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To contrast and reverse skeletal muscle weakness by Full-Body In-Bed Gym in chronic COVID-19 pandemic syndrome

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Abstract

Mobility-impaired persons, either very old or younger but suffering with systemic neuromuscular disorders or chronic organ failures, spend small amounts of time for daily physical activity, contributing to aggravate their poor mobility by resting muscle atrophy. Sooner or later the limitations to their mobility enforce them to bed and to more frequent hospitalizations. We include among these patients at risk those who are negative for the SARS-COV-2 infection, but suffering with COVID-19 pandemic syndrome. Beside managements of psychological symptoms, it is mandatory to offer to the last group physical rehabilitation approaches easy to learn and self-managed at home. Inspired by the proven capability to recover skeletal muscle contractility and strength by home-based volitional exercises and functional electrical stimulation, we suggest also for chronic COVID-19 pandemic syndrome a 10–20 min long daily routine of easy and safe physical exercises that can activate, and recover from weakness, the main 400 skeletal muscles used for every-day mobility activities. Persons can do many of them in bed (Full-Body in-Bed Gym), and hospitalized patients can learn this light training before leaving the hospital. It is, indeed, an extension of well-established cardiovascular-respiratory rehabilitation training performed after heavy surgical interventions. Blood pressure readings, monitored before and after daily routine, demonstrate a transient decrease in peripheral resistance due to increased blood flow of many muscles. Continued regularly, Full-Body in-Bed Gym may help maintaining independence of frail people, including those suffering with the COVID-19 pandemic syndrome.

Key Words: skeletal muscle weakness; home-based Full-Body in-Bed Gym; older olds; borderline mobility impaired persons; COVID-19 pandemic syndrome.

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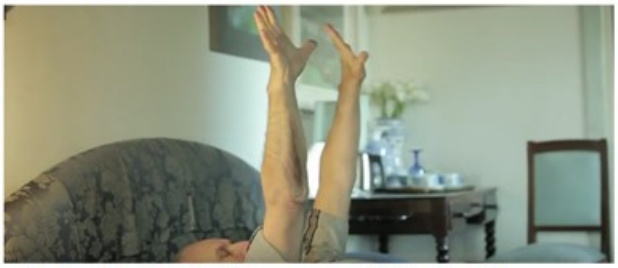
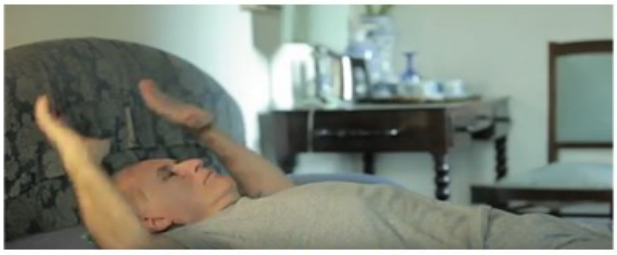
There are about 700 named skeletal muscles in the human body, including 400 that are important only for medical specialists. Better known are the roughly 200 skeletal muscles that are serious bone-movers, plus another 100 little muscles of hands, feet, and face. The aim of this report is to convince persons-in-need, and their practitioners, to counteract muscle atrophy-sarcopenia-cachexia, maintaining at their best function and shape of the majority of their body muscles.[1] Geriatric subjects, due to advanced age and/or associated diseases, spend only a short amount of time for daily physical activity. The consequent disuse muscle atrophy contributes to limit their independence ultimately enforcing them to bed and to hospitalization for long periods. Low mobility-related muscle atrophy is associated with neuromuscular weakness, functional limitations, thromboembolism, and high costs.[2-4] All


Exercise 1: Lying in bed, flex and extend your feet

Exercise2: Lying in bed, arms up and down. Notice the hands fully open or fully closed


Exercise 3: Lying in bed, cycling movements of legs



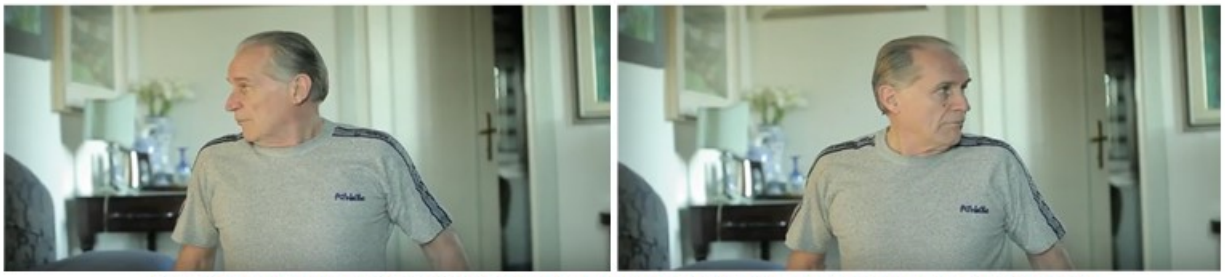

Exercise 4: Lying in bed, deep breathings, raising arms and open hands during inspiration


Exercise 5: Lying in bed, raising the pelvis and maintaining the up position for 2sec.

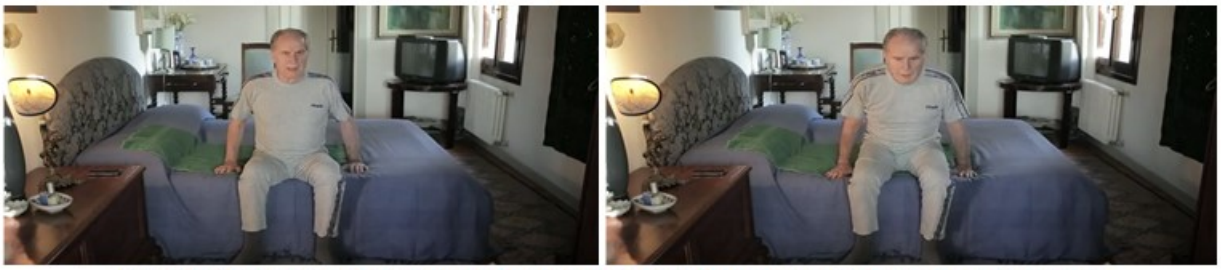
Fig 1. *The purpose of the routine is to contract all major skeletal muscles, alternating exercises to mobilize arms and legs, spine and neck, diaphragm and accessory ventilation muscles Duration of the routine (i.e., the number of repetitions and subsequently their speed of execution) must always reach the fatigue threshold.*

progressive muscle contractile impairments need permanent management. Besides eventual pharmacological treatment, a home-based physical exercise approach is helpful in counteracting muscle atrophy. Awaiting development of implantable devices for muscle stimulation, as effective as pacemakers for cardiac arrhythmias,[5] implantable stimulators for ventilatory supports,[6,7] or cochlear implants for hearing

Exercise 6: Lying in bed, lean forward. Notice the outstretched arms.



Exercise7: Sitting on the bed with your legs dangling, turn your head left and right



Exercise 8: Sitting on the bed with your legs dangling, lift your body up with your arms

Exercise 9: Sitting on the bed with your legs dangling, bend your head and trunk back and forth

Exercise 10: In a seated position, alternately raise one thigh and fully extend the leg.

Fig 2. *The aim of the routine is to contratc all main skeletal muscles, alternating exercises to mobilize arms and legs, spinal cord and neck, diaphragm and ventilation accessory muscles. Intensity of the routine (as number of repetitions and then speed) must be up to fatigue threshold.*

loss,[8,9] education of sedentary patients to perform home physical exercises could be an effective low-cost alternative during and after hospitalization.[10-12]

Cardiovascular and respiratory physical rehabilitation protocols of surgical patients are well established approaches, whose main goal is to reverse muscle weakness/atrophy.[13,14] We extended those routines to a

Exercise 11: Sitting on the bed with your legs dangling, fully rotate the head in the two directions

Exercise12: Sitting on the bed with your legs dangling, get up

Exercise 13: And get up on toes

Exercise 14: Lie down and get up slowly to avoid ruinous falls

Exercise 15: For active people only, push-ups performed as the last exercise. To increase its effectiveness, keep the down flexion until the sweat of the forehead is visible and collectable

Fig 3. *The aim of the routine is to contratc all main skeletal muscles, alternating exercises to mobilize arms and legs, spinal cord and neck, diaphragm and ventilation accessory muscles. Intensity of the routine (as number of repetitions and then speed) must be up to fatigue threshold.*

daily short (10–20 min) sequence of easy-to-learn and safe volitional physical exercises to be performed in bed (Full-Body in-Bed Gym) to improve muscles and, hence, mobility of impaired persons.

Chronic COVID-19 pandemic syndrome is characterized by the psychological response to the global problem of COVID-19 pandemic, and often by muscle weakness that negatively influences the quality of life of persons for

weeks or months before or after resolution of the infection.[15-17] This syndrome is believed to affect up to 10% of the population, because it could already be observed as an acute stress reaction to the spread of the SARS-CoV-2 infection. Certainly it changes in people the ordinary lifestyle for the forced lockdown measures imposed to control the epidemics.[18,19] However, the most severe responses are expected later on after recovering COVID-19. In this case the pandemic syndrome is similar to post-traumatic stress disorders. The problem is that pandemic syndrome will affect the working capacity of population even when economic recovery will be possible and essential. Adequate prophylaxis and management of the syndrome in high-risk groups are important for maintaining global mental health and economy. Beside pharmacological support and psychotherapy in the acute phases, it will be mandatory to prevent and control the mild cases by general prophylactic measures and healthy lifestyle, i.e., by normalization of sleep-wake schedule, by controlling dietary intake of vitamins and microelements and by inducing moderate physical activity. All these measures are important to maintain a good physical condition that improves body adaptive potentials and the immune system.

Here our contribution is to convince practitioners,[20-23] and the population at large that Full-Body in-Bed Gym is an option to be taken seriously, despite its apparent minimal requested effort.[10-12]

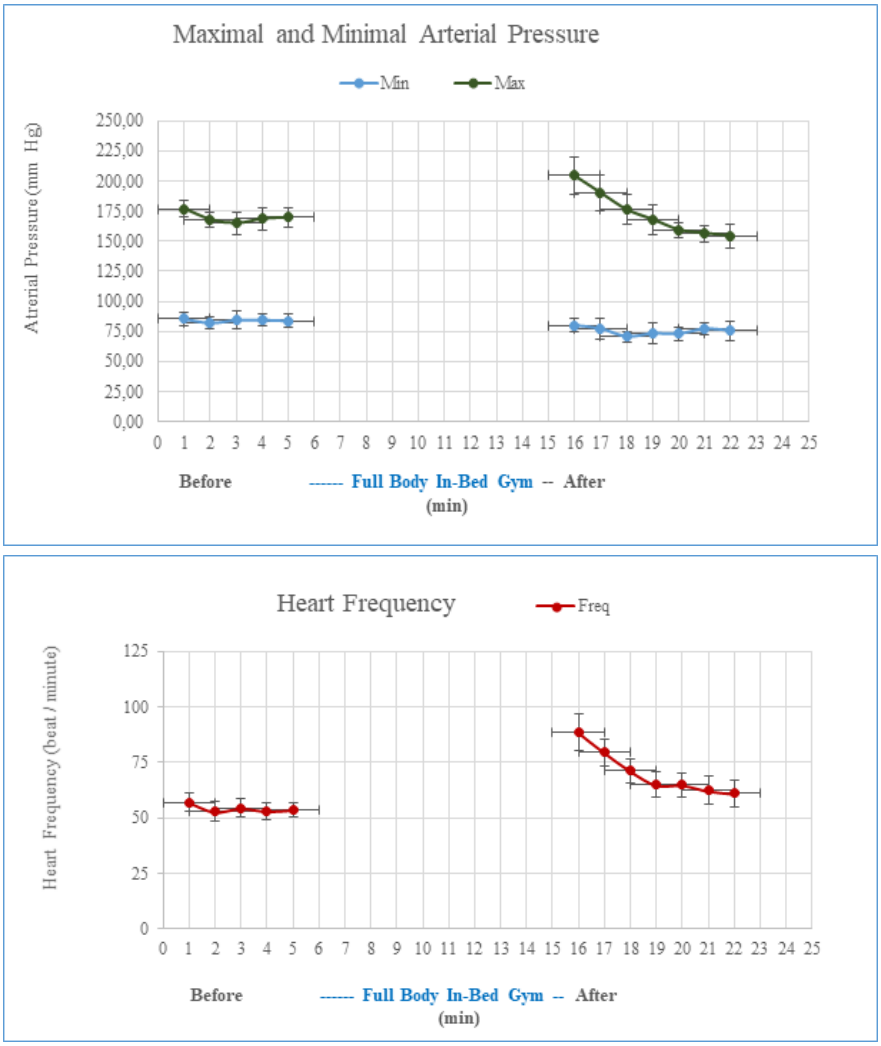


Fig 4. *Arterial pressure and cardiac frequency before and after 10 minutes of Full Body in-Bed Gym (25 repetitions of each exercise, including push-up) during seven consecutive days (November 8 to 14, 2016). Mean +/- SD. After a self-challenging routine, cardiac and ventilatory frequency increased together with the maximal, but not the minimal arterial pressure. Indeed, the latter is more related to peripheral blood resistance. The exercise-induced increase of blood perfusion of all the main skeletal muscle of the body occurs if the series of exercise reach the level of fatigue threshold.*

Suggested workout

In Figures 1, 2 and 3, the Exercises 1 to 14 show the routine that could be a seasonal warm up also for active persons (typically at early spring after a long winter to recover fitness for demanding physical activities), i. e, those able to make at least 20 consecutive push-ups in 3 min (Figure 3, Exercise 15). After advice of his/her family physician to avoid the very low risks of exercise pain and eventual muscle and joint damage, any sedentary people may start with five repetitions of each exercise. After one-two weeks of training, they may add groups of five additional repetitions, up to 30, every additional week. If compliant, even older olds will progressively increase their muscle strength, if they reach and maintain 15 or 20 daily repetitions. It is safer to start performing the exercises at very slow speed, but when the maximum number of each exercise is reached (15 or 20 repetitions), improving effects will be obtained by speeding up each exercise and thus increasing intensity.
The daily routine may last from 10 min (in the beginning) to 30 min (for complete session in accustomed persons). Figures 1, 2 and 3, show the exercises and the captions provide some details.
A video,[24] describes them dynamically: https://www.youtube.com/watch?v=N1RuG3371-Y&feature=youtu.be
If sedentary persons without major comorbidities, but with rest-related muscle weakness, avoiding much stress, challenge themselves in a few weeks of Full-Body in-Bed Gym may increase their muscle strength, fatigue resistance and independence in daily life activities.
Cautious Full-Body in-Bed Gym may help patients to recover earlier after hospitalization, decreasing the risk of thromboembolism after surgical interventions, and concurring to reduce eventual arterial hypertension.[25] Indeed, after a routine that challenge personal fitness, i. e., like inducing sweat to the forehead, increasing cardio-respiratory rates, and maximal, but not minimal blood pressure, in a few minutes the increased values return to the pre-exercise values, as the minimal arterial pressure. One example of those behaviors of the cardiovascular responses to a challenging series of a week of trainings are exemplified in Figure 4. There is strong evidence that peripheral arterial resistance decreased during the series of challenging exercises because blood perfusion is increased by relaxation of the perforating arteries of the main skeletal muscles of the body, i.e. for the systemic functional hyperemia of the main body muscles.[12]
Furthermore, Full-Body in-Bed Gym routine mitigates the bad mood that is usually associated to mobility limitations,[26,27] strengthening confidence of patient in recovering partial or total independence, and it reduces risks of accidental falls. Eventually, during hospitalizations the monitoring of the responses to challenging trainings could include oxygen saturation and many more fitness variables. Furthermore to speed-up positive changes, the trainings could be performed twice a day to improve fatigue resistance and cardio-respiratory reserve.[28,29] Wearable devices are an emerging and cost-effective technology that allows to monitor several biometric data,[30] and have been tested in many diseases.[31] It might be interesting to add one of these devices (e.g. smartwatches, fitbands, smartphones, etc.) which could represent a guide for the patient during workout (heart rate monitoring and oxyhemoglobin saturation, reminder to perform exercises every day, stopwatch for timing her/his workout.[32] In any case, during the initial learning period of Full Body In-bed Gym, all seniors, if not hospitalized, must be supervised by at least one trainer, if not a health professional to avoid harmful exercise. These, in fact, are linked to their fitness and, nothing to say, to comorbidities often present in elderly population. If elderly persons cannot, or are reluctant to perform volitional physical rehabilitation protocols, functional electrical stimulation may mimic those exercises and be almost equally effective.[33-41] As detailed in Kern et al., in 2014,[36] old persons may be exposed to regular neuromuscular electrical stimulation training. Stimulators for surface electrical stimulation (ES) that are especially suited for elderly people requirements were designed and implemented in Vienna, Austria.[42] These constant voltage stimulation devices can be safely applied during home use. Starting two times a week, for a total amount of 24 training sessions (3 × 10 minutes for each session) ES is safe and effective. The subjects ought to be instructed to increase the stimulation intensity until their maximal tolerance is reached. Using this approach a full knee extension is achieved in all subjects. The outcome is a significant increase in muscle strength, associated with an increase of fast muscle fibers, which are the first to respond to ES and are well related to the power of skeletal muscle. ES significantly increased the size of fast type muscle fibers, and the number of Pax7- and NCAM-positive satellite cells. Moreover, analyzed muscle biopsies did not presented signs of muscle damage and/or cellular inflammation.[36,43] Altogether, previous results demonstrated that physical exercise, either voluntary or induced by electrical stimulation, improves the functional performance of skeletal muscles, including those essential for ventilation, a main problem in COVID-19 patients. Indeed, it is worth noting that one of the most successful clinical application of skeletal muscles ES is the ventilatory support to person-in-need by pacing of a conditioned diaphragm in quadriplegia and beyond.[6,7,44-47] In conclusion, it is never too early and it is never too late to increase daily levels of volitional or FES-induced muscle contractions in aging and early-aging syndromes.[19-22] Full-Body in-Bed Gym could help patients suffering with mild cases to prevent chronic COVID-19 syndrome and to recover from weakening of skeletal muscles.

List of acronyms

COVID-19 - Coronavirus disease 2019
FES – functional electrical stimulation
SARS - Severe Acute Respiratory Syndrome

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Conflict of Interest

The authors declare no competing interests.

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