CHANGES IN QUALITY OF LIFE, STRENGTH AND HEART RATE VARIABILITY AFTER 4-WEEKS OF SUPERVISED ONLINE BURPEES TRAINING DURING THE COVID-19 QUARANTINE IN HEALTHY YOUNG ADULTS: A PILOT STUDY

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Abstract:

In order to maintain physical fitness during the COVID-19 quarantine, we designed a short-term intervention with one body-weight exercise – burpees. Thus, the aim of this study was to understand level of feasibility and potential benefits of our protocol to different variables in young adults during the COVID-19 quarantine. An online 4-week intervention was administered to 13 young adults (age 22.5±1.39 years, weight 71.8±10.1 kg). The main phase of each session consisted of burpees, a calisthenics body-weight exercises. The training was administered daily. Data regarding quality of life (QoL), body composition, posture, heart rate variability (HRV), cardiovascular health, and strength were collected before and after the intervention period. Participants' QoL significantly increased after four weeks (p=.025). Also, participants' strength improved, assessed by the push-up test (p=.017). Systolic blood pressure showed no difference between the pre- and post-measures, while a significant reduction was found in diastolic blood pressure. The HRV assessment showed increased mean RR (p=.005) and RMSSD (p=.014) and decreased mean HR (p=.004) (in the time-domain). For the frequency-domain variables, no significant difference was found. No significant changes were noted in body composition, posture, handgrip strength and countermovement squat jump height. Our preliminary results suggest that the 4-week daily online burpees intervention is a feasible method that could improve QoL, upper body strength and HRV in young adults. This non-time-consuming approach could be easily administered to promote healthy living and counteract physical inactivity during COVID-19 restrictions thanks to its feasibility, short duration, and low cost.

Key words: *exercise, coronavirus, internet-based intervention, health promotion*

Introduction

The World Health Organization (WHO) declared that the COVID-19 outbreak was a public international health concern in January 2020 (WHO, 2020a) and after a few months announced the pandemic COVID-19 disease (March 2020) (WHO, 2020b).

In 2021, within the European Union (Mathieu, et al.), restrictive government acts were still required in order to contain the virus transmission due to viruses' new more transmissible SARS-CoV-2 mutations (e.g. the English variant) (WHO, 2021) and the delay in the administration of the vaccines (BBC, 2021; Mathieu, et al., 2021). Also in Italy, several restrictions were applied between February to April 2021 (Republica Italiana, 2021). Thus, high schools and universities were still employing a full or partial online approach. The online lesson regimen could cause stress in students (Mheidly, Fares, & Fares, 2020). Also, gyms were closed (from November 2020; Republica Italiana, 2020) whereby students' and young adults' physical activity was limited, increasing sedentary time (Giustino, et al., 2020). To counteract sedentary lifestyle is important for the individual's psychophysical health status because higher physical fitness levels can limit cardiovascular diseases and other health-related concerns (Blair, et al., 1989; Lavie, Ozemek, Carbone, Katzmarzyk, & Blair, 2019; Young, et al., 2016).

Moreover, due to the pandemic social restrictions, our quality of life (QoL) decreased (Amit Aharon, Dubovi, & Ruban, 2021; Ferreira, Pereira, da Fé Brás, & Ilchuk, 2021). Over the last year, the QoL decline was also found in children and adolescents (Nobari, et al., 2021).

Physical exercise has the power to limit persons' QoL decline, reducing depression and anxiety (Antunes, et al., 2021; Hu, Tucker, Wu, & Yang, 2020), although the hyper-connected daily schedule makes it seems a time-consuming and non-effective approach. Therefore, it is important for young adults to find a non-time-consuming exercise approach by which to obtain the highest effect in a shorter amount of time, aiming to improve especially QoL. A time-saving approach could also avoid the tedium of an individualized home-based exercise session. Low-load workouts could be useful strategies for breaks between screen-working phases as well (Carter, Jones, & Gladwell, 2015), aiming to improve people's health (Colley, Bushnik, & Langlois, 2020).

Short-term approaches, known also as high-intensity interval trainings (HIIT), are commonly used in different sports and are implemented either by means of expensive training equipment (treadmill, cycle ergometer, arm ergometer) or body-weight exercises. These trainings are administered in the form of short high-intensity exercise sets alternating with active or passive recovery phases. The advantage is a high metabolic response over a brief training period (Burgomaster, et al., 2008; Gibala, et al., 2006). The benefits of HIIT are usually greater physiological adaptations (MacInnis & Gibala, 2017). More comprehensive exercises, which involve upper, lower and core muscles and endurance capacity, must be chosen to program a HIIT intervention aiming at improving quality of life and obtaining the highest physiological response. An exercise, commonly used in calisthenics protocols (Gist, Freese, Ryan, & Cureton, 2015; Thomas, et al., 2017), with the described characteristics is the burpee. The burpee is a body-weight exercise created by combining a squat jump and a push-up and was developed from a physical fitness test originally created by Burpee (Burpee, 1940; Gist, Freese, & Cureton, 2014; Gist, et al., 2015). Authors demonstrated that the burpee provides higher metabolic demands (during three sets of 10 repetitions) than common resistance exercises (bench press, squat, curl, bent-over row, high pull, lunge or deadlift, also performed in three sets of 10 repetitions at 75% of their relative 1-RM) (Ratamess, et al., 2015). The simultaneous involvement of major muscle groups and the use of dynamic transitions between phases augment the metabolic demands during the burpee when compared to resistance exercises. Only a few studies applied only a burpee exercise intervention and, to our knowledge, none of them assessed the effects on quality of life (QoL) and heart rate variability (HRV). HRV is particularly a valuable non-invasive strategy to assess the physiological status of the autonomous nervous system (ANS) (McRae, et al.) through the analysis of the heart beat behavior. Regarding this parameter, the review by Grässler, Thielmann, Böckelmann, and Hökelmann, (2021) showed that different exercise typologies had beneficial effects on HRV and cardiovascular health in healthy young and middle-aged adults . However, in the included studies and exercise typologies used in them no single body-weight calisthenics exercise protocol was presented. Moreover, assessing the effects of a specific exercise protocol on young adults' HRV during the pandemic era could be useful to understand whether or not it can improve ANS balance.

In addition, live online communication strategies could be an essential tool for trainers during the pandemic. However, studies using the online approaches usually implement online video recorded (or DVD) lessons and motivational/behavior management smartphone apps or software in order to deliver the intervention (Hui, et al., 2018; Iannaccone, et al., 2020). Conversely, we preferred a fully supervised live online approach, implemented through a video-communication system, to monitor and analyze training phases and exercise techniques.

Furthermore, no studies with burpees were proposed during the COVID-19 pandemic. For this reason, we designed a progressive online burpees training program to test its level of feasibility and its influence on different variables (both physiological and psychological), QoL and HRV included. Thus, the aim of this study was to emphasize participants' adherence and potential benefits of a progressive online burpees training program to quality of life, body composition, posture, heart rate variability, cardiovascular health, and strength among young adults during the COVID-19 quarantine.

Methods

Study protocol

This is a 1-arm pilot, pre-post intervention study, assessing the feasibility and potential benefits of a 4-week daily online burpees training program to young healthy adults.

Participants

The Ethical Committee of the University of Palermo approved the research project (n. 45/2021). The approved project included the pilot phase the aim of which was to test the feasibility of the protocol and subsequent original investigation. We planned to include participants 18 to 30 years of age. Healthy young adults (male or female), willing to participate, in agreement with the presented informed consent, were recruited to test the feasibility of our protocol. For this pilot phase, the only two exclusion criteria were a diagnosed disease or any limitation that could preclude the participation in the physical activity intervention. After the recruitment period, 14 participants (10 males, four females) were included. One male participant was a dropout at the post-test due to his COVID-19 infection, although he completed all the exercise sessions. For these reasons only 13 participants (age 22.5±1.39 years, body mass 71.8±10.1 kg, height 171±8.66 cm) completed the final assessments and were included in the analysis.

Burpees' protocol

In order to implement the online training protocol, an expert was trained concerning the training sessions, phases, week progression, exercise techniques and the online procedure. The training session was completed with feedback focused discussion at the end. This approach allowed the solutions of existing issues or limitations from the trainer's point of view.

The intervention is summarized in Table 1. Each training session was being administered using an online video communication software, in order to implement a fully supervised approach, for four weeks. The lessons were provided once a day, five days a week by the expert. This method was required due to the pandemic situation, and we supposed it was more efficient than the classic DVD-video online-delivered approaches in obtaining high adherence rates. Every session started with a warm-up consisting of a short set of joint mobility exercises followed by 10 push-ups, five squats and five squat jumps. At the end of a training session, a 10-minute static stretching session was administered as a cool-down. In the main phase of a session burpees were executed, calisthenics bodyweight exercises consisting of push-ups and squat jumps performed in rapid succession. A different, increased, burpees amount (of sets and repetitions) each week, according to the progression principle (Hoffman, 2014), was implemented. No recommendations about diet habits were given to the participants.

Variables and materials

All assessments of each participant were completed during a single evaluation session. The included assessments were the following: quality of life (QoL) questionnaire, body composition analysis, cardiovascular assessments, posture evaluation and functional fitness tests. Functional fitness tests were administered at the end of the assessment session to avoid any influence on the other tests. Two expert investigators carried out the evaluations before and after the 4-week intervention. All the assessments were completed following the appropriate procedures for COVID-19 prevention (Venturelli, et al., 2020).

Quality of life. After signing the informed consent, participants' QoL was assessed through the Italian version of the SHORT FORM—36 questionnaire (SF-36) using a computer (Apolone & Mosconi, 1998; Ware & Sherbourne, 1992). All scores were calculated according to the instructions provided by the RAND Corporation (RAND Corporation, 2021).

Body composition. Participants' body composition was evaluated through an AKERN 101 (AKERN SRL, RJL Systems, Detroit, USA) body composition analyzer (Barrea, et al., 2017). In order to complete the assessment, participants' height and weight were recorded before the analysis, using a wall-mounted stadiometer and a digital weight scale. Participants were asked to remove all the metal accessories to avoid bias in the analysis. After the individual registration on the Akern software, participants were asked to remove shoes and socks in order to place the electrodes. Electrodes were placed on the right hand and foot. The posterior surface of the right hand was used to place the electrodes (the transmitting electrode was placed on the distal end of the third metacarpal bone, 5-cm apart from the receiving electrode placed between the radial and ulna styloid process). The anterior surface of the right foot (transmitting electrode

Table 1. Intervention

	Week 1			Week 2			Week 3			Week 4		
	Sets	Reps	Rest	Sets	Reps	Rest	Sets	Reps	Rest	Sets	Reps	Rest
	Warm-up			Warm-up			Warm-up			Warm-up		
Burpees	10	10	1'	10	12	1'	11	12	1'	12	12	1'
	Cool-down			Cool-down			Cool-down			Cool-down		
Daily volume (n)	100			120			132			144		
Weekly volume (n)	500			600			660			720		

placed on the distal end of the second metatarsal bone) and of the ipsilateral ankle (receiving electrode placed between medial and lateral malleoli) were used. At the end of the test, the following information was extracted: fat-free mass (FFM), fat mass (FM), intracellular water (ICW) and extracellular water (ECW).

Cardiovascular assessment. Cardiovascular characteristics included were the following: systolic and diastolic blood pressure (SBP and DBP), oxygen saturation (SpO_2) and heart rate variability (HRV).

SBP and DBP and the SpO_2 were assessed using a digital sphygmomanometer (OMRON EVOLV HEM-7600T-E) and a finger pulse oximeter, respectively. Both tests were implemented in a sitting relaxed position with the right hand placed on the right thigh, whereas the assessment was performed using the left arm and the left hand's second finger.

The HRV assessment was implemented using a POLAR H10 belt. The sensor was placed at the distal end of the xiphoid process on the participant's chest. We used a "short-term measurement" approach with a 5-minute recording (Electrophysiology, TFOTESCOCTNASOP, 1996; Shaffer & Ginsberg, 2017). During the recording, participants maintained the sitting position, in a relaxation status, without speaking or moving (da Silva, de Oliveira, Silveira, Mello, & Deslandes, 2015). KUBIOS software was used to analyze the extracted data to estimate the time and frequency-domain variables. Regarding the time-domain variables, we collected the following: means of RR (inter-beat) intervals in milliseconds (ms), mean HR (heart rate) in beats per minute (bpm), standard deviations of normal inter-beat intervals (SDNN) in ms, root mean square of consecutive differences of normal beats (RMSSD) in ms, number of beats with normal to normal intervals that differ by more than 50 ms (NN50); triangular index measures and the triangular interpolation of the NN interval histogram (TINN). The triangular index and TINN are geometric variables derived from the ratio between the integral of the density of the RR interval histogram and its height and the baseline width of a NN intervals histogram in ms, respectively (Electrophysiology, TFOTESCOCTNASOP, 1996).

For the frequency-domain variables, fast Fourier transformations allowed us to split the frequency components of HRV into the following: ultra-low-frequency band (ULF), very-low-frequency band (VLF), low-frequency band (LF) and high-frequency band (HF) (Electrophysiology, TFOTESCOCTNASOP, 1996; Shaffer & Ginsberg, 2017). ULF data are usually included only from a long-term HRV assessment, thus they were excluded in this analysis (Xhyheri, Manfrini, Mazzolini, Pizzi, & Bugiardini, 2012). For this reason, only power in ms^2 and percentage of VLF, LF and HF were collected. In addition, the ratio between the LF and HF, usually considered as a value determined through the balance between the sympathetic and parasympathetic activity, was included (Bilchick & Berger, 2006; Venturelli, et al., 2019).

Posture. After the HRV analysis, the postural stability of the participants was analyzed using a FREEMED posturographic platform and the FREESTEP v.1.0.3 software (SENSOR MEDICA, Guidonia Montecelio, Roma, Italy). Postural sway frequency sampling was set at 100Hz. Participants were asked to maintain the Romberg standard position (distance between the heels 4-cm, and feet placed with a 30° angle between them) in two different standing tests: one was performed with the open eyes and the other one with the closed eyes. We collected the coordinates of the postural sway both with open and closed eyes.

Functional fitness assessments. The functional assessments included a handgrip test, a countermovement jump test (CMJ), and a push-up test to exhaustion. An appropriate warm-up and rest were administered between the tests and trials.

The grip strength was assessed using a digital dynamometer (KERN MAP 80K1, KERN&Sohn GmbH, Barlinger, Germany) in two trials for each hand (if the results were not within a 5% confidence interval, an additional trial was performed). The best results were recorded. The test was performed in a standing position, holding the dynamometer comfortably, with the screen directed to the participant's body, with the elbow flexed at 90° in the tested arm, while the non-tested arm was fully extended.

In order to assess the jump ability, a CMJ test was administered. The CMJ height was recorded using the optical system OPTOJUMP (MICROGATE) and the OPTOJUMP NEXT software, saving the best result of two attempts.

The push-up test to exhaustion was performed on the floor, with the body in a straight-line position with the hands and arms placed on the floor in a comfortable position (between-hands distance was slightly wider than the shoulder width creating a 45° angle between the body and the humerus). The fingers were pointed away from the body with a slight external rotation in the wrist and feet were kept together. Participants were asked to perform the maximum number of repetitions, with full elbow extension in order to complete the concentric phase and with at least 90° flexion in the elbows during the eccentric phase. The test was performed until the participant reached the point where he/she was not able to push any longer the body from the floor. Due to the nature of this test, just one attempt was allowed. At the end of the push-up test, the rate of perceived exertion (RPE, Borg scale) was administered to understand if the effort made was really to exhaustion (Borg, 1982).

Statistical analysis

The statistical analysis was performed using the R-based software JAMOVI (The JAMOVI project, 2021; ver. 1.6 [Computer Software]. Retrieved from https://www.jamovi.org). Data were reported as mean and standard deviations. Normality assessment using the Shapiro-Wilk test was performed. Paired sample *t*-test or the Wilcoxon ranks were applied for the normally and non-normally distributed data, respectively, in order to test the difference between pre- and post-intervention measurements. Significance was set at p<.05. The test-retest reli-

Table 2. Results, summary

Variables	Pre	Post	CI 95%	p	r
Weight (kg)	71.8±10.12	72.2±9.89	[-1.26, 0.47]	.341	0.990
BMI (kg/m^2)	24.5±2.89	24.7±2.72	[-0.43, 0.17]	.353	0.986
QoL	78.1±8.70	84.8±7.66	[-12.36, -0.99]	.025*	0.280
Functional assessment					
HG Right (kg)	41.2±9.67	41.4±10.88	[-2.65, 2.29]	.879	0.928
HG Left (kg)	37.7±8.58	39.0±9.56	[-3.18, 0.69]	.185	0.943
CMJ (cm)	34.9±7.12	35.9±6.89	[-2.39, 0.33]	.125	0.949
Push-up (n)	29.9±8.92	32.5±10.51	[-4.54, -0.54]	.017*	0.955
RPE	16.2±1.17	16.2±2.42	[-1.44, 1.44]	1.000	0.275
Body composition					
FFM (kg)	53.9±8.58	54.6±8.75	[-1.56, 0.32]	.174	0.984
FM (kg)	17.9±6.43	17.7±5.44	[-0.64, 1.10]	.572	0.985
ICW (l)	24.6±4.01	24.9±4.08	[-0.76, 0.16]	.179	0.983
ECW (l)	15.0±2.31	15.1±2.33	[-0.41, 0.08]	.174	0.985
Posture					
OE					
Sway (mm)	1342.5±446.49	1222.7±413.22	[-40.09, 279.67]	.129	0.813
Ellipse (mm^2)	49.8±45.93	112.7±161.48	[-94.78, 11.70]	.191	-0.051
Xmed (mm)	1.6±13.27	0.23±14.78	[-3.25, 5.99]	.530	0.857
Ymed (mm)	-23.6±8.84	-18.7±10.43	[-11.31, 1.38]	.114	0.416
CE					
Sway (mm)	1465.7±600.27	1345.6±621.81	[-126.86, 367.12]	.310	0.777
Ellipse (mm^2)	63.8±67.52	124.5±106.10	[-123.48, 2.17]	.057	0.349
Xmed (mm)	1.2±12.64	1.18±17.36	[-5.10, 5.17]	.989	0.886
Ymed (mm)	-21.8±8.04	-18.25±10.43	[-8.73, 1.56]	.155	0.602
Cardiovascular variables					
Mean RR (ms)	694.9±102.36	767.3±89.51	[-118.40, -26.52]	.005*	0.694
Mean HR (bpm)	88.2±13.72	79.4±10.24	[3.00, 17.50]	.004*	0.614
SBP (mmHg)	123.0±9.78	123.9±13.03	[-7.41, 5.72]	.784	0.579
DBP (mmHg)	80.4±8.51	73.54±8.27	[2.59, 11.10]	.004*	0.648
SDNN (ms)	45.1±18.33	52.5±20.33	[-14.96, 0.11]	.053	0.797
RMSSD (ms)	35.8±16.47	42.7±19.40	[-12.11, -1.67]	.014*	0.897
NN50	62.5±59.44	74.3±59.75	[-33.58, 9.89]	.258	0.818
Triangular Index	11.4±4.13	13.0±5.16	[-3.98, 0.81]	.174	0.657
TINN	223.7±76.96	264.9±102.17	[-74.60, -7.71]	.020*	0.846
LF/HF	2.3±2.79	2.4±2.03	[-0.61, 1.08]	.455	0.467

Note. Pre-Post means and confidence intervals (CI 95%) of the included variables; *=significant difference; BMI= body mass index; QoL= quality of life; SpO_2= peripheral oxygen saturation; HG= handgrip; CMJ= counter movement squat jump; RPE= rate of perceived exertion based on Borg scale; FFM= free fat mass; FM= fat mass; ICW= intracellular water; ECW= extracellular water; OE= open eyes; CE= closed eyes; RR= inter-beat intervals; HR= heart rate; SBP= systolic blood pressure; DBP= diastolic blood pressure; SDNN= standard deviations of normal inter-beat interval; RMSSD= root mean square of consecutive differences of normal beats; NN50= number of beats with normal to normal intervals that differ by more than 50 ms; TINN= triangular interpolation of the NN interval histogram; LF/HF= ratio between the low frequency band and high frequency band.

ability coefficient was provided using the Pearson r correlation. GRAPHPAD PRISM 8 was used to generate the graphs.

Results

The results confirmed the expected high adherence rate because all the participants completed all the training sessions (including the drop-out participant who was not able to complete the post-assessment due to COVID-19).

The results showing pre-post intervention means ± SD, CI 95% and p-values are summarized in Table 2.

A significant improvement in the participants' QoL was found after the online intervention (p=.025). SF-36 QoL score increased from 78.1 ± 8.70 to 84.8 ± 7.66 after four weeks (CI 95% [-12.36, -0.99]) (Fig. 1).

For the anthropometrical values, no difference was found in participants' weight and BMI between the pre- and post-intervention measurements. Consistently, also no differences were found in the included variables regarding the body composition assessment: FFM (from 53.9 ± 8.58 to 54.6 ± 8.75 kg; CI 95% [-1.56 , 0.32]; p=.174), FM (from 17.9 ± 6.43 to 17.7 ± 5.44 kg; CI 95% [-0.64 , 1.10]; p=.572), ICW (from 24.6 ± 4.01 to 24.9 ± 4.08 kg; CI 95% [-0.76 , 0.16]; p=.179) and ECW (from 15.0 ± 2.31 to 15.1 ± 2.33 kg; CI 95% [-0.41 , 0.08] p=.174).

The analysis of the postural stability variables also showed no significant changes between the pre- and post-intervention assessments.

There were no significant differences between the pre- and post-intervention measurements in the handgrip strength (of both hands) and the CMJ elevation. However, the functional fitness assessment revealed a significant difference (p=.017) in the number of repetitions executed during the push-up test to exhaustion (pre 29.9 ± 8.92 to post 32.5 ± 10.51 repetitions; CI 95% [-4.54, -0.54]) (Fig. 2). No difference was found in the RPE, confirming the same level of effort to perform the test to exhaustion at the end of the intervention period, despite the increased number of repetitions performed**.**

Blood pressure analysis showed no difference in pre- to post-measures regarding the SBP (pre 123.0 ± 9.78 to post 123.9 ± 13.03 mmHg; CI 95% [-7.41, 5.72]; p=.784), while a significant difference was found in DBP that showed a reduction from 80.4 ± 8.51 to 73.54 ± 8.27 mmHg (CI 95% [2.59, 11.10]; p=.004).

The HRV assessment showed significant difference in the majority of the time-domain included variables: increased mean RR (from 694.9 ± 102.36 to 767.3 ± 89.51 ms; CI 95% [-118.40, -26.52]; p=.005); decreased mean HR (from 88.2 ± 13.72 to 79.4 ± 10.24 bpm; CI 95% [3.00, 17.50]; p=.004); increased RMSSD (from 35.8 ± 16.47 to 42.7 ± 19.40 ms; CI 95% [-12.11, -1.67]; p=.014) (Fig. 3); increased TINN (from 223.7 ± 76.96 to 264.9 ± 102.17; CI 95% [-74.60, -7.71]; p=.020). Non-significant increase was noted regarding SDNN (from

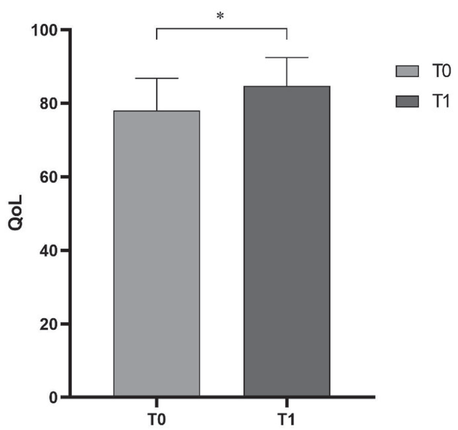

Figure 1. Quality of life pre- (T0) and post- (T1) assessment.

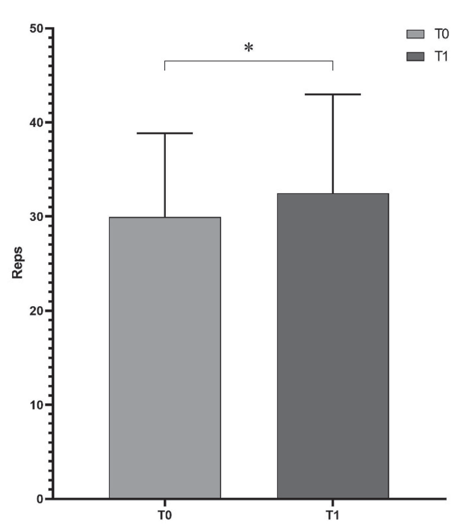

Figure 2. Push-up repetitions pre- (T0) and post- (T1) assessment.

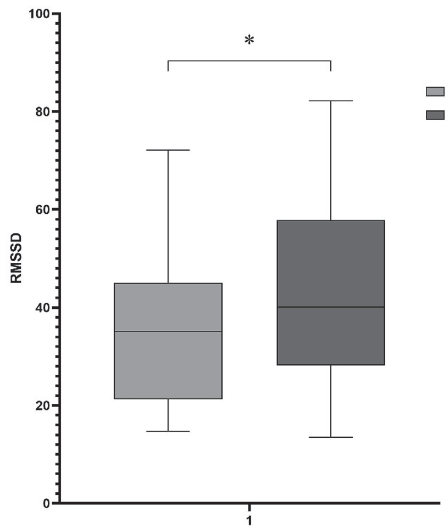

Figure 3. RMSSD pre- (T0) and post- (T1) measurements.

45.1 ± 18.33 to 52.5 ± 20.33; CI 95% [-14.96, 0.11]; p=.053). No differences were found in NN50 and triangular index. For the frequency domain variables, no significant difference was found in the included variables.

Discussion and conclusions

The aim of this pilot study was to identify the potential effects of a progressive online burpees training on young adults during the COVID-19 quarantine, focusing, in the first place, on the protocol feasibility. Thanks to this first pilot phase, we were able to highlight the feasibility and safety of our protocol. After our intervention, we detected some potential benefits. Improvements in participants' QoL, push-up test to exhaustion, and HRV variables (showing a tendency to an increased parasympathetic activity) were found.

With our work, we showed that a single-exercise high-intensity online approach is a feasible method that could be applied to manage quality of life in young adults during the pandemic era. To our knowledge, no studies assessing QoL used an only-burpees intervention. However, two studies (Sperlich, et al., 2017, 2018) used the SF-36 questionnaire before and after different HIIT body-weight interventions. In the first work, authors assessed the effects of two different 9-week interventions on overweight women, showing improvement in some quality of life dimensions, physical fitness (i.e. strength and oxygen consumption) and body composition (Sperlich, et al., 2017). The second study showed the effects of a 4-week mobile-based body weight HIIT on young adults (Sperlich, et al., 2018). The latter showed consistent results with our work regarding QoL, because it demonstrated that the 4-week intervention was effective on this variable (Sperlich, et al., 2018). In addition, the authors showed improvement in strength of young adults but not in cardiorespiratory fitness or body composition (Sperlich, et al., 2018). Also, Evangelista et al. (2019) showed that a 6-week body-weight HIIT protocol caused no variation in body composition (although it improved the push-up test). We found similar results on body composition. The short intervention period and the unrestricted participants' diet could have been two reasons behind this result. Only four weeks of HIIT burpees training, even though daily scheduled, is probably insufficient to generate body composition variations among young healthy adults. However, we have chosen this short-intervention period during this first pilot phase. Moreover, due to the energy expenditure of burpees (Ratamess, et al., 2015), it is predictable that, without diet restrictions, participants could have increased their daily food intake after workouts. Thus, body composition changes (i.e. a possible fat mass reduction) could have been somewhat hidden. The healthy condition of our participants could be another reason for these unexpected non-changes in body composition. Probably, for this reason, also non-significant changes were observed for postural control.

Despite the short duration of our daily burpees intervention, we saw a significant increase in the number of push-ups performed during a push-up test to exhaustion. These results are consistent with that shown in the aforementioned studies (Sperlich, et al., 2017, 2018). However, it was the only significant result obtained after the intervention period regarding functional strength. The other assessment on handgrip strength probably showed only non-significant changes because the specific skills required during this test are not trained by performing only burpees exercise (specificity principle) (Thomas, et al., 2021). These results are similar to those presented by McRae et al. (2012) that demonstrated that a 4-week Tabata intervention was effective on aerobic and muscular endurance of female participants, but not on grip strength. Moreover, due to the characteristics of burpees, it is quite reasonable to assume that the implementation was focused on the push-up and squat phases, non-emphasizing the jump elevation, in order to maintain a reasonable effort compared to the prescribed number of sets. Furthermore, due to the healthy condition of our sample, it is possible that after only four weeks of intervention changes in the height of the CMJ were more difficult to achieve, compared to inactive/overweight individuals (Sperlich, et al., 2017).

Only one work (Gist, et al., 2015) implemented a similar burpee intervention on army cadets and compared it to standard military training. They showed that a 4-week HIIT burpees training was effective to maintaining aerobic and anaerobic function of trained army cadets (Gist, et al., 2015). Moreover, the authors showed also that the level of performance in a specific army fitness test (comprised of push-ups, sit-ups and running) was maintained after the intervention (Gist, et al., 2015).

Lastly, despite our pilot design, we found preliminary promising results after our intervention among HRV variables. The analyzed variables seem to underline an increased parasympathetic activity (Electrophysiology, TFOTESCOCT-NASOP, 1996; Shaffer & Ginsberg, 2017). First, the direct control of the vagal nerve on the reduction of the heartbeats could have been increased considering that a significant reduction of the mean HR in bpm was found. Due to the high sensibility of our heart rate to external stimuli, this parameter alone is not sufficient to highlight an increased parasympathetic activity. Other time-domain variables underlined this variation. The RMSSD, calculated using NN interval differences, is strictly related to the vagal activity (Electrophysiology, TFOTESCOCT-NASOP, 1996), and its value showed a significant increase. Also, the TINN value, although usually analyzed during long-term (24h) assessments (Electrophysiology, TFOTESCOCTNASOP, 1996), displayed a significant increase. RMSSD and TINN results are consistent because they both derive from NN interval measures. No significant changes among frequency-domain variables were observed. However, it is important to note that the autonomous nervous system activity results from the sympathetic and parasympathetic activities that are not mutually exclusive but are balanced and active in different ways (Shaffer & Ginsberg, 2017). For this reason, our results showing no significant difference regarding the LF/HF ratio (a parameter that is expression of the two autonomous branches' balance) could be also consistent: an increased parasympathetic is not necessarily related to a sympathetic depression. This is also consistent with our sample characteristics, because it is plausible that in healthy young adults the two systems work in a stable balance (Electrophysiology, TFOTESCOCTNASOP, 1996; Shaffer & Ginsberg, 2017). However, it is important to consider that, as suggested by da Silva et al. (2015), taking into consideration the time-domain could led to safer interpretation in the analysis of chronic ANS cardiovascular adaptations to exercise. Notwithstanding, our results are consistent with those reported by Zaffalon Júnior, Viana, de Melo, and De Angelis, (2018) which have shown that active women present better HRV than sedentary women. Additionally, we also have shown that a single exercise 4-week protocol could be enough to target HRV improvements.

Regarding the cardiovascular assessments, we also found a significant DBP decrease but no significant difference in SBP. Acute BP reductions have been shown after resistance training sessions, with a greater reduction obtained with a greater exercise volume (Figueiredo, et al., 2015). However, we only noted a reduction in DBP and not in SBP. This result is more likely related to the session duration than exercise volume, since Cornelissen and Smart (2013) showed, in their systematic review and meta-analysis, that short exercise sessions (30-45') led to a significant DBP decrease but not to a significant decrease in SBP. However, SBP results are probably also related to our short-intervention pilot design.

This pilot study presents some limitations. First, we did not include an untrained control group in this pilot phase. Moreover, the small sample size and the short intervention period are to be considered in the interpretation of our preliminary results.

One strength of our study is the fully supervised online burpees intervention that led to a 100% adherence rate for the participants that were included in the analysis. Thanks to this approach, also the participant that did not come back for the post-test assessments completed all the exercise sessions. This confirms our hypothesis about the high adherence rate and feasibility of the protocol. Moreover, thanks to the online supervised approach, we were also able to implement a daily workout (five days a week) during the quarantine due to COVID-19 and this factor could have been crucial in the aforementioned variations. More studies, with a proper sample size and an untrained control group are still warranted in order to clearly determine the effects of our protocol.

In conclusion, our preliminary results suggest that a 4-week daily online burpees intervention is a feasible method that could improve young adults' quality of life, upper body strength and heart rate variability. This non-time-consuming approach could be easily administered to young adults to promote healthy living and counteract physical inactivity during COVID-19 quarantine period thanks to its feasibility, short duration, and low cost.

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