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Effects of 12 Weeks Whole Body Vibration Training on Long Covid Syndrome Symptoms – A Single Case Study

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Abstract

Background: More than 760 million people have been infected with COVID-19. Many of them have not yet recovered, although symptoms such as cough or fever have disappeared. They suffer from fatigue, depression, attention deficits and reduced motor performance. Exercise therapy has been well studied in various diseases that have similar symptoms, including Whole Body Vibration. Therefore, this study investigates an exercise intervention using Whole Body Vibration as a gentle therapeutic alternative to medication.

Materials and Methods: A 42-year-old female Long Covid patient underwent a training intervention on a vibration platform (12 weeks, 2 x/week 30 min, each set lasting 60 s with a rest between sets of 60 s). Investigated were depression (BDI-II), fatigue (FAS), attention (d2-test), and motor fitness before and after the intervention.

Results: Improvements in depression, fatigue and attention are visible as well as improvements in motor fitness parameters.

Conclusions: Whole body vibration seems to be a good alternative to improve Long Covid syndrome symptoms. For this, a pilot study should follow, comparing Whole Body Vibration vs. conventional training therapy vs. a control group. Such a study is on planning.

Keywords
Long Covid, Exercise therapy, Whole body vibration, Rehabilitation

1. Introduction

To date, over 760 million people have been infected with COVID-19. Nearly seven million people have died from or due to COVID-19 [1]. Many people continue to suffer after symptoms such as cough or fever have resolved, or symptoms persist for a very long time. Long covid refers to this persistent symptomatology over four to 12 weeks on the one hand, and post covid on the other hand, when it persists after 12 weeks [2].

The symptomatology of long covid syndrome is varied. The most common symptoms are fatigue associated with poorer physical performance, depression and concentration problems [3,4].

For the everyday life of those affected, this means that even elementary activities such as housework, shopping or working are severely restricted or no longer possible at all. They are quickly exhausted and need frequent breaks. For some patients, participation in the sense of the ICF is no longer possible [5]. The following figure 1 illustrates how Long Covid Syndrome affects the domains of the ICF.

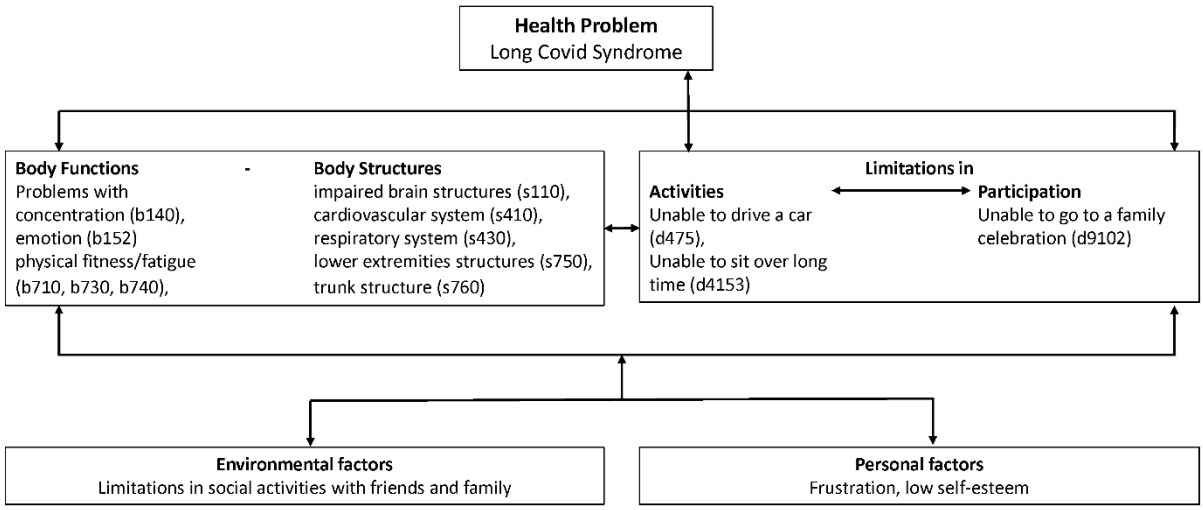

Figure 1. Meaning and impact of long covid syndrome in terms of ICF (adapted from [5])

Those who suffer from the health problem "Long Covid syndrome" show problems in concentration, emotions (depression), physical fitness and fatigue in the area of body functions. This is attributed to damaged body structures, in the area of brain structures, cardiovascular system, respiratory system, lower extremity structures and trunk. This affects activities, especially mobility. The patient is unable to drive a car. As a result, she/he is also limited in her/his participation, so she/he cannot attend a family party. She/he is thus limited in social activities with friends and family, which leads to frustration and lowers self-esteem.

Much research is being done in the field of conventional therapy, such as antiviral drugs, antibody treatment, or plasma therapy [6]. A review showed that there are no concrete studies on the efficacy of exercise therapy on symptomatology so far [7].

Exercise therapy has been well studied in many disorders that have depression, fatigue, cognitive, or motor deficits as symptoms: Carek et al. [8] state in their review that physical exercise is an effective alternative to medication for depressive and anxiety syndromes. Gujral et al. [9] demonstrate why exercise can help improve symptoms of depression. Some brain structures associated with depression could be positively affected by exercise, such as hippocampal volume and regional tissue density, prefrontal cortex, striatum, or white matter. A meta-analysis shows that exercise has a significant positive effect on fatigue in cancer patients [10], as well as another meta-analysis showing positive effects of exercise on fatigue in patients with multiple sclerosis [11]. It is concluded that exercise improves cognitive function [12]. Physical activity is thought to influence various aspects of cognitive mechanisms. The physiological mechanisms, such as increased cerebral blood flow, altered neurotransmitter release, structural changes in the central nervous system, and altered arousal levels, are due to physical changes that are a consequence of physical activity. Similarly, it is possible that physical training selectively increases angiogenesis, synaptogenesis, and neurogenesis. In addition, there are consistent data at the molecular, cellular, behavioral, and systemic levels supporting the notion that physical activity positively affects cognition [13]. Whole Body Vibration (WBV) is a gentle form of exercise therapy. It involves the patient standing or sitting on a vibration platform in a predetermined, standardized manner or performing strengthening or stretching exercises on the plate. There are different systems: vertical and sinusoidal vibrating plates. There are virtually no side effects, and few contraindications that need to be considered [14,15]. In the last 20 years, there have been numerous studies with different groups of patients suffering from depression, fatigue, or cognitive deficits, testing the efficacy of short- and long-term applications on improving motor skills. WBV was shown to have a significant positive effect on depression, anxiety, stress, and quality of life compared

to an exercise program without vibration [16]. A rat model is used to show why these effects of WBV on depression and stress could be achieved: it could reverse depressive-like behavioral disorders, inhibit neuronal degeneration, alleviate neuronal damage and pathological changes of glial cells, increase the expression of trophic factors, and improve the downregulation of dendritic and synaptic proteins after chronic stress. The effect could be achieved by decreasing neuronal degeneration in hippocampus and improving the expression of synaptic proteins. Here, it is concluded that WBV training has multifactorial benefits in depression, supporting its use as a promising alternative therapeutic option to improve depression-like behaviors [17]. Moretti et al [18] do not find any positive effects of WBV on fatigue in fibromyalgia patients, in contrast to Collado-Moreno et al [19] who consider that WBV has a positive effect on fatigue in this group of patients, but it depends on the duration of training and the type of vibration plate used, preferring the Galileo system. Wen et al [20] summarized in their review that WBV can improve cognitive functions, especially attention and inhibition, even with a short-term intervention. Positive effects of WBV on flexibility are also noted, although the improvements seem to depend on the amplitude and frequency used [21]. WBV can also improve coordination ability, which has been shown in patients with cerebral palsy [22]. Another review summarizes the significant positive effects on leg strength [23]. In addition, Gloeckl et al [24] showed in their review that WBV can significantly improve endurance performance in COPD patients.

As shown, exercise and especially WBV can improve depression, fatigue, cognition and motor fitness in various disorders.

So far there is no meaningful study that investigates WBV on Long Covid symptoms. However, the application is already recommended during treatment in the hospital [25].

For this, the present single case study wants to investigate the effect of WBV on the described Long Covid symptoms.

Hypothesis

A 12-week training program with WBV will improve physical fitness, concentration, depression, and fatigue in Long Covid syndrome.

2. Material and Methods

2.1 Sample of persons

One female participant, 42 years old, regularly physically active until corona infection in October 2020 (about five hours per week of housework and gardening, about two hours per week of walk with the family dog). She was hospitalized for two weeks for treatment of the infection. Concomitant diseases: Hypertension, obesity, and lipedema, 1.63 m tall, 95 kg. Long Covid syndrome was suspected by the primary care physician because she complained of constant fatigue, concentration problems, and aphasia.

2.2 Variable sample

BDI-II: Beck Depression Inventory, second edition. Here, a total of 21 questions are answered regarding pessimism, sadness, feelings of failure, loss of pleasure, self-worth, fatigue, energy, etc. Between 0 and 3 points are awarded per task. All points are added to a total score. A classification of the total score is made as follows: 0 to 13 points = no depression, 14 to 19 points = mild depression, 20 to 28 points= moderate depression, 29 and more points = severe depression [26]. The total score of the questionnaire is evaluated.

FAS: Fatigue Assessment Scale. The questionnaire consists of ten questions about physical and mental fatigue, tiredness, concentration, etc. The total score of the questionnaire is evaluated. Between 1 and 5 points are awarded for each task. All points are added up to a total value. A classification of the total score is made as follows: 10 to 21 points = no fatigue, 22 to 34 points = moderate fatigue, 35 to 50 points = extreme fatigue. A minimally important difference is given as 4 points or 10% change [27]. The total score of the questionnaire is evaluated.

D2 test: D2 test for measuring the ability to concentrate. The test consists of 14 test rows with "d" and "p", each with one to four small dashes at the top and/or bottom. For each row, the respondent has 20 seconds to circle as many "d"s with 2 dashes. For the 40- to 60-year-old age group, a GZ (total number of items processed) of 340 or an F% (proportion of errors) of 17.4% with a SW (standardized value) of 87 is classified (corresponding to the 10th percentile), a GZ between 366 and 392 or an F% between 17.3% and 8.9% with a SW between 90 and 93, a GZ of 453 or an F% of 4.7% with a SW of 100, a GZ of 506 or an F% of

2.5% corresponds to a SW of 106, a GZ between 541 and 567 or an F% between 2.4 and 1.1% corresponds to a SW of 110 to 113, a GZ of 628 or an F5 of 1.0% corresponds to a SW of 120 [28]. Total number of items processed (GZ), correctly solved items (R), incorrectly solved items (F), proportion of errors (F%), total number minus errors (GZ-F), and standardized value (SW) are evaluated.

Motor fitness test: Testing of motor abilities (fitness) with the tasks hop run, ball grasping, ball throw with rotation, figure-eight circles in one-leg stand, walking backwards (coordination), sit-ups, push-ups, standing long jump (strength), shouldering out, stand & reach (flexibility) and 2 km walking (endurance). With the exception of walking, the subject has two attempts at each task. The items are scored according to age and gender [29]. The raw scores and age- and gender-normalized scores of the tasks as well as the total score are evaluated.

2.3 Treatment sample

Training twice a week for 30 minutes over a period of 12 weeks with a vibration plate (Galileo Med Advanced). A frequency of 20 Hz was applied with a set length of one minute followed by a set break of one minute. The exercises (number of sets, static/dynamic) were increased in the course of the weeks according to the personal feeling of the test person as follows: In the first training session, two sets were performed in a hip-width stance with slightly bent knees for familiarization. This was followed by one set each of static squat position (hip-width stance, mark 1.5), static sit-up position, static push-up position (hands shoulder-width, mark 2.5, arms slightly flexed). From the fourth week, the number of sets was increased to two for all exercises. From the eighth week, all exercises were performed dynamically. From the ninth week, the number of sets was increased to three for squats, sit-ups, and push-ups.

3. Results

The test person tolerated the intervention well. On two of the sessions, she felt that during the standing application, her ankles became hot and itchy. This could be an unwanted side effect, if applicable. In addition, a positive side effect occurred, namely that the lipedema on the upper arms and thighs was reduced. The circumference of the upper arm was reduced by three cm and that of the thigh by five cm. During these 12 weeks, she lost 3 kg of weight.

The following table 1 provides an overview of the results in pre- and posttest in BDI-II, FAS, D2 test and motor fitness test.

Table 1. Results in pre- and posttest of the Beck Depression Inventory BDI-II, Fatigue Assessment Scale FAS, d2-Test (GZ = total number of processed items, R = correctly solved items, F = incorrectly solved items, F% = error percentage in %, GZ-F = tot

Variables	Pretest	Posttest	Change
BDI-II	24	17	-7
FAS	44	25	-19
D2 GZ	389	485	+96
D2 R	133	148	+15
D2 F	29	52	+23
D2 F%	7.46	10.72	+3.26
D2 GZ-F	360	333	-27
D2 SW	92	103	+11
Hop run RV (number of correct hops)	5	5	0
Ball grasping RV (number of correct grasps)	5	5	0
Ball throw with rotation RV (number of correct rotations)	0	1	+1
Figure-eight circles RV (number of correct eights)	5	5	0
Walking backwards RV (m/s)	0.34	0.39	+0.05
Stand & reach RV (cm)	-2	2	+4
Shouldering out RV (cm)	Not possible	65	+65
Sit-up RV (number of correct sit-ups)	4	6	+2
Push-up RV (number of correct push-ups)	4	9	+5
Standing long jump RV (cm)	95	115	+20
2 km Walking RV(min)	24:23	20:38	-3:45
Hop run SV	1	1	0
Ball grasping SV	1	1	0
Ball throw with rotation SV	0	1	+1
Figure-eight circles SV	1	1	0
Walking backwards SV	2	3	+1
Stand & reach SV	1	2	+1
Shouldering out SV	0	2	+2
Sit-up SV	0	0	0
Push-up SV	0	1	+1
Standing long jump SV	0	2	+2
2 km Walking SV	0	0	0
Fitness Total Value	3	10.33	+7.33

There are both decreases in values (BDI-II, FAS, D2 GZ-F, and 2 km walking RV), increases in values (D2 GZ, D2 R, D2 F, D2 F %, D2 SW, ball throw RV and SV, walking backwards RV and SV, shouldering out RV and SV, stand & reach RV and SV, standing long jump RV and SV, sit-ups RV, push-ups RV and SV, and total fitness value). Some values show no change (hop run RV and SV, ball grasping RV and SV, figure eight circles RV and SV, sit-ups SV, and 2 km walking SV).

4. Discussion

The test person showed an immense reduction of seven points in the BDI-II. This symptom has thus improved from a medium to a light status, and in total about 30 % of the raw value. This is consistent with the findings of Chawla et al. [16] who show a significant positive effect of WBV on depression.

In the FAS, an immense reduction of nineteen points can be observed. In the pretest, the result is to be classified as extreme fatigue, in the posttest as medium fatigue [27]. Thus, this symptom has also improved about 43 % concerning the raw value. This result is consistent to Collado-Moreno et al. [19] who are in the opinion that WBV has a positive effect on, depending on the duration and the vibration plate used, favoring the Galileo system.

In the D2 test, 96 more items were processed in the posttest and 15 more were solved correctly. The error rate has thus increased by 3.26 %. The total number minus errors has not improved and the classification of the standard value has risen from the 5th quintile to the 4th quintile [28]. Thus, it can be assumed that the concentration performance has partly improved. It seems that only the processing speed has increased, i.e., more items were processed, but also more errors were made. This is consistent with the findings from Wen et al. [20] who summarize in their review that WBV can improve cognitive functions, especially attention.

In the area of physical fitness, many improvements can be found in the raw values for nearly all test items, excepting ball grasping and hop run. Here, the maximum value was already reached in the pretest.

With an age of 42 years, the test person is in the range of middle adulthood, which is characterized by a decrease in motor performance if no training takes place [30]. There is a clear difference between exercisers and non-exercisers in coordination and flexibility [31]. The improvement in flexibility is consistent with the findings by Fowler et al. [21], as well as the improvement in coordination to Duquette et al. [22]. Even if no specific flexibility exercises were performed on the vibration plate, the flexibility improved. This could possibly be related to the fact that the vibration loosened the muscles and made them more elastic.

The trunk strength has improved significantly, for abdominals about 50 %, for upper arms/chest more than 100 %, and for legs about 21 %. This was to be expected, since exactly these muscle groups were also trained. In middle adulthood, strength continues to decline, although this decline can be slowed, or even prevented or reversed, through regular training [32]. Strengthening exercises not only strengthen the muscles themselves, but also increase self-confidence, body awareness, and confidence in movement [30]. The improvement in strength is consistent to the findings by Osawa et al. [23]. Nevertheless, the abdominal muscles in particular are still very weak, which the patient must continue to work on.

There is an improvement in the 2 km walking of 3:45 min. This is consistent to the findings by Gloeckl et al. [24] who show an improved endurance capacity. However, this improvement could also have been due to an increase in strength in the leg muscles, as no specific endurance exercises were performed, but the focus was on strengthening exercises.

In comparison with a recent single case study using WBV once a week, many results are in the same direction. Improvements are found in both test persons in BDI-II, FAS, D2-GZ, D2-R, D2-SW, as well as in the raw values of walking backwards, stand & reach, shouldering out, sit-ups, push-ups, 2 km walking and total fitness value. All raw values in hop run, ball grasping and figure eight circles show no changes. The values for D2-F, and D2-F% show an improvement in the patient with once-a-week training and a deterioration in the patient with the current study. This could be related to the fact that the test person in the first study has been able to work again for some time, while the test person in the current study has been on sick leave for five months and will not be able to work again in the near future.

Limitations: Since this is a single case study, the results should be treated with caution. It is possible that the test person would also have improved if the exercises had been performed without support from the vibration plate. Therefore, further studies must follow.

5. Conclusions

The present single case study was able to show that an improvement of depressiveness, fatigue, concentration and physical fitness in Long Covid syndrome is possible, even if an exercise session takes place twice a week. Therefore, a pilot study should follow to compare the effectiveness of one with two training sessions per week as well as a training condition without WBV. It seems to be important that the intensity is regularly adapted to the subjective condition of the test persons (individualization), or if the training leader determines that an increase in the number of sets or transition from static to dynamic exercises seems to be useful.

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