adults, and to people from different countries and performed different modalities of coaching programs. Only three studies [20,21,27] showed no benefit or some benefit that was not completely effective. First, Ferreira et al. [20] reported that the intervention in adolescents consisting of sending educational information on physical activities according to the Brazilian guidelines using illustrated messages through WhatsApp was not effective in increasing physical activity and reducing the time spent on sedentary behavior. In this study, participants did not receive specific coaching but only illustrated information. Much of the efforts in health promotion to the public are based on the idea that information is powerful, e.g., if the person knows that there are negative consequences of not exercising, they will surely take action and exercise. However, information alone is not enough to change behavior. The fundamental principles of health behavior and psychological strategies must be considered, which truly help people adhere to healthy programs that are beneficial to them [28]. Self-monitoring strategies such as step-counting by means of the use of accelerometers, smartphone applications, or other body-tracking devices can help improve adherence to and the persistence of physical activity and exercise performance. Indeed, these types of strategies have been shown to be effective in terms of short- and long-term increases in physical activity [29]. Second, Granet et al. [21] reported the beneficial effects of a web-based physical activity intervention in improving functional capacities and the physical activity level during the COVID-19 lockdown, with a slightly higher adherence and lower drop-out rate in the live interactive group compared to the group following a recorded video, suggesting the preference of the first option instead of the recorded modality. Third, Teuber et al. [27] used a digital nudging intervention of daily digital motivational prompts among university students who studied at home most of the time. The intervention did not show any significant effect on their likelihood to participate in physical activity breaks. However, the longer a student studied at home during the day, the more their likelihood of taking part in a physical activity break increased. The authors concluded that relying solely on digital nudging is not enough to encourage interrupting sedentary behavior. As in the study by Ferreira et al. mentioned above, programs that are not proactive, as were the interventions in the other eight studies showed to be strongly effective [17–19,22–26], are not sufficient to modify behaviors and significantly increase physical activity during social restriction measures.

According to the 2020 WHO Guidelines for Physical Activity and Sedentary Behavior [4], extensive and growing cumulative evidence reinforces the universal recommendation of "moving more and sitting less" as a fundamental measure for the prevention and treatment of numerous diseases. Unfortunately, inactivity and sedentary lifestyles have grown and continue to rise in modern societies. Despite the benefit of improvements in living conditions, new technologies induce people to move around less, posing a serious public health problem worldwide. In the USA alone, the cost of not complying with the recommended level of physical activity amounts to about 117 billion USD in healthcare costs per year and nearly 10% of related premature deaths [30]. A sedentary lifestyle has been linked to a number of adverse health effects, including all-cause and cardiovascular mortality, cardiovascular disease, incident type 2 diabetes, and some types of cancer [31]. In older adults, it is essential to maintain autonomy by performing physical activity adapted to each person's conditions. Various studies have shown the positive associations of a higher level of physical activity and less sedentary lifestyle with maintenance of the ability to perform activities of daily living [32,33], as well as with better muscular strength and power [34,35] and cognitive performance [6,7,36]. A recent meta-analysis including 17 cohort studies and over 200,000 participants followed for a median of 7.1 years reported a significant inverse association between daily step count and all-cause and cardiovascular mortality [37]; a 1000-step increment was associated with a 15% decreased risk of all-cause mortality, while a 500-step increment was associated with a 7% decreased risk of cardiovascular mortality.

Just as the crucial role that physical activity plays in maintaining health is universally accepted, compelling evidence supports its association with the prevention and improvement of several chronic non-communicable diseases [4,8,30,38]. Even short periods of inactivity can significantly increase adverse health effects. Older adults subjected to bed rest for 10 days experienced about a three-fold greater loss in lean leg muscle mass compared with a cohort of younger adults confined to bed for 28 days [39–41], resulting in substantial lower extremity strength, power, and aerobic capacity [42]. Likewise, a period as short as five days of bed rest caused arterial stiffness, endothelial dysfunction, and increased diastolic blood pressure in healthy adults [43], while two weeks of step reduction decreased their insulin sensitivity and cardiorespiratory fitness in parallel with an increase in body fat and liver fat [44]. These modifications are mostly reversible in young people, as opposed to what happens in older adults, in whom they can lead to chronic immobility.

A comprehensive review of various databases aiming to describe the deleterious effects of prolonged bed rest on the body systems of older adults found 1639 articles on the subject. After the application of the established criteria, 9 articles remained, and 20 were added to maintain the citations of the primary sources, giving a total of 29 articles. The authors found that most of the articles confirmed that the immobility associated with prolonged bed rest is detrimental to the health of older adults, as it affects several systems, such as the cardiovascular, pulmonary, gastrointestinal, musculoskeletal, and urinary systems, which may lead to the onset of diseases in addition to those that led to the bed rest [45]. Moreover, a recent systematic review and meta-analysis aiming to evaluate the magnitude of effects on muscle mass, strength, power, and functional capacity changes as well as the mechanisms, molecules, and pathways involved in muscle decay during bedrest included a total of 25 studies in the qualitative synthesis and 17 studies in the meta-analysis. Overall, the total lean body mass decreased by 1.5 kg, while there was no relationship between the bed rest duration and outcomes. The meta-analysis showed that bed rest produced large statistically significant effects on muscle power. The knee extension power was decreased by 14.65 N/s, and meta-regression showed a significant relationship between the bed rest duration and knee extension power. Moderate, statistically significant effects were observed after bed rest intervention in terms leg muscle mass in both old and young adults with a higher magnitude of change in older than younger adults [46]. The negative effects of bed rest are not confined to the musculoskeletal system but may extend to other organs. For example, only a short period of bed rest is needed to observe a deterioration in cardiovascular function and structure, with a similar impact to spaceflight [47]. In as little as seven days of bed rest, the left ventricular diameter is reduced, and the isovolumetric relaxation time is prolonged [48].

In addition to its prime impact on physical functions, the effects of physical inactivity on psychological well-being are well documented. This was particularly evident during the COVID-19 pandemic, with restriction measures leading to a significant increase in the risks of depression and anxiety [49]. Before the pandemic, it had already been shown that leisure time physical activity (LTPA) was associated with well-being [50,51]. Using data from the 1970 British Cohort Study (n = 5197), a higher LTPA intensity at baseline was associated with lower psychological distress. The baseline LTPA frequency and intensity were associated with a higher psychological well-being [50]. A recent meta-analysis including 157 studies with 190 independent samples and 524,770 participants found that the majority of effects (82.24%) were positive, indicating that participants who exercise physically had higher well-being scores compared to those who do not exercise. The relation between physical activity and subjective well-being was stronger in intervention studies with structured physical activity programs compared to correlational and quasi-experimental studies. Overall, the results of the meta-analysis showed the small but significant effect of physical activity on subjective well-being, which was independent of the prior fitness level of the participants and of the characteristics of the physical activity intervention [51].

The clear positive association between physical activity and mental well-being during the pandemic was reported in a systematic review by Li et al. [52]. Based on the results of 23 studies, the authors found that regular physical activity, high-intensity physical activity, and a physical activity duration of 30–60 min or more per day were associated with a lower risk of anxiety, depression, and negative emotions. Contrariwise, residents with no exercise or with physical inactivity were more likely to have anxiety, depression, sleep disturbances, and lower subjective well-being [52]. For all these reasons, it is crucial to identify methods to maintain or even increase physical activity during forced social restrictions. As shown in the present systematic review, diverse strategies of tele-coaching have been proven effective for this purpose.

The strengths of the present systematic review comprise the possibility of identifying quality RCTs among the numerous publications proposed on the subject during the pandemic period, which allowed us to verify the effectiveness of the remote interventions in improving physical activity, which may be applied even outside the pandemic in circumstances that prevent in-person programs. Another strength is the possibility of updating the available information in the medical literature on a relevant public health burden such as fighting against a sedentary lifestyle. However, the findings of the present systematic review should be interpreted with reference to its limitations. First, only 11 RCTs were identified as suitable for the analyses according to the PRISMA recommendations. Although this may seem a small number, these studies were of discrete quality according to JBI, and the number of participants was adequate (1770 participants, half in the intervention groups and half in the control groups). Another limitation is that the studies used different methods for the interventions, and there was not enough information to allow the performance of a meta-analysis. Finally, the data on some important determinants of the response to physical activity, such as ethnicity, were poorly reported, not allowing any speculation about this point. Likewise, given the heterogeneity of the information available, it is not possible to quantify the degree of improvement that physical activity can produce in sedentary people.

5. Perspective

Although there were very negative consequences for humanity due to the COVID-19 pandemic, there have also been great opportunities, and many lessons can be learned from this particular period in human history. Our review highlights how it is possible to obtain positive results with intervention programs aimed at increasing physical activity using online programs (tele-coaching), even when people cannot access these activities in person. The incentive of online media and cell phones shows that it is possible to use the technology commonly used today in this regard. This can reinforce the objective of increasing the levels of physical activity in the population in times outside of the pandemic, even in people who cannot access gyms and sports clubs, whether due to physical limitations, economic difficulties (tele-strategies are much less expensive), or not having the habit of frequenting these settings. The promotion of physical activity and exercise among the global population is a powerful driver not only of health and well-being but also of sustainable development and the promotion of human rights in accordance to the Agenda 2030 for Sustainable Development, the Kazan Action Plan, the WHO Global Action Plan on Physical Activity 2018–2030, and allied developments across the sports movement [53].

6. Conclusions

The results of the present systematic review on RCTs of interventions to increase physical activity in sedentary people during the COVID-19 lockdown show the beneficial effects of diverse online-delivered strategies, which can be applied even after the pandemic in conditions in which access to in-person activities is not possible.

Author Contributions: Conceptualization, L.J.D. and N.V.; methodology, S.C., C.C., A.D., A.G., S.E.M.L. and F.B.; validation, N.V., L.J.D. and M.B.; formal analysis, N.V.; writing—original draft preparation, L.J.D., N.V. and S.C.; writing—review and editing, G.B., G.M., V.G., A.P. and M.B. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Data Availability Statement: The original contributions presented in the study are included in the article, further inquiries can be directed to the corresponding author.

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

Appendix A

Table A1. Quality of the studies included using the JBI tool.

Author	Year	1	2	3	4	5	6	7	8	9	10	11	12	13
Barğı [17]	2022	Yes	Yes	Yes	NO	Unclear	Unclear	Yes	Yes	NO	Yes	Yes	Yes	Yes
Brazo-Sayavera [18]	2021	NO	NO	NO	NO	Unclear	Yes	Yes	NO	NO	Yes	Yes	Yes	NO
Garcia Perez De Sevilla [19]	2021	Yes	Yes	Yes	NO	Unclear	Unclear	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Ferreira Silva, R.M. [20]	2023	Yes	Yes	Yes	NO	Unclear	Unclear	Yes	Yes	NO	Yes	Yes	Unclear	Yes
Granet [21]	2022	Yes	Yes	Yes	NO	Unclear	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Han X [22]	2022	Yes	NO	Yes	NO	Unclear	Unclear	Yes	Yes	NO	Yes	Yes	Yes	Yes
Litt [23]	2023	Yes	NO	Yes	Unclear	Yes	Yes	NO	Yes	Yes	Yes	Yes	Yes	Yes
Maddison [24]	2023	Yes	Yes	Yes	NO	Yes	Yes	Unclear	Yes	Yes	Unclear	Yes	Yes	Yes
McDonough [25]	2021	Yes	Yes	Yes	NO	Yes	Yes	NO	Yes	Yes	Yes	Yes	Yes	Yes
Teuber [27]	2022	Yes	Yes	Yes	NO	Yes	NO	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Wilke [26]	2021	Yes	Yes	Yes	NO	Unclear	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

The domains assessed in the JBI were: 1. Was true randomization used for assignment of participants to treatment groups? 2. Was allocation to treatment groups concealed? 3. Were treatment groups similar at the baseline? 4. Were participants blind to treatment assignment? 5.Were those delivering treatment blind to treatment assignment? 6. Were outcomes assessors blind to treatment assignment? 7. Were treatment groups treated identically other than the intervention of interest? 8. Was follow up complete and if not, were differences between groups in terms of their follow up adequately described and analyzed? 9. Were participants analyzed in the groups to which they were randomized? 10. Were outcomes measured in the same way for treatment groups? 11. Were outcomes measured in a reliable way? 12. Was appropriate statistical analysis used? 13. Was the trial design appropriate, and any deviations from the standard RCT design (individual randomization, parallel groups) accounted for in the conduct and analysis of the trial?

References

1. Ayouni, I.; Maatoug, J.; Dhouib, W.; Zammit, N.; Fredj, S.B.; Ghammam, R.; Ghannem, H. Effective public health measures to mitigate the spread of COVID-19: A systematic review. *BMC Public Health* **2021**, *21*, 1015. [CrossRef] [PubMed]

2. Haug, N.; Geyrhofer, L.; Londei, A.; Dervic, E.; Desvars-Larrive, A.; Loreto, V.; Pinior, B.; Thurner, S.; Klimek, P. Ranking the effectiveness of worldwide COVID-19 government interventions. *Nat. Hum. Behav.* **2020**, *4*, 1303–1312. [CrossRef]
3. Chen, P.; Mao, L.; Nassis, G.P.; Harmer, P.; Ainsworth, B.E.; Li, F. Coronavirus disease (COVID-19): The need to maintain regular physical activity while taking precautions. *J. Sport Health Sci.* **2020**, *9*, 103–104. [CrossRef] [PubMed]
4. Bull, F.C.; Al-Ansari, S.S.; Biddle, S.; Borodulin, K.; Buman, M.P.; Cardon, G.; Carty, C.; Chaput, J.P.; Chastin, S.; Chou, R.; et al. World Health Organization 2020 guidelines on physical activity and sedentary behaviour. *Br. J. Sports Med.* **2020**, *54*, 1451–1462. [CrossRef] [PubMed]
5. Warburton, D.E.R.; Bredin, S.S.D. Health benefits of physical activity: A systematic review of current systematic reviews. *Curr. Opin. Cardiol.* **2017**, *3*, 541–556. [CrossRef] [PubMed]
6. Veronese, N.; Soysal, P.; Demurtas, J.; Solmi, M.; Bruyere, O.; Christodoulou, N.; Ramalho, R.; Fusar-Poli, P.; Lappas, A.S.; Pinto, D.; et al. Physical activity and exercise for the prevention and management of mild cognitive impairment and dementia: A collaborative international guideline. *Eur. Geriatr. Med.* **2023**, *14*, 925–952. [CrossRef]
7. Dominguez, L.J.; Veronese, N.; Vernuccio, L.; Catanese, G.; Inzerillo, F.; Salemi, G.; Barbagallo, M. Nutrition, Physical Activity, and Other Lifestyle Factors in the Prevention of Cognitive Decline and Dementia. *Nutrients* **2021**, *13*, 4080. [CrossRef] [PubMed]
8. Lee, I.M.; Shiroma, E.J.; Lobelo, F.; Puska, P.; Blair, S.N.; Katzmarzyk, P.T. Effect of physical inactivity on major non-communicable diseases worldwide: An analysis of burden of disease and life expectancy. *Lancet* **2012**, *380*, 219–229. [CrossRef] [PubMed]
9. Diaz, K.M.; Howard, V.J.; Hutto, B.; Colabianchi, N.; Vena, J.E.; Safford, M.M.; Blair, S.N.; Hooker, S.P. Patterns of Sedentary Behavior and Mortality in U.S. Middle-Aged and Older Adults: A National Cohort Study. *Ann. Intern. Med.* **2017**, *167*, 465–475. [CrossRef]
10. Ding, D.; Kolbe-Alexander, T.; Nguyen, B.; Katzmarzyk, P.T.; Pratt, M.; Lawson, K.D. The economic burden of physical inactivity: A systematic review and critical appraisal. *Br. J. Sports Med.* **2017**, *51*, 1392–1409. [CrossRef] [PubMed]
11. Katzmarzyk, P.T.; Powell, K.E.; Jakicic, J.M.; Troiano, R.P.; Piercy, K.; Tennant, B. Sedentary Behavior and Health: Update from the 2018 Physical Activity Guidelines Advisory Committee. *Med. Sci. Sports Exerc.* **2019**, *51*, 1227–1241. [CrossRef]
12. Steenkamp, L.; Saggers, R.T.; Bandini, R.; Stranges, S.; Choi, Y.H.; Thornton, J.S.; Hendrie, S.; Patel, D.; Rabinowitz, S.; Patricios, J. Small steps, strong shield: Directly measured, moderate physical activity in 65,361 adults is associated with significant protective effects from severe COVID-19 outcomes. *Br. J. Sports Med.* **2022**, *56*, 568–576. [CrossRef] [PubMed]
13. Stockwell, S.; Trott, M.; Tully, M.; Shin, J.; Barnett, Y.; Butler, L.; McDermott, D.; Schuch, F.; Smith, L. Changes in physical activity and sedentary behaviours from before to during the COVID-19 pandemic lockdown: A systematic review. *BMJ Open Sport Exerc. Med.* **2021**, *7*, e000960. [CrossRef] [PubMed]
14. Wilke, J.; Rahlf, A.L.; Füzéki, E.; Groneberg, D.A.; Hespanhol, L.; Mai, P.; de Oliveira, G.M.; Robbin, J.; Tan, B.; Willwacher, S.; et al. Physical Activity during Lockdowns Associated with the COVID-19 Pandemic: A Systematic Review and Multilevel Meta-analysis of 173 Studies with 320,636 Participants. *Sports Med. Open* **2022**, *8*, 125. [CrossRef]
15. Page, M.J.; McKenzie, J.E.; Bossuyt, P.M.; Boutron, I.; Hoffmann, T.C.; Mulrow, C.D.; Shamseer, L.; Tetzlaff, J.M.; Akl, E.A.; Brennan, S.E.; et al. The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *BMJ* **2021**, *372*, n71. [CrossRef] [PubMed]
16. Tufanaru, C.; Munn, Z.; Aromataris, E.; Campbell, J.; Hopp, L. Systematic reviews of effectiveness. In *Joanna Briggs Institute Reviewer's Manual*; The Joanna Briggs Institute Adelaide: Adelaide, Australia, 2017; pp. 3–10.
17. Barğı, G. Effectiveness of Physical Activity Counseling in University Students Educated by Distance Learning during COVID-19 Pandemic: A Randomized-Controlled Trial. *J. Basic Clin. Health Sci.* **2022**, *6*, 374–384. [CrossRef]
18. Brazo-Sayavera, J.; Lopez-Torres, O.; Martos-Bermudez, A.; Rodriguez-Garcia, L.; Gonzalez-Gross, M.; Guadalupe-Grau, A. Effects of Power Training on Physical Activity, Sitting Time, Disability, and Quality of Life in Older Patients with Type 2 Diabetes During the COVID-19 Confinement. *J. Phys. Act. Health* **2021**, *18*, 660–668. [CrossRef] [PubMed]
19. de Sevilla, G.G.P.; Guido, O.B.; De la Cruz, M.P.; Fernandez, A.B.; Alejo, L.B.; Goercke, M.I.R.; Pérez-Ruiz, M. Remotely Supervised Exercise during the COVID-19 Pandemic versus in-Person-Supervised Exercise in Achieving Long-Term Adherence to a Healthy Lifestyle. *Int. J. Environ. Res. Public Health* **2021**, *18*, 12198. [CrossRef] [PubMed]
20. Silva, R.M.F.; Terra, L.F.; da Silva, V.F.M.; Noll, P.; de Almeida, A.A.; Noll, M. Physical Activity and Sedentary Behavior in High School Students: A Quasi Experimental Study via Smartphone during the COVID-19 Pandemic. *Children* **2023**, *10*, 479. [CrossRef]
21. Granet, J.; Peyrusque, E.; Ruiz, F.; Buckinx, F.; Abdelkader, L.B.; Dang-Vu, T.T.; Sirois, M.J.; Gouin, J.P.; Pageaux, B.; Aubertin-Leheudre, M. Web-Based Physical Activity Interventions Are Feasible and Beneficial Solutions to Prevent Physical and Mental Health Declines in Community-Dwelling Older Adults During Isolation Periods. *J. Gerontol. A Biol. Sci. Med. Sci.* **2023**, *78*, 535–544. [CrossRef]
22. Han, X.; Tian, Z.; Zhao, M.; Zhou, Z. An Intervention Pattern of Family Parent-Child Physical Activity Based on a Smartphone App for Preschool Children during COVID-19. *BioMed. Res. Int.* **2022**, *2022*, 2777079. [CrossRef]
23. Litt, J.S.; Alaimo, K.; Harrall, K.K.; Hamman, R.F.; Hebert, J.R.; Hurley, T.G.; Leiferman, J.A.; Li, K.; Villalobos, A.; Coringrato, E.; et al. Effects of a community gardening intervention on diet, physical activity, and anthropometry outcomes in the USA (CAPS): An observer-blind, randomised controlled trial. *Lancet Planet. Health* **2023**, *7*, e23–e32. [CrossRef] [PubMed]
24. Maddison, R.; Hargreaves, E.A.; Jiang, Y.; Calder, A.J.; Wyke, S.; Gray, C.M.; Hunt, K.; Lubans, D.R.; Eyles, H.; Draper, N.; et al. Rugby Fans in Training New Zealand (RUFIT-NZ): A pilot randomized controlled trial of a healthy lifestyle program

for overweight men delivered through professional rugby clubs in New Zealand. *BMC Public Health* **2019**, *19*, 166. [CrossRef] [PubMed]
25. McDonough, D.J.; Helgeson, M.A.; Liu, W.; Gao, Z. Effects of a remote, YouTube-delivered exercise intervention on young adults' physical activity, sedentary behavior, and sleep during the COVID-19 pandemic: Randomized controlled trial. *J. Sport Health Sci.* **2022**, *11*, 145–156. [CrossRef] [PubMed]
26. Wilke, J.; Mohr, L.; Yuki, G.; Bhundoo, A.K.; Jiménez-Pavón, D.; Laiño, F.; Murphy, N.; Novak, B.; Nuccio, S.; Ortega-Gómez, S.; et al. Train at home, but not alone: A randomised controlled multicentre trial assessing the effects of live-streamed tele-exercise during COVID-19-related lockdowns. *Br. J. Sports Med.* **2022**, *56*, 667–675. [CrossRef] [PubMed]
27. Teuber, M.; Leyhr, D.; Moll, J.; Sudeck, G. Nudging digital physical activity breaks for home studying of university students-A randomized controlled trial during the COVID-19 pandemic with daily activity measures. *Front. Sports Act. Living* **2022**, *4*, 1024996. [CrossRef] [PubMed]
28. Kangovi, S.; Asch, D.A. Behavioral Phenotyping in Health Promotion: Embracing or Avoiding Failure. *JAMA* **2018**, *319*, 2075–2076. [CrossRef] [PubMed]
29. Chaudhry, U.A.R.; Wahlich, C.; Fortescue, R.; Cook, D.G.; Knightly, R.; Harris, T. The effects of step-count monitoring interventions on physical activity: Systematic review and meta-analysis of community-based randomised controlled trials in adults. *Int. J. Behav. Nutr. Phys. Act.* **2020**, *17*, 129. [CrossRef] [PubMed]
30. Piercy, K.L.; Troiano, R.P.; Ballard, R.M.; Carlson, S.A.; Fulton, J.E.; Galuska, D.A.; George, S.M.; Olson, R.D. The Physical Activity Guidelines for Americans. *JAMA* **2018**, *320*, 2020–2028. [CrossRef] [PubMed]
31. Dempsey, P.C.; Biddle, S.J.H.; Buman, M.P.; Chastin, S.; Ekelund, U.; Friedenreich, C.M.; Katzmarzyk, P.T.; Leitzmann, M.F.; Stamatakis, E.; van der Ploeg, H.P.; et al. New global guidelines on sedentary behaviour and health for adults: Broadening the behavioural targets. *Int. J. Behav. Nutr. Phys. Act.* **2020**, *17*, 151. [CrossRef]
32. Roberts, C.E.; Phillips, L.H.; Cooper, C.L.; Gray, S.; Allan, J.L. Effect of Different Types of Physical Activity on Activities of Daily Living in Older Adults: Systematic Review and Meta-Analysis. *J. Aging Phys. Act.* **2017**, *25*, 653–670. [CrossRef] [PubMed]
33. Gomes, A.E.S.; Ramsey, K.A.; Rojer, A.G.M.; Reijnierse, E.M.; Maier, A.B. The Association of Objectively Measured Physical Activity and Sedentary Behavior with (Instrumental) Activities of Daily Living in Community-Dwelling Older Adults: A Systematic Review. *Clin. Interv. Aging* **2021**, *16*, 1877–1915. [CrossRef]
34. Ramsey, K.A.; Rojer, A.G.M.; D'Andrea, L.; Otten, R.H.J.; Heymans, M.W.; Trappenburg, M.C.; Verlaan, S.; Whittaker, A.C.; Meskers, C.G.; Maier, A.B.; et al. The association of objectively measured physical activity and sedentary behavior with skeletal muscle strength and muscle power in older adults: A systematic review and meta-analysis. *Ageing Res. Rev.* **2021**, *67*, 101266. [CrossRef]
35. Lu, L.; Mao, L.; Feng, Y.; Ainsworth, B.E.; Liu, Y.; Chen, N. Effects of different exercise training modes on muscle strength and physical performance in older people with sarcopenia: A systematic review and meta-analysis. *BMC Geriatr.* **2021**, *21*, 708. [CrossRef] [PubMed]
36. Rojer, A.G.M.; Ramsey, K.A.; Gomes, E.S.A.; D'Andrea, L.; Chen, C.; Szoeke, C.; Meskers, C.G.; Reijnierse, E.M.; Maier, A.B. Objectively assessed physical activity and sedentary behavior and global cognitive function in older adults: A systematic review. *Mech. Ageing Dev.* **2021**, *198*, 111524. [CrossRef]
37. Banach, M.; Lewek, J.; Surma, S.; Penson, P.E.; Sahebkar, A.; Martin, S.S.; Bajraktari, G.; Henein, M.Y.; Reiner, Ž.; Bielecka-Dąbrowa, A.; et al. The association between daily step count and all-cause and cardiovascular mortality: A meta-analysis. *Eur. J. Prev. Cardiol.* **2023**, *30*, 1975–1985. [CrossRef] [PubMed]
38. Garcia, L.; Pearce, M.; Abbas, A.; Mok, A.; Strain, T.; Ali, S.; Crippa, A.; Dempsey, P.C.; Golubic, R.; Kelly, P.; et al. Non-occupational physical activity and risk of cardiovascular disease, cancer and mortality outcomes: A dose-response meta-analysis of large prospective studies. *Br. J. Sports Med.* **2023**, *57*, 979–989. [CrossRef] [PubMed]
39. Kortebein, P.; Ferrando, A.; Lombeida, J.; Wolfe, R.; Evans, W.J. Effect of 10 days of bed rest on skeletal muscle in healthy older adults. *JAMA* **2007**, *297*, 1772–1774. [CrossRef] [PubMed]
40. Paddon-Jones, D.; Leidy, H. Dietary protein and muscle in older persons. *Curr. Opin. Clin. Nutr. Metab. Care* **2014**, *17*, 5–11. [CrossRef] [PubMed]
41. Paddon-Jones, D.; Sheffield-Moore, M.; Urban, R.J.; Sanford, A.P.; Aarsland, A.; Wolfe, R.R.; Ferrando, A.A. Essential amino acid and carbohydrate supplementation ameliorates muscle protein loss in humans during 28 days bedrest. *J. Clin. Endocrinol. Metab.* **2004**, *89*, 4351–4358. [CrossRef] [PubMed]
42. Kortebein, P.; Symons, T.B.; Ferrando, A.; Paddon-Jones, D.; Ronsen, O.; Protas, E.; Conger, S.; Lombeida, J.; Wolfe, R.; Evans, W.J. Functional impact of 10 days of bed rest in healthy older adults. *J. Gerontol. A Biol. Sci. Med. Sci.* **2008**, *63*, 1076–1081. [CrossRef]
43. Nosova, E.V.; Yen, P.; Chong, K.C.; Alley, H.F.; Stock, E.O.; Quinn, A.; Hellmann, J.; Conte, M.S.; Owens, C.D.; Spite, M.; et al. Short-term physical inactivity impairs vascular function. *J. Surg. Res.* **2014**, *190*, 672–682. [CrossRef] [PubMed]
44. Davies, K.A.B.; Sprung, V.S.; Norman, J.A.; Thompson, A.; Mitchell, K.L.; Halford, J.C.G.; Wilding, J.P.; Kemp, G.J.; Cuthbertson, D.J. Short-term decreased physical activity with increased sedentary behaviour causes metabolic derangements and altered body composition: Effects in individuals with and without a first-degree relative with type 2 diabetes. *Diabetologia* **2018**, *61*, 1282–1294. [CrossRef] [PubMed]
45. Guedes, L.P.C.M.; de Oliveira, M.L.C.; de Azevedo, C.G. Deleterious effects of prolonged bed rest on the body systems of the elderly—A review. *Rev. Bras. Geriatr. Gerontol.* **2018**, *21*, 499–506. [CrossRef]

46. Di Girolamo, F.G.; Fiotti, N.; Milanovic, Z.; Situlin, R.; Mearelli, F.; Vinci, P.; Šimunič, B.; Pišot, R.; Narici, M.; Biolo, G. The Aging Muscle in Experimental Bed Rest: A Systematic Review and Meta-Analysis. *Front. Nutr.* **2021**, *8*, 633987. [CrossRef] [PubMed]
47. Hughson, R.L.; Helm, A.; Durante, M. Heart in space: Effect of the extraterrestrial environment on the cardiovascular system. *Nat. Rev. Cardiol.* **2018**, *15*, 167–180. [CrossRef] [PubMed]
48. Platts, S.H.; Martin, D.S.; Stenger, M.B.; Perez, S.A.; Ribeiro, L.C.; Summers, R.; Meck, J.V. Cardiovascular adaptations to longduration head-down bed rest. *Aviat. Space Environ. Med.* **2009**, *80* (Suppl. S5), A29–A36. [CrossRef] [PubMed]
49. Zhu, C.; Zhang, T.; Li, Q.; Chen, X.; Wang, K. Depression and Anxiety during the COVID-19 Pandemic: Epidemiology, Mechanism, and Treatment. *Neurosci. Bull.* **2023**, *39*, 675–684. [CrossRef] [PubMed]
50. Werneck, A.O.; Stubbs, B.; Kandola, A.; Oyeyemi, A.L.; Schuch, F.B.; Hamer, M.; Vancampfort, D.; Silva, D.R. Prospective Associations of Leisure-Time Physical Activity with Psychological Distress and Well-Being: A 12-Year Cohort Study. *Psychosom. Med.* **2022**, *84*, 116–122. [CrossRef] [PubMed]
51. Buecker, S.; Simacek, T.; Ingwersen, B.; Terwiel, S.; Simonsmeier, B.A. Physical activity and subjective well-being in healthy individuals: A meta-analytic review. *Health Psychol. Rev.* **2021**, *15*, 574–592. [CrossRef] [PubMed]
52. Li, M.; Wang, Q.; Shen, J. The Impact of Physical Activity on Mental Health during COVID-19 Pandemic in China: A Systematic Review. *Int. J. Environ. Res. Public Health* **2022**, *19*, 6584. [CrossRef] [PubMed]
53. Yelamos, G.M.; Carty, C.; Clardy, A. Sport. A driver of sustainable development, promoter of human rights, and vehicle for health and well-being for all. *Sport Bus. Manag. Int. J.* **2019**, *9*, 315–327. [CrossRef]