ORIGINAL ARTICLE

Effect of 10-week Isometric handgrip exercise at home on hemodynamic and psychological factors of sedentary hypertensive women during COVID-19: A randomized controlled trial

Elham Shakoor. *Department of Exercise Physiology. Faculty of Sport Sciences. Alzahra University. Tehran, Iran.*
Pezhman Motamedi . *Department of Exercise Physiology. Faculty of Physical Education and Sport Sciences. Kharazmi University. Tehran, Iran.*
Farnaz Banaee. *Department of Internal Medicine. Shiraz University of Medical Sciences. Shiraz, Iran*.
Nemat Jaafari. *Centre for Research on Cognition and Learning. University of Poitiers. Poitiers, Nouvelle-Aquitaine, France.*
Christine Sylvain. *Poitiers University and University Hospital. Poitiers, Nouvelle-Aquitaine, France.*

ABSTRACT

Background and Objective: COVID-19 poses significant public health threats and impacts physical activity, particularly in hypertensive patients. The aim of this study is to examine the ten weeks of isometric handgrip exercise impact on hypertensive women during quarantine. Methods: thirty female volunteers with high blood pressure participated in this randomized controlled trial study. The isometric handgrip (IHG) exercise group performed the exercise for ten weeks (3 sessions per week, 4x2 min isometric contractions at 30% MVC, separated by 2 minutes rest) via video call at home, and the control group had no exercise program. The blood pressure (systolic, diastolic, and mean), heart rate, and myocardial oxygen consumption were measured before and after exercise program; DASS21 and quality of life (Sf-36) questionnaires were then completed by the participants. Results: Systolic, diastolic, and mean blood pressure showed a significant decrease (5 mmHg, 2 mmHg, respectively); quality of life and DASS21 scores showed a significant improvement after IHG exercise compared to the control ($p < .05$). Conclusion: IHG exercise activity at home is highly effective and useful for improving blood pressure and quality of life of hypertensive women, and it is also a treatment option to reduce stress, depression and anxiety due to COVID-19.
Keywords: Sport medicine, Blood pressure, Quality of life, Anxiety, Depression, Stress.

Cite this article as:
Shakoor, E., Motamedi, P., Banaee, F., Jaafari, N., & Sylvain, C. (2025). Effect of 10-week Isometric handgrip exercise at home on hemodynamic and psychological factors of sedentary hypertensive women during COVID-19: A randomized controlled trial. *Journal of Human Sport and Exercise, 20*(1), 22-38. https://doi.org/10.55860/m1tqbv39

Corresponding author. *Department of Exercise Physiology. Faculty of Physical Education and Sport Sciences. Kharazmi University. Tehran, Iran.*
E-mail: Pezhman.motamedi@khu.ac.ir
Submitted for publication June 21, 2024.
Accepted for publication July 27, 2024.
Published August 06, 2024.
Journal of Human Sport and Exercise. ISSN 1988-5202.

doi: https://doi.org/10.55860/m1tqbv39

INTRODUCTION

The current pandemic due to COVID-19, which is caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), appeared for the first time in late December 2019 in Wuhan, China; it has been currently described as the worst public health crisis in the world (Wang, Horby, Hayden, & Gao, 2020). Social distancing and home quarantine became mandatory to deal with the spread of COVID-19 because this virus has a high potential of infectivity, as well as death rate and prevalence (Organization, 2020). Many countries resorted to distance working, as well as closing schools, universities, sports halls, and public parks, and billions of people around the world were socially isolated by such measures (Rogers et al., 2020). These factors, namely obligatory restrictions during the COVID-19 pandemic, have created unique structural barriers to maintaining a physically active lifestyle, which on the one hand increased the prevalence of several chronic and underlying diseases, including Cardiovascular Diseases (CVD) and hypertension (Stockwell et al., 2021), and on the other hand, decreased the quality of life of patients and led to an increase in mental health disorders, depression and anxiety (De Sousa et al., 2021).

In this regard, recent epidemiological surveys reported that elderly people followed by those with underlying diseases, such as blood pressure, diabetes, and cardiovascular disorders are the most vulnerable this regard (Ma, Song, & Huang, 2021). These persons are more susceptible to COVID-19 so approximately 50% of them who were admitted to the hospital due to COVID-19 were afflicted with at least one underlying disease. In older persons and those with underlying diseases, the mortality rate is much higher than other patients (Wang et al., 2020).

Studies also showed that 24% of patients diagnosed with the severe spectrum of COVID-19 had hypertension as the underlying disease (Nasrollahzadeh Sabet et al., 2020; Schiffrin, Flack, Ito, Muntner, & Webb, 2020). This high rate has been attributed to the fact that SARS-CoV-2 binds and enters cells through angiotensin-converting enzyme 2 receptor (ACE2), which is abundantly found in alveolar cells, cardiac myocytes and vascular endothelial cells. Considering the high binding affinity of COVID-19 to ACE2, a large number of viruses infect these cells. The interaction of SARS-CoV-2 with ACE2 in endothelial cells raises the possibility that endothelial dysfunction, which commonly occurs in hypertension, is exacerbated through the effect of the virus. In other respect, COVID-19 also leads to cardiovascular complications by causing thrombosis in arteries and veins. Inflammation, activation of platelets, dysfunction and blockage of blood vessel are responsible for thrombosis in COVID-19. In fact, COVID-19 poses a serious risk to patients with high blood pressure (Nadar, Tayebjee, Stowasser, & Byrd, 2020; South, Diz, & Chappell, 2020).

Moreover, the emergence of COVID-19 and its resulting stress-anxiety are related to pathophysiology of hypertension, in such a way that the high sensitivity of sympathetic nervous system (SNS) increases the heart rate and blood pressure, which can escalate the severity of disease by compromising the immune system (Pfefferbaum & North, 2020). Hypertension by itself is a major challenge for the global health system and a main mortality factor of nearly 7,000,000 people in the world, the prevalence of which will increase by 60% by 2025. For prevention, control and non-drug treatment of high blood pressure, exercise is a good intervention that can reduce blood pressure (Millar, MacDonald, Bray, & McCartney, 2009; Shakoor, Salesi, Daryanoosh, & Izadpanah, 2020), and it is also an effective strategy to improve the positive changes in physiological process of the body and to ameliorate psychology as well as physical and mental health status of people during COVID-19 pandemic (De Sousa et al., 2021).

It seems that physical exercise at home is the best way to prevent COVID-19 contraction through the air and to deal with negative effects of quarantine, such as lack of physical activity, increase in mental disorders and depression, reduced quality of life, and most importantly, to create long-term adherence to exercise (Ashworth, Chad, Harrison, Reeder, & Marshall, 2005; Qiu et al., 2020). In this respect, isometric handgrip exercises at home are safe, simple, applicable, and without risk for most people with clinical diseases, and (most importantly) require little equipment, space, and time, so that they can be practiced at any time and place with relatively inexpensive equipment. Despite the low volume of these exercises, they significantly reduce blood pressure and its related factors (Shakoor et al., 2020; TAYLOR et al., 2017). As a result, isometric handgrip exercise may be a safe alternative for sports activities in closed places and gyms during quarantine. These features of IHG exercise can be crucial for increasing motivation and self-efficacy, as well as keeping people physically active.

Physiologically, compared to aerobic exercises, isometric exercise is associated with a lower myocardial oxygen demand because of the slight increase in heart rate, as well as the increase of diastolic blood pressure (in contrast to aerobic exercise) and coronary blood flow. Besides, adding isometric exercises to dynamic aerobic exercise reduces ST-segment depression as well as occurrence of myocardial ischemia. Another sign of a proper and safe blood pressure response during isometric exercise is spontaneous breathing without using Valsalva maneuver (i.e., breathing under closed glottis pressure) (Cornelissen & Smart, 2013; Peters et al., 2006).

Considering the novelty of SARS-CoV-2, there has been no coherent scientific research on COVID-19, high blood pressure and exercise. As a result, the purpose of this research is to investigate the impact of 10-week exercise at home on blood pressure, quality of life and quality of sleep of hypertensive women during COVID-19 quarantine.

METHODS

Study design and trial registration

This study is a randomized controlled trial with parallel arms, which was conducted and reported in accordance with CONSORT guidelines for non-drug treatment (Boutron et al., 2008). The participants were recruited using information and documents registered in family doctor general health system (SIB) from Sa'adi Neighborhood of Shiraz. Sixty-five patients with high blood pressure were contacted by phone. Afterward, 30 participants were selected voluntarily considering inclusion and exclusion criteria and were randomly assigned to control and IHG exercise groups (15 participants in each group). Recruiting finished once the number of required volunteers was reached.

Initially, the participants were invited through social media to fill out an online questionnaire using Google Forms software. Therefore, before starting the program, all participants completed an informed consent form, namely voluntary participation that was sent to them online (using the Google Forms software; Mountain View, CA, USA).

Ethics approval

This study was approved by Ethics Committee of Sport Sciences Research Institute of Iran (No: IR.SSRC.REC.1402.027). All procedures followed national standards and the Declaration of Helsinki.

Sample size calculation

With reference to the paper by Taylor et al, (2017) Row 10 of Table 1 (Awake DBP), sample size was calculated 15 participants in each group (N = 30) using the following formula by considering n_1 = 92.1, n_2 = 87.2, S_1 = 1.4, S_2 = 3.3, α = 0.05, β = 0.2, 80% power and 30% dropout:

$$n_1 = n_2 = \frac{\left(S_1^2 + S_2^2\right)\left(Z_{1-\frac{\alpha}{2}} + Z_{1-\beta}\right)^2}{\left(\bar{X}_1 - \bar{X}_2\right)^2}; \alpha = 0/05, \beta = 0/2$$

$$\bar{X}_1 = 92.1$$
$$\bar{X}_1 = 87.2 \qquad Z_{1-\frac{\alpha}{2}} = 1.96, Z_{1-\beta} = 0/84$$
$$S_1^2 = 1.4$$
$$S_2^2 = 3.3$$

Participants

Eligibility criteria

Thirty women with stage 1 hypertension and prehypertension (systolic blood pressure 138 ± 2 mmHg and diastolic blood pressure 89 ± 3 mmHg) and mean age of 36 ± 4 years (range: 30-45) whose data was registered in family doctor general health system (SIB) from Sa'adi Neighborhood of Shiraz were recruited in this study. Considering the participants' available records at their specialists, the required assessments for stage 1 hypertension and prehypertension were done online, and they were then recruited to the study.

Inclusion criteria

All participants were non-smokers, had no history of CVD (coronary artery disease, arrhythmia, heart failure), metabolic and renal diseases, did not consume drugs affecting blood pressure, had no cognitive and mental, neuromuscular or skeletal disorders (for performing exercise), had a sedentary lifestyle (≤150 minutes of aerobic exercise per week using International Physical Activity Questionnaire (Chtourou et al., 2020; Zhang, Zhang, Ma, & Di, 2020) and were not infected with COVID-19 over the last few months as well as during the exercise period.

Exclusion criteria

The exclusion criteria were as follows: not attending more than two sessions, concurrent participation in another clinical trial and having the following symptoms: chest pain, chills, diarrhea, dizziness, dry cough, eyes, and mouth, fatigue, fever >37.9°C, headache, anorexia, loss of sense of smell (anosmia), muscle or body pain, congestion or runny nose, nausea or vomiting, shortness of breath, difficulty breathing, dyspnea, joint pain or sore throat before and during the study were the exclusion criteria. None of the participants reported flu-like symptoms over this period.

Randomization

The participants were randomized into one of two groups (three interventions and one control) using an online randomization system (randomizer.org) (see Figure 1). A member of the research team not involved in the selection of samples determined the randomization sequence using a computer program. The participants were notified of their group allocation using a sealed envelope.

This is a randomized controlled clinical trial with single-blind data analysis. Single blind method was used to reduce the bias or distortions related to the intervention and assessment of results.

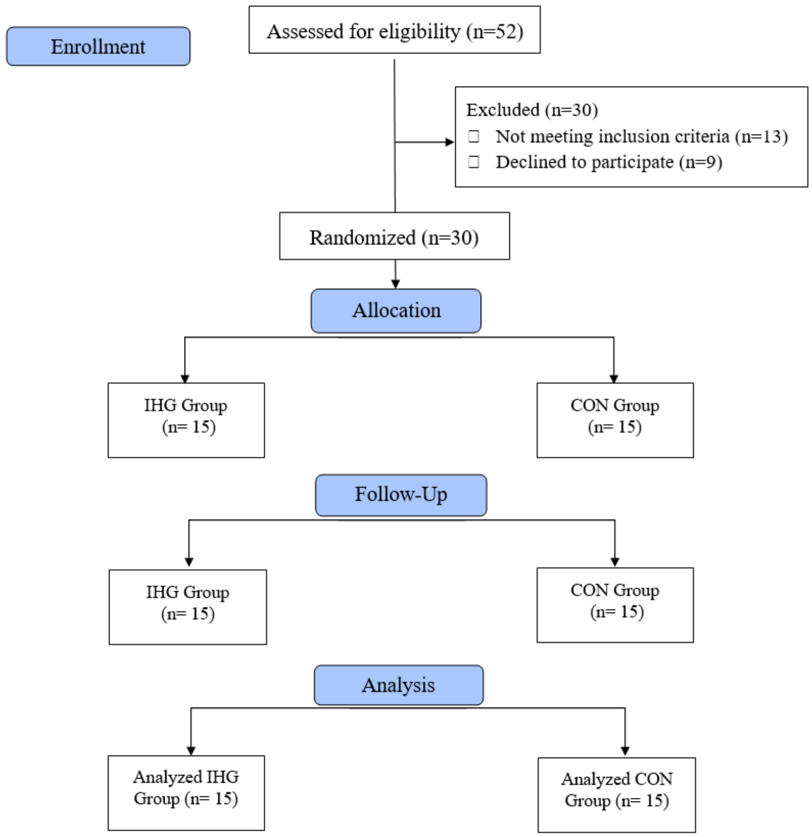

Figure 1. Flow chart of the randomized control trial.

Adherence strategies

After the volunteers presented their consent, they received notifications through SMS, e-mail and phone call to attend sessions. The volunteers could make round the clock contact with the coordinator of intervention and with researchers through e-mail or mobile phone.

Interventions

The participants were randomly assigned to control and exercise groups. The exercise group performed the exercise for 10 weeks (three sessions per week), during which the control group did not have sport activity.

IHG exercise group

The exercise group performed 30 sessions of physical activity using a digital isometric handgrip device (Saehan Grip, model DHD-3, made in South Korea) with the non-dominant hand unilaterally based on recommendations provided by American Heart Association (AHA) and American College of Sports Medicine (ACSM) (Cornelissen & Smart, 2013). The isometric handgrip protocol was performed as follows:

IHG: 4x2 min isometric contractions at 30% of Maximal Voluntary Contraction (MVC), separated by 2 minutes' rest, overall session with non-dominant hand unilaterally. The length of training session was 14 minutes, reaching 22 minutes with 5 minutes of warm-up and 3 minutes of cool down (Figure 2) (Thompson, Arena, Riebe, Pescatello, & American College of Sports, 2013; van Assche, Buys, de Jaeger, Coeckelberghs, & Cornelissen, 2017).

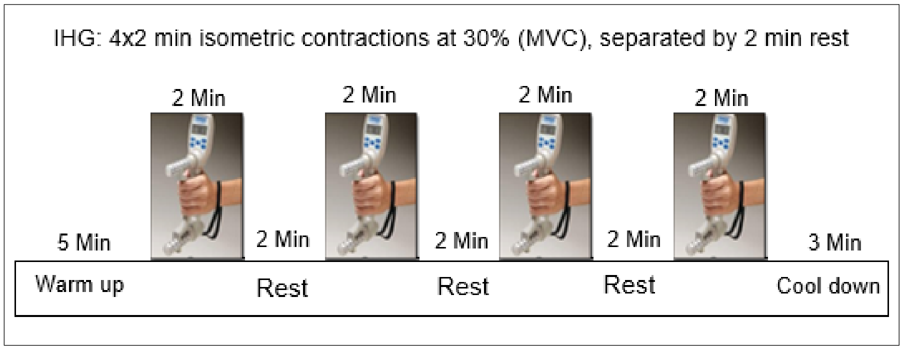

Figure 2. The handgrip exercise protocols.

The exercise intensity in these 10 weeks was 30% MVC. To comply with the principle of overload, the participants' MVC was measured online every two weeks, and they performed their exercise based on new values (TAYLOR et al., 2017; Thompson et al., 2013). Each participant did her training online under supervision of the researcher three times a week (every other day) between 8 and 11 AM, a period showing the greatest reduction in blood pressure (de Brito et al., 2015). All training programs were individualized and progressive. The Borg Rating of Perceived Exertion scale (RPE scale) was used to gauge intensity during exercise sessions. The RPE consists of a scale of 6 (no exertion at all) to 20 (maximal exertion) (Thompson et al., 2013) (Pescatello, Arena, Riebe, & Thompson, 2013) (Pescatello et al., 2013). All the patients were repeatedly informed about the progress of the study and its partial results during the follow-up period. In addition, the researchers maintained constant contact with the physicians responsible for each patient. At the end of the study, both physicians and patients received the final report along with the results.

Maximal Voluntary Contraction (MVC)

To measure MVC, the participants sat down on the chair of isometric handgrip device (Saehan Grip, model DHD-3, made in South Korea) with their non-dominant hand, the soles of their feet on the floor and knees at a 90-degree angle. In addition, the participants' elbow was in contact with the chair handle or the table, and they were informed of their performance by reading the values shown on the device during performance. Before performing each protocol, the participants applied their maximum force to the device by their non-dominant and training hand after warming up with low intensity using the handgrip device in three contractions without Valsalva maneuver, and the average force recorded in the device was considered their MVC.

Control group

During this time, the control group was encouraged to continue their normal daily routine, not participate in any other program and not have any special exercise. Their blood pressure was checked online every week just to adhere to the research Study.

Measurements or evaluation of outcomes

Primary and secondary outcome measures were evaluated according to American College of Sports Medicine guidelines for health-related physical assessment (Ware & Sherbourne, 1992). Initial and final assessment was done before the start of the first session and 48 hours after the last exercise session, respectively.

Before each assessment, the participants were asked to avoid consuming alcohol, tea, coffee, soft drinks or any food/beverage containing caffeine 6 hours before measurement, not to do strenuous activities 24 hours before assessment, and to drink plenty of water. They were also encouraged to have enough rest and proper sleep (6-8 hours) the night before the evaluation. In addition, the participants were requested to record their activities for 24 hours after the experiment, including working hours, sleep schedule, meals, medication use, and any complications they considered to be important (e.g., stressful situations).

The primary outcome measure includes blood pressure (systole, diastole and average), Rate pressure product (RPP), Heart Rate (HR), and the secondary outcome variables were Quality of life and DASS-21 questionnaires.

Primary outcomes

Blood pressure measurement

An automated oscillometric cuff, namely Omron 705CP (Omron, Matsusaka, Matsusaka City, Japan), was fastened around the participants' left arm during the home visit and after 5 minutes of rest in a sitting position to measure systolic blood pressure (SBP) and diastolic blood pressure (DBP) according to the established guidelines (Dorans, Mills, Liu, & He, 2018).

All blood pressure measurements were repeated; the average of two values was recorded and used for analysis. If the values differed by 5 mmHg, a third measurement was done, and the two closest values were averaged.

Mean Arterial Pressure (MAP) was calculated as the sum of 2/3 DBP and 1/3 SBP.

$$MAP = 1/3\ SBP + 2/3\ DBP$$

Rate Pressure Product was also calculated by multiplying systolic blood pressure by heart rate.

$$RPP = SBP \times HR$$

Secondary outcomes

Using Google® Forms software, the questionnaires were distributed through an online platform to all participants who were interested in participating in the survey. These questionnaires were divided into three parts as follows:

The first part included age, disease history, weight and height to calculate BMI, physical activity history before and during the outbreak of COVID-19.

The second part was the quality-of-life questionnaire, and the third part was DASS21 questionnaire.

Anthropometrics

Weight (kg) and height (m) were measured using standard techniques. Body mass index (BMI) was calculated based on the following formula: BMI = height (m^2)/weight (kg).

Quality of life

SF-36, the short form of HRQOL, is an instrument to assess quality of life, which is widely used in general and mental health care (Aaronson et al., 1998; Ware & Sherbourne, 1992). SF-36 consists of 36 items, 35 of which are divided into 8 health concepts as follows:

1. Physical Functioning (PF) (questions = 3,4,5,6,7,8,9,10,11,12).
2. Bodily Pain (BP) (questions = 21,22).

3. Role limitations due to physical problems (RP) (questions = 13,14,15,16).
4. Role limitations due to emotional problems (RE) (questions = 17,18,19).
5. General Mental health (GM) (questions = 24,25,26,28,30).
6. Social functioning (SF) (questions = 20,32).
7. Vitality (energy and fatigue) (VT) (questions = 23,27,29,31).
8. General Health perceptions (GH) (questions = 1,2,34,35,36).

Another part deals with changes in health status. The response options are different for each item. For each of the eight domains, item scores were coded, summed and converted to a scale from 0 (worst possible health status as measured by the questionnaire) to 100 (best possible status).

In general, the questions and background concepts of the scale structure and summary measurements of SF-36 questionnaire are classified in three levels as follows (Aaronson et al., 1998; Ware & Sherbourne, 1992):

1. Questions.
2. Eight scales that are obtained from combining 2-10 questions.
3. Two summary measurements obtained by integrating the scales as follows:
    - Physical health (PH) = Physical function (PF) + physical limitation (RP) + physical pain (BP) + general health (GH).
    - Mental health (MH) = Social functioning (SF) + emotional problems (RE) + mental health (GM) + vitality (VT).

DASS-21

Depression Anxiety Stress Scale-21 (DASS-21) questionnaire was developed by Lovibond in 1995 and contains 21 questions based on four-point Likert scale with never, a few, sometimes and always options (Henry & Crawford, 2005).

The answers are scored according to the four-point Likert scale and pass through 0 points (did not apply to me at all); 1 (applied to me to some degree, or some of the time); 2 (applied to me to a considerable degree or a good part of time), and 3 (applied to me very much or most of the time.

Seven questions are related to depression (items: 3, 5, 10, 13, 16, 17 and 21), 7 questions examine anxiety (items 2, 4, 7, 9, 15, 19 and 20) and 7 other questions are concerned with stress level of patients (items 1, 6, 8, 11, 12, 14 and 18). The scoring ranges 0-3, with a score of 0 indicating the never option, 1 a little option, 2 sometimes option, and 3 always option. Because the short form questionnaire has 21 questions, each score is multiplied by two.

The DASS-21 scale scores are classified by summing the relevant items. Cutoff points for the anxiety subscale are as follows: normal (<7), mild (8–9), moderate (10–14), severe (15–19), and extremely severe (>20). For depression subscale, normal (<9), mild (10–13), moderate (14–20), severe (21–27), and extremely severe (>28). The cutoff points for the stress subscale are normal (<14), mild (15–18), moderate (19–25), severe (26–33), and extremely severe (>34) (Chew et al., 2020; Henry & Crawford, 2005).

Statistical analysis

Data were analyzed using SPSS software (version 23). Analysis of covariance (ANCOVA) was conducted to find the difference between post-test, and baseline variables as covariates. When applicable, Bonferroni post hoc tests were used to check the difference between the groups. Besides, paired t-test was employed to compare within-group (pre- and post-test) differences. The effect size of each variable was tested using partial eta squared (η^2) values (small effect = 0.01, medium effect = 0.06, and large effect = 0.14). α = 0.05 was considered significance level in this study. In addition, one-way analysis of variance was applied on baseline scores across groups.

RESULTS

Anthropometric and resting hemodynamic parameters (SBP, DBP, MBP, HR) of participants are shown in Table 1. With ANCOVA, no significant difference was observed between factors under study in the baseline state (Table 1). All participants (30 women) took part in the randomized controlled trial.

Table 1. Anthropometric variables of participants between groups (mean ± SD).

Variables	IHG group (n = 15)	Control (n = 15)	*p*-value
Age (Years)	49.53 ± 3.73	48.53 ± 4.24	.49
weight (kg)	68.73 ± 8.68	67.46 ± 7.85	.74
height (cm)	166.86 ± 5.06	167.66 ± 5.60	.68
BMI (Kg/m^2)	28.66 ± 6.68	29.85 ± 10.18	.71
SBP (mmHg)	139.20 ± 1.08	138.86 ± 1.64	.51
DBP (mmHg)	89.26 ± 1.62	88.40 ± 3.77	.42
MAP (mmHg)	105.91 ± 1.08	105.17 ± 2.57	.35
Resting HR (bpm)	74.06 ± 2.96	72.40 ± 2.44	.10
RPP (mmHg x bpm)	10310.13 ± 422.87	10052.13 ± 302.19	.06

Note. IHG: Isometric Handgrip, BMI: Body Mass Index, SBP: Systolic Blood Pressure, DBP: Diastolic Blood Pressure, MAP: Mean Arterial Pressure, HR: Heart Rate, RPP: Rate pressure product.

Between group comparisons

Blood pressure

The results of the study show that there was significant difference between groups in the systolic blood pressure SBP ($f_{(1,27)}$ = 12.46, p = .002, η^2 = 0.31), Diastolic Blood Pressure DBP ($f_{(1,27)}$ = 16.96, p = .001, η^2 = 0.38), Mean Arterial Pressure MAP ($f_{(1,27)}$ = 41.75, p = .001, η^2 = 0.60), RPP ($f_{(1,27)}$ = 43.84, p = .001, η^2 = 0.61).

Quality of life (SF-36 Domains)

The results of the study show that there was significant difference between groups in the Physical Functioning (PF) ($f_{(1,27)}$ = 619.73, p = .001, η^2 = 0.95). In addition, there was significant difference between groups in the Bodily Pain (BP) ($f_{(1,27)}$ = 95.57, p = .001, η^2 = 0.78), Role limitations due to Physical problems (RP) ($f_{(1,27)}$ = 66.74, p = .001, η^2 = 0.71), Role limitations due to Emotional problems (RE) ($f_{(1,27)}$ = 56.98, p = .001, η^2 = 0.67), general Mental Health (GM) ($f_{(1,27)}$ = 243.55, p = .001, η^2 = 0.90), Social functioning (SF) ($f_{(1,27)}$ = 143.07, p = .001, η^2 = 0.84), Vitality (VT) ($f_{(1,27)}$ = 757.23, p = .001, η^2 = 0.96), General Health perceptions (GH) ($f_{(1,27)}$ = 507.54, p = .001, η^2 = 0.94), Total score of Quality of life ($f_{(1,27)}$ = 1160.661, p = .001, η^2 = 0.97), Physical health (PH) ($f_{(1,27)}$ = 654.619, p = .001, η^2 = 0.96) and Mental health (MH) ($f_{(1,27)}$ = 435.33, p = .001, η^2 = 0.94).

DASS-21

The results of study show that there was significant difference between groups in Depression ($f_{(1,27)}$ = 29.33, p = .001, η^2 = 0.51) and Anxiety ($f_{(1,27)}$ = 50.39, p = .001, η^2 = 0.65). In addition, there was significant difference between groups in Stress ($f_{(1,27)}$ = 29.52, p = .001, η^2 = 0.52). and in the Total score of the DASS-21 ($f_{(1,27)}$ = 101.03, p = .001, η^2 = 0.78).

Within group comparisons

The paired t-test was employed to control intra-group changes (pre-test and post-test). The results of paired t-test were illustrated in the Blood Pressure Table 2, Quality of life (SF-36 Domains) Table 3 and DASS-21 Table 4.

Table 2. Comparison of the blood pressure variables within (paired t-test) exercise and control groups.

Variable		Group	Baseline	Post Test	Within group	
					t	p
Blood Pressure	SBP (mmHg)	IHG	139.20 ± 1.08	134.40 ± 1.95	7.01	.001
		Control	138.86 ± 1.64	139.20 ± 4.67	0.26	.79
	DBP (mmHg)	IHG	89.26 ± 1.62	87.40 ± 1.35	4.40	.001
		Control	88.40 ± 3.77	89.66 ± 2.35	1.53	.14
	MAP (mmHg)	IHG	105.91 ± 1.08	103.06 ± 1.26	7.29	.001
		Control	105.17 ± 2.57	106.17 ± 2.03	1.88	.80
	RPP (mmHg x bpm)	IHG	10310.13 ± 422.87	9614.40 ± 373.49	11.79	.001
		Control	10052.13 ± 302.19	10189.53 ± 461.09	1.43	.17

Note. SBP: systolic blood pressure, DBP: Diastolic blood pressure, MAP: Mean arterial pressure, RPP: rate pressure product.

Table 3. Comparison of the Quality of life (SF-36 Domains) variables within (paired t-test) exercise and control groups.

	Variable	Group	Baseline	Post Test	Within group	
					t	*p*
Quality of life (SF-36 Domains)	PF	IHG	21.67 ± 5.87	84.67 ± 9.15	27.03	.001
		Control	24.67 ± 9.15	12 ± 6.76	4.83	.09
	BP	IHG	31.33 ± 12.74	83.67 ± 14.84	14.13	.001
		Control	21.83 ± 11.93	20.83 ± 16.16	0.9	1
	RP	IHG	20 ± 16.90	71.67 ± 20.84	7.27	.001
		Control	23.33 ± 17.59	15 ± 18.42	2.09	.75
	RE	IHG	13.33 ± 21.08	80 ± 24.56	9.160	.001
		Control	17.78 ± 21.33	15.56 ± 21.33	0.26	.79
	GM	IHG	30.33 ± 9.15	84 ± 7.60	20.98	.001
		Control	25.33 ± 10.25	31.33 ± 9.90	1.79	.95
	SF	IHG	28.33 ± 15.28	85.83 ± 12.38	15.05	.001
		Control	18.33 ± 12.38	17.50 ± 18.17	0.23	.81
	VT	IHG	22.33 ± 10.15	85.33 ± 8.33	24.94	.001
		Control	19 ± 10.03	11.67 ± 6.45	2.62	.61
	GH	IHG	21.33 ± 8.50	82.13 ± 9.89	19.43	.001
		Control	18.93 ± 10.08	11.47 ± 6.56	2.55	.074
	Total	IHG	850.33 ± 160.729	2964.33 ± 200.739	38.77	.001
		Control	809.33 ± 200.311	612.67 ± 26.5	3.58	.082
	PH	IHG	94.33 ± 24.76	322.13 ± 31.92	24.51	.001
		Control	88.77 ± 33.88	60.30 ± 24.35	3.28	.065
	MH	IHG	94.33 ± 26.57	335.17 ± 33.60	25.17	.001
		Control	80.44 ± 26.19	76.06 ± 35.83	0.59	.56

Note. SF-36: Short Form survey 36-item, PF: Physical Functioning, BP: Bodily Pain, RP: Role limitations due to Physical problems, RE: Role limitations due to Emotional problems, GM: general Mental Health, SF: Social functioning, VT: Vitality (energy and fatigue), GH: General Health perceptions, PH: Physical health, MH: Mental health.

Table 4. Comparison of the DASS-21 variables within (paired t-test) exercise and control groups.

Variable		Group	Baseline	Post Test	Within group	
					t	*p*
DASS-21	Depression	IHG	9.60 ± 3.46	6.47 ± 3.54	4.96	.001
		Control	8.27 ± 4.16	9.60 ± 3.64	2.64	.78
	Anxiety	IHG	8.73 ± 2.96	5.80 ± 2.51	8.19	.001
		Control	9.20 ± 3.25	10.27 ± 3.36	2.21	.059
	Stress	IHG	9.80 ± 2.39	6.67 ± 2.25	3.59	.003
		Control	10.07 ± 3.57	11.47 ± 3.42	3.50	.1
	Total	IHG	28.13 ± 6.11	18.93 ± 5.78	7.99	.001
		Control	27.53 ± 9.10	31.33 ± 8.96	5.92	.09

Note. DASS-21: Depression, Anxiety and Stress Scale - 21 Items.

DISCUSSION

The purpose of this study was to investigate the effect of isometric handgrip exercise at home on hemodynamic and psychological factors of women with hypertension during the quarantine period of COVID-19. The results showed a decrease in systolic blood pressure (6 mm Hg), diastolic blood pressure (2 mm Hg), and mean arterial pressure (2 mm Hg) along with improved quality of life, stress, anxiety and depression in participants who followed the handgrip exercise program.

IHG exercise and blood pressure

Infection control and safety precautions are essential given the concerns about the increasing spread of COVID-19. Staying at home is a basic safety step that could prevent from extensive infection. However, staying at home for a long time can lead to behaviors that increase inactivity and related diseases, such as CVD and hypertension.

High blood pressure is the most important correctable factor of cardiovascular diseases that affects more than 1,000,000,000 people worldwide, imposing a significant financial and life burden on societies. Lifestyle modifications, such as regular exercise, have been used to prevent and control high blood pressure (BP) (Cornelissen & Smart, 2013). Therefore, physical activity and regular exercise in a safe environment (home) can be an important strategy for a healthy life during COVID-19 crisis effective in the treatment of hypertension (Schiffrin et al., 2020).

IHG exercise is considered a non-drug treatment in hypertensive patients, which can decrease blood pressure and its related factors, so that through 2-3 mm Hg decrease in systolic blood pressure, it is possible to reduce the death rate due to stroke by 6% and CVD by 4% (Shakoor et al., 2020).

Blood pressure decrease due to IHG exercise can be attributed to two dominant mechanisms: sympathetic inhibition and changes in vascular reactivity following exercise. In fact, isometric handgrip exercise activity reduces blood pressure through its effect on baroreceptors, weakening baroreflex control and reducing sympathetic nerve traffic along with predominance of parasympathetic system (vagal tone) (Heffernan & Jae, 2020). Some researchers believe that after exercise, dopamine beta hydroxylase decreases in the hypothalamus, reducing the peripheral activity of epinephrine in response to emotions and other stimuli and contributing to decreased blood pressure. It has also been reported that the decrease in sympathetic nerve activity and the improvement of presser reflex function after exercise are due to the continuous decrease of angiotensin II and angiotensin receptors in CNS (Badrov, Freeman, Zokvic, Millar, & McGowan, 2016). The noteworthy point is that exercise training can probably reinforce ACE2-Ang1-7-Mas receptor axis, increase the synthesis of vasodilator pathway activator and create an anti-inflammatory and anti-fibrotic effect, which simultaneously inhibits ACE-Ang II-AT1 receptor pathway (Heffernan & Jae, 2020).

In particular, isometric handgrip exercises with repeated contractions, local ischemia and subsequent hyperemia raise the shear stress, which is followed by vasodilation because of increase in two vasodilator factors, namely FMD and nitric oxide (NO) (Chew et al., 2020; van Assche et al., 2017), decreasing vascular resistance and subsequently blood pressure.

In addition, after isometric handgrip exercise training, modulation of oxidative stress has been shown as a possible mechanism for the improvement of high blood pressure in the study by Peters et al. (2006) who investigated the role of ROS in reducing blood pressure during isometric handgrip exercises. They showed that in isometric handgrip exercises, ischemia and reperfusion caused by release of contraction increase the antioxidant capacity and decrease the activity of ROS, which reduce the damage to blood vessels. Perhaps handgrip exercise can be effective in improving endothelial function by reducing free oxygen radicals (Shakoor et al., 2020; van Assche et al., 2017). Vascular endothelial growth factor and fibroblast growth factor have been mentioned in relation to the improvement of endothelial function as a result of exercise training, both of which cause an increase in NO and dilation of blood vessels, followed by the decrease in blood pressure. Moreover, under hypoxia conditions, hypoxia-inducible factor-1 increases the expression of vascular endothelial growth factor gene (Cornelissen & Smart, 2013).

Therefore, perhaps the most important mechanism behind the blood pressure-lowering effects of exercise has been attributed to the enhancement of the arterial wall distensibility, reduction of peripheral resistance, and improvements in endothelial function.

It seems that IHG reduces blood pressure by increasing the number of capillaries in active skeletal muscle, rising cardiac output, decreasing vascular resistance due to vasodilation, reducing blood flow resistance, improving blood vessel neural regulation, decreasing peripheral resistance, and reducing the heart rate during rest (Cornelissen & Smart, 2013; TAYLOR et al., 2017).

IHG exercise, quality of life and DASS21 (stress, anxiety and depression)

The outcomes of this study showed that the IHG exercise training significantly improved quality of life variables in hypertensive women, mainly physical and mental health aspects.

The global COVID-19 pandemic has brought significant changes in lifestyle and has affected the physical and mental health of many individuals, particularly those suffering from hypertension. As mentioned above, with the increasing incidence of COVID-19, while staying at home is almost the only effective measure to prevent the infection in a majority of people and can simultaneously lower the risk of COVID-19, quarantine could increase the prevalence of chronic diseases such as high blood pressure as well as leading to the rise in psychiatric diseases and mood-psychological disorders, including higher levels of anxiety, depression and stress. Quarantine also affects mental health and can disrupt quality of life, self-image, and personal relationships (Schiffrin et al., 2020). Moreover, depression and anxiety have a negative effect on several dimensions of quality of life, including physical activity, and in patients with high blood pressure, the quality of life related to health is poorer compared to those with normal blood pressure (De Sousa et al., 2021; Strohle, 2009).

The present study investigated the potential benefits of IHG exercise on DASS21 scores in hypertensive women during the COVID-19 pandemic. Our findings suggest that the participants who engaged in IHG exercise had a significant reduction in their depression, anxiety, and stress levels as measured by the DASS21 compared to the control group who did not engage in any exercise. These results support previous findings that exercise can have a positive impact on mental health outcomes.

Nevertheless, exercise has been widely recommended as a non-drug approach to reduce the consequences of social distancing/isolation during COVID-19 pandemic (Heffernan & Jae, 2020), which is commonly used to treat people with depression or anxiety. Therefore, regular exercise, physical activity, or physical exercise may be a complementary treatment for improving mental and social health. In other respect, lack of exercise and inactivity have been reported as an important factor increasing depression and anxiety. In the meantime, exercise is a factor that can reduce stress in the body. These changes during COVID-19 epidemic reduce stress and improve the quality of life during daily activities (De Sousa et al., 2021; Li, Yu, Chen, Quan, & Zhou, 2018). These anti-anxiety, anti-depression and anti-stress effects of exercise can be explained by different mechanisms; isometric handgrip exercise is no exception, and physiological and psychological mechanisms can be mentioned in this respect (Schuch et al., 2014).

From a physiological standpoint, exercise can affect the neurotransmitters involved in anxiety, leading to the decrease in anxiety and stress via increase in beta-endorphins and uplifting hormones (De Sousa et al., 2021). Like other exercises, IHG probably strengthens the brain parts related to emotions, leading to happiness, relaxation and subsequently reduced depression (Schuch et al., 2014). Furthermore, IHG can exert its anti-depressant effect by modulating oxidative stress by decreasing the level of pro-oxidative markers as well as increasing antioxidant markers. Like aerobic exercise training, IHG is likely to increase the adaptation in thiobarbituric acid reactive species (TBARS) and the average total frequency in these individuals, leading to the improvement of various aspects of mental health (Schuch et al., 2016). It can also improve anxiety and depression and subsequently advance the quality of life through neurogenesis effects and increasing the level of brain-derived neurotrophic factor (BDNF) (De Sousa et al., 2021; Schuch et al., 2014).

From a psychological point of view, we can state that because isometric handgrip exercise has reduced blood pressure in the present research, it can probably increase the self-confidence and efficiency of an individual by improving mental conditions, as well as bettering various aspects of the quality of life and reducing people's anxiety and depression. For this reason, it can be stated that physical activity is an important and effective factor during COVID-19 pandemic or similar diseases.

Limitation of study

The study was limited by its small sample size and short duration. It is recommended that future studies include a larger sample size and longer duration to determine the long-term impact of IHG exercise on blood pressure levels. To conclude, the current study provides evidence that IHG exercise can be an effective intervention to decrease blood pressure levels during a quarantine period, where access to equipment and facilities is limited. It is important to note that while our study saw significant improvements in DASS21 and quality of life scores for the IHG exercise group, further research is needed to determine the long-term effects and optimal dosage of IHG exercise on mental health outcomes. Research on ACE2, SARS-CoV-2 infection, and physical exercise is in its infancy. Given the positive impact of regular exercise on mental, neurological and cardiovascular health, this is a vast area that needs to be explored.

CONCLUSION

The spread of COVID-19 prompted most countries in the world to take quick and protective measures in order to stop the transmission chain of this disease. For this purpose, people stayed at home to avoid contracting the disease, and in the meantime, inactivity and higher prevalence of chronic diseases such as high blood pressure became more prevalent. These circumstances can lead to mental disorders and affect psychological health. Therefore, it is necessary to develop strategies that can reduce the impact of COVID-19 on mental health, including exercise. Maintaining physical activity and regular exercise in the safe setting of home is an important strategy for healthy living during COVID-19 crisis.

Our findings suggest that regular IHG exercise may potentially serve as an effective preventative measure for hypertension and its related cardiovascular diseases during situations where physical activity may be restricted. IHG exercise activity can cause physiological changes as follows: improving blood pressure, reducing stress, depression and anxiety, and most importantly, increasing the quality of life, and these factors can be of high importance during COVID-19 pandemic.

AUTHOR CONTRIBUTIONS

Conceptualization: Elham Shakoor, Pezhman Motamedi, Farnaz Banaee. Data Collection: Elham Shakoor, Farnaz Banaee. Formal Analysis: Elham Shakoor, Pezhman Motamedi, Farnaz Banaee, Nemat Jaafari, Christine Sylvain. Supervision: Nemat Jaafari, Christine Sylvain. Writing – original draft: Elham Shakoor, Pezhman Motamedi, Farnaz Banaee, Nemat Jaafari, Christine Sylvain. Writing – review & editing: Elham Shakoor, Pezhman Motamedi, Farnaz Banaee, Nemat Jaafari, Christine Sylvain.

SUPPORTING AGENCIES

No funding agencies were reported by the authors.

DISCLOSURE STATEMENT

No potential conflict of interest was reported by the authors.

ACKNOWLEDGMENT

We are grateful to all the participants who enabled the implementation of this research with their presence.

REFERENCES

Aaronson, N. K., Muller, M., Cohen, P. D., Essink-Bot, M. L., Fekkes, M., Sanderman, R., . . . Verrips, E. (1998). Translation, validation, and norming of the Dutch language version of the SF-36 Health Survey in community and chronic disease populations. J Clin Epidemiol, 51(11), 1055-1068. https://doi.org/10.1016/S0895-4356(98)00097-3

Ashworth, N. L., Chad, K. E., Harrison, E. L., Reeder, B. A., & Marshall, S. C. (2005). Home versus center based physical activity programs in older adults. Cochrane Database Syst Rev, 2005(1), CD004017. https://doi.org/10.1002/14651858.CD004017.pub2

Badrov, M. B., Freeman, S. R., Zokvic, M. A., Millar, P. J., & McGowan, C. L. (2016). Isometric exercise training lowers resting blood pressure and improves local brachial artery flow-mediated dilation equally in men and women. Eur J Appl Physiol, 116(7), 1289-1296. https://doi.org/10.1007/s00421-016-3366-2

Boutron, I., Moher, D., Altman, D. G., Schulz, K. F., Ravaud, P., & Group, Consort. (2008). Extending the CONSORT statement to randomized trials of nonpharmacologic treatment: explanation and elaboration. Ann Intern Med, 148(4), 295-309. https://doi.org/10.7326/0003-4819-148-4-200802190-00008

Chew, N. W. S., Lee, G. K. H., Tan, B. Y. Q., Jing, M., Goh, Y., Ngiam, N. J. H., . . . Sharma, V. K. (2020). A multinational, multicentre study on the psychological outcomes and associated physical symptoms amongst healthcare workers during COVID-19 outbreak. Brain Behav Immun, 88, 559-565. https://doi.org/10.1016/j.bbi.2020.04.049

Chtourou, H., Trabelsi, K., H'Mida, C., Boukhris, O., Glenn, J. M., Brach, M., . . . Bragazzi, N. L. (2020). Staying Physically Active During the Quarantine and Self-Isolation Period for Controlling and Mitigating the COVID-19 Pandemic: A Systematic Overview of the Literature. Front Psychol, 11, 1708. https://doi.org/10.3389/fpsyg.2020.01708

Cornelissen, V. A., & Smart, N. A. (2013). Exercise training for blood pressure: a systematic review and meta-analysis. J Am Heart Assoc, 2(1), e004473. https://doi.org/10.1161/JAHA.112.004473

de Brito, L. C., Rezende, R. A., da Silva Junior, N. D., Tinucci, T., Casarini, D. E., Cipolla-Neto, J., & Forjaz, C. L. (2015). Post-Exercise Hypotension and Its Mechanisms Differ after Morning and Evening Exercise: A Randomized Crossover Study. PLoS One, 10(7), e0132458. https://doi.org/10.1371/journal.pone.0132458

De Sousa, Ricardo Augusto Leoni, Improta-Caria, Alex Cleber, Aras-Júnior, Roque, de Oliveira, Edilamar Menezes, Soci, Úrsula Paula Reno, & Cassilhas, Ricardo Cardoso. (2021). Physical exercise effects on the brain during COVID-19 pandemic: links between mental and cardiovascular health. Neurol. Sci, 42, 1325-1334. https://doi.org/10.1007/s10072-021-05082-9

Dorans, K. S., Mills, K. T., Liu, Y., & He, J. (2018). Trends in Prevalence and Control of Hypertension According to the 2017 American College of Cardiology/American Heart Association (ACC/AHA) Guideline. J Am Heart Assoc, 7(11), e008888. https://doi.org/10.1161/JAHA.118.008888

Heffernan, Kevin S, & Jae, Sae Young. (2020). Exercise as medicine for COVID-19: An ACE in the hole? Med. Hypotheses, 142, 109835. https://doi.org/10.1016/j.mehy.2020.109835

Henry, J. D., & Crawford, J. R. (2005). The short-form version of the Depression Anxiety Stress Scales (DASS-21): construct validity and normative data in a large non-clinical sample. Br J Clin Psychol, 44(Pt 2), 227-239. https://doi.org/10.1348/014466505X29657

Li, Jianzhi, Yu, Jiangdong, Chen, Xi, Quan, Xuewen, & Zhou, Lan. (2018). Correlations between health-promoting lifestyle and health-related quality of life among elderly people with hypertension in Hengyang, Hunan, China. Medicine, 97(25). https://doi.org/10.1097/MD.0000000000010937

Ma, L., Song, K., & Huang, Y. (2021). Coronavirus Disease-2019 (COVID-19) and Cardiovascular Complications. J Cardiothorac Vasc Anesth, 35(6), 1860-1865. https://doi.org/10.1053/j.jvca.2020.04.041

Millar, P. J., MacDonald, M. J., Bray, S. R., & McCartney, N. (2009). Isometric handgrip exercise improves acute neurocardiac regulation. Eur J Appl Physiol, 107(5), 509-515. https://doi.org/10.1007/s00421-009-1142-2

Nadar, S. K., Tayebjee, M. H., Stowasser, M., & Byrd, J. B. (2020). Managing hypertension during the COVID-19 pandemic. J Hum Hypertens, 34(6), 415-417. https://doi.org/10.1038/s41371-020-0356-y

Nasrollahzadeh Sabet, Mehrdad, Khanalipour, Mohammad, Gholami, Milad, Sarli, Abdolazim, Rahimi Khorrami, Arefeh, & Esmaeilzadeh, Emran. (2020). Prevalence, clinical manifestation and mortality rate in COVID-19 patients with underlying diseases. J Arak Uni Med Sci, 23(5), 740-749. https://doi.org/10.32598/JAMS.23.COV.5797.1

Organization, World Health. (2020). Coronavirus disease (COVID-19): situation report, 198.

Pescatello, Linda S, Arena, Ross, Riebe, Deborah, & Thompson, Paul D. (2013). SNEAK PEEK: Preview of ACSM's Guidelines for Exercise Testing and Prescription. ACSMs Health Fit J, 17(2), 16-20. https://doi.org/10.1249/FIT.0b013e318282a46d

Peters, P. G., Alessio, H. M., Hagerman, A. E., Ashton, T., Nagy, S., & Wiley, R. L. (2006). Short-term isometric exercise reduces systolic blood pressure in hypertensive adults: possible role of reactive oxygen species. Int J Cardiol, 110(2), 199-205. https://doi.org/10.1016/j.ijcard.2005.07.035

Pfefferbaum, B., & North, C. S. (2020). Mental Health and the Covid-19 Pandemic. N Engl J Med, 383(6), 510-512. https://doi.org/10.1056/NEJMp2008017

Qiu, Jianyin, Shen, Bin, Zhao, Min, Wang, Zhen, Xie, Bin, & Xu, Yifeng. (2020). A nationwide survey of psychological distress among Chinese people in the COVID-19 epidemic: implications and policy recommendations. Gen. Psychiatry, 33(2). https://doi.org/10.1136/gpsych-2020-100213

Rogers, Nina Trivedy, Waterlow, Naomi R, Brindle, Hannah, Enria, Luisa, Eggo, Rosalind M, Lees, Shelley, & Roberts, Chrissy H. (2020). Behavioral change towards reduced intensity physical activity is disproportionately prevalent among adults with serious health issues or Self-Perception of high risk during the UK COVID-19 Lockdown. Front Public Health, 8, 575091. https://doi.org/10.3389/fpubh.2020.575091

Schiffrin, Ernesto L, Flack, John M, Ito, Sadayoshi, Muntner, Paul, & Webb, R Clinton. (2020). Hypertension and COVID-19 (Vol. 33, pp. 373-374): Oxford University Press US. https://doi.org/10.1093/ajh/hpaa057

Schuch, F. B., Deslandes, A. C., Stubbs, B., Gosmann, N. P., Silva, C. T., & Fleck, M. P. (2016). Neurobiological effects of exercise on major depressive disorder: A systematic review. Neurosci Biobehav Rev, 61, 1-11. https://doi.org/10.1016/j.neubiorev.2015.11.012

Schuch, F. B., Vasconcelos-Moreno, M. P., Borowsky, C., Zimmermann, A. B., Wollenhaupt-Aguiar, B., Ferrari, P., & de Almeida Fleck, M. P. (2014). The effects of exercise on oxidative stress (TBARS) and BDNF in severely depressed inpatients. Eur Arch Psychiatry Clin Neurosci, 264(7), 605-613. https://doi.org/10.1007/s00406-014-0489-5

Shakoor, Elham, Salesi, Mohsen, Daryanoosh, Farhad, & Izadpanah, Payman. (2020). Effect of Acute High-Intensity Interval Training and Isometric Handgrip Exercise on Hemodynamic Responses in Hypertensive Women. Women's Health Bulletin, 7(3), 60-69.

South, A. M., Diz, D. I., & Chappell, M. C. (2020). COVID-19, ACE2, and the cardiovascular consequences. Am J Physiol Heart Circ Physiol, 318(5), H1084-H1090. https://doi.org/10.1152/ajpheart.00217.2020

Stockwell, Stephanie, Trott, Mike, Tully, Mark, Shin, Jae, Barnett, Yvonne, Butler, Laurie, . . . Smith, Lee. (2021). Changes in physical activity and sedentary behaviours from before to during the COVID-19 pandemic lockdown: a systematic review. BMJ open sport & exercise medicine, 7(1), e000960. https://doi.org/10.1136/bmjsem-2020-000960

Strohle, A. (2009). Physical activity, exercise, depression and anxiety disorders. J Neural Transm (Vienna), 116(6), 777-784. https://doi.org/10.1007/s00702-008-0092-x

Taylor, Beth A, Thompson, Paul D, Macdonald, Hayley V, Lamberti, Lauren, Ming-Hui, Chen, Farinatti, Paulo, Deshpande, Ved. (2017). The antihypertensive effects of aerobic versus isometric handgrip resistance exercise. J.Hypertens, 35(2), 291. https://doi.org/10.1097/HJH.0000000000001176

Thompson, P. D., Arena, R., Riebe, D., Pescatello, L. S., & American College of Sports, Medicine. (2013). ACSM's new preparticipation health screening recommendations from ACSM's guidelines for exercise testing and prescription, ninth edition. Curr Sports Med Rep, 12(4), 215-217. https://doi.org/10.1249/JSR.0b013e31829a68cf

van Assche, T., Buys, R., de Jaeger, M., Coeckelberghs, E., & Cornelissen, V. A. (2017). One single bout of low-intensity isometric handgrip exercise reduces blood pressure in healthy pre- and hypertensive

individuals. J Sports Med Phys Fitness, 57(4), 469-475. https://doi.org/10.23736/S0022-4707.16.06239-3
Wang, C., Horby, P. W., Hayden, F. G., & Gao, G. F. (2020). A novel coronavirus outbreak of global health concern. Lancet, 395(10223), 470-473. https://doi.org/10.1016/S0140-6736(20)30185-9
Ware, J. E., Jr., & Sherbourne, C. D. (1992). The MOS 36-item short-form health survey (SF-36). I. Conceptual framework and item selection. Med Care, 30(6), 473-483. https://doi.org/10.1097/00005650-199206000-00002
Zhang, Y., Zhang, H., Ma, X., & Di, Q. (2020). Mental Health Problems during the COVID-19 Pandemics and the Mitigation Effects of Exercise: A Longitudinal Study of College Students in China. Int J Environ Res Public Health, 17(10), 3722. https://doi.org/10.3390/ijerph17103722