

Measurement of the Body Physical Parameters by Bioelectrical Impedance Method in Individuals Survived after Covid-19

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ABSTRACT

Objective: The coronavirus disease 2019 (Covid-19) has significantly affected human health around the world, causing many complications. However, it is not fully understood how the body compositions of individuals affected in the short or long term after disease. In this study, we aimed to show the effects of Covid-19 on body composition and phase angle values, using Bioelectrical Impedance Analyzer.

Methods: Subjects were selected from individuals in the 18-60 age group, who had survived COVID-19 disease. 33 individuals who had survived it 1-3 months ago, and 30 individuals who had survived it 3-6 months ago were included in the study.

Results: Effects of COVID-19 on basal metabolism and body composition and the ratio of damaged cells in the body after the disease were determined. Basal metabolic rate, lean body mass, body cell mass, total body fluid, intracellular fluid, and phase angle values were found to be significantly changed in the 3-6 months range compared to that of 1-3 months.

Conclusions: These results indicate that the basal metabolism and body composition parameters of the body become better, and the proportion of damaged cells decreases as time goes on after suffering COVID-19, reaching values close to normal in 1-3 months and quite better values in 3-6 months. It can be concluded that, although covid-19 influences body composition parameters and cell integrity in survivors of Covid 19 disease, these effects are limited to 3-6 months.

Keywords: Bioelectrical impedance analyzer, phase angle, coronavirus disease, fat mass.

INTRODUCTION

In December 2019, unknown viral pneumonia appeared in the Chinese province of Wuhan, which later turned into an epidemic that spread worldwide (1, 2). The Chinese authorities have identified a new type of coronavirus, called severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) (3). On February 11th, 2020, the infectious disease caused by this viral virus has been officially designated COVID-19 (Coronavirus Disease 2019) by the World Health Organization (WHO) (4). To date, COVID-19 has spread over at least 180 countries and caused the death of millions of people, and the World Health Organization has officially declared a pandemic of the viral disease COVID-19 (4).

According to the analysis of nearly 45,000 confirmed cases, 19% of the COVID-19 patients has been identified as severe cases and critical illness cases involving severe pneumonia and metabolic disorders, developing into acute respiratory distress syndrome (ARDS) and multi-organ disorder (5–8). In another study, basal metabolic rate (BMR) levels were measured, and BMR was observed to change in male and female migrant workers, quaran-

tined during the COVID-19 pandemic. However, no study has been conducted in the literature on the phase angle parameter, which gives the ratio of damaged cells in the body and physical strength of the body, as well as Basal Metabolic Rate and body composition values (body fat mass, muscle mass, extracellular fluid, intracellular fluid) in individuals who survived COVID-19.

In a study conducted in Shenzhen (China), obesity was associated with a 142% higher risk of developing severe pneumonia (9). The National Audit and Research Center for Intensive Care in the United Kingdom observed that 72.1% of confirmed COVID-19 cases were overweight or obese, and 60.9% of patients with a body mass index (BMI)>30 died in intensive care (10). Among the 4103 patients in New York City, BMI> 40 kg/m² was observed to be the second strongest independent predictor for hospitalization following old age (11). In a retrospective and single-centered study, evaluating 124 consecutive patients in France, 47.6% of the cases had obesity (BMI> 30 kg/m²) and 28.2% had severe obesity (BMI> 35 kg/m²). The need for invasive mechanical ventilation was associated with a BMI of 35 kg/m² (11). Previously,

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Figure 1. Significantly altered parameters were found between those who had the disease between 1-3 months and those who had it between 3-6 months.

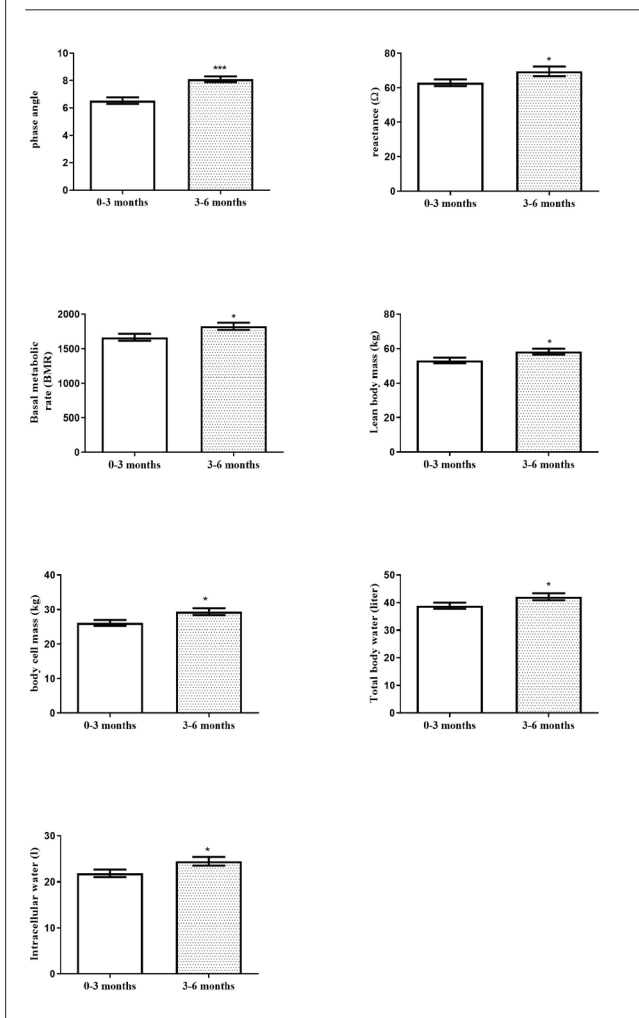
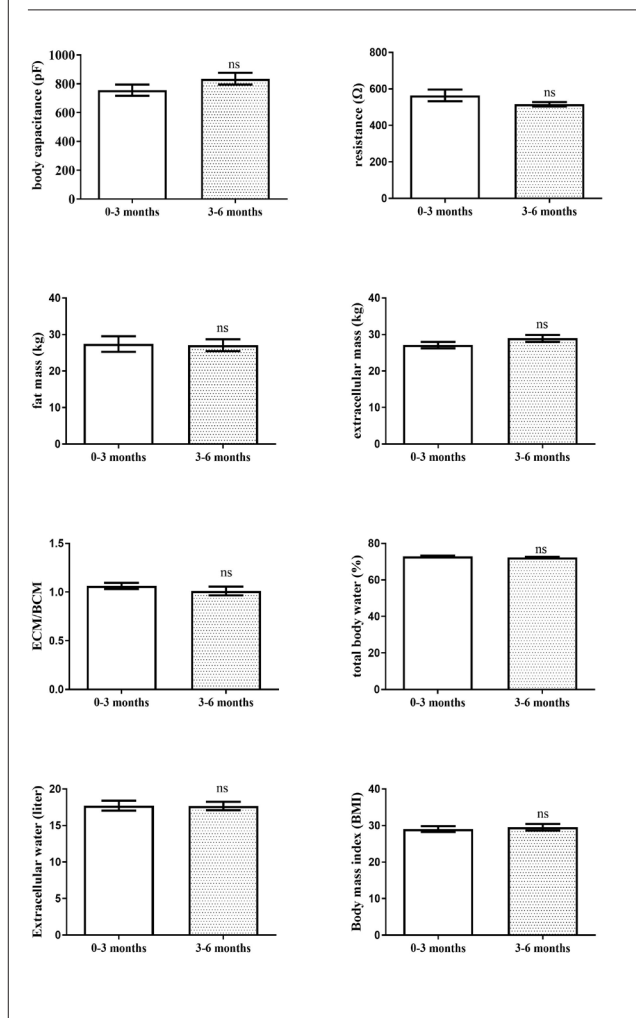


Figure 2. Parameters that did not change significantly between those who had the disease between 1-3 months and those who had it between 3-6 months.



numerous reports around the world have defined obesity and severe obesity as risk factors for hospitalization and mechanical ventilation in the H1N1 influenza virus (12).

An increased glucose level in a study in which data of mild and severe COVID-19 cases, as well as young children suffering from COVID-19, were analyzed to explore their metabolic changes and immune profiles. The increased glucose is partly due to the cells' reduced glucose consumption. This, in turn, indicates that the metabolism has changed. The findings show that acute respiratory distress syndrome (ARDS) I-III and glucose, lipid, uric acid, etc. metabolic disorders, even multiple organ dysfunction (MODS) and disseminated intravascular coagulation (DIC) is common in severe cases (13,14).

In one study, extraordinarily low serum uric acid was observed in severe cases [176µmol / L (IQR, 131-256)], and extremely low CD4 + T-cells and CD8 + T cells, but unusually high neutrophils [6.5 × 10⁹ / L (IQR, 4.8-9.6)] procalcitonin [0.27 ng/mL (IQR, 0.14-1.94)], C-reactive protein [66 mg/l (IQR, 25-114)] and extremely

high interleukin-6 levels were observed in the late stages and in severe cases of COVID-19. Diabetes comorbidity was observed in three patients, and high blood glucose was observed in 18 patients who had no diabetes mellitus [7.4 mmol/L (IQR, 5.9-10.1)]. In severe cases (71%), glucose was found in the urine and urinary ketone in nine (43%) out of 21 patients. The increased glucose was partly due to the cells' reduced glucose consumption. The findings suggest that severe cases have acute respiratory distress syndrome (ARDS) I-III and glucose, lipid, uric acid, etc. metabolic disorders, even multiple organ dysfunction (MODS) (15).

Regarding the immune response, there is a clear, and innate association between obesity and chronic inflammation, which can alter adaptive immune responses and make the immune system more vulnerable to infections. Obesity is associated with low-level inflammation due to adipocyte hypoxia and dysfunction. This, in turn, results in a strong secretion of pro-inflammatory cytokines such as tumor necrosis factor α (TNF-α), interleukin (IL) 1β and interleukin 6, as well as adipokines, which leads to the aggregation of immune cell macrophages, T cells, and B cells (16).

The aim of this study is to determine the physical strength of the body, basal metabolism change, body composition change, and damaged cell ratio by measuring all these parameters.

METHODS

In this study, parameters such as phase angle, which gives the ratio of damaged cells, basal metabolism, and body composition values (body fat mass, muscle mass, extracellular fluid, intracellular fluid) were determined by measuring through BIA (Bioelectrical Impedance Analyzer, BIA-450) in individuals who had COVID-19 infection. Subjects were selected from individuals in the 18-60 age group, who had survived COVID-19 disease 1-3 months and 3-6 months ago, 33 individuals who had survived it 1-3 months ago, and 30 individuals who had survived it 3-6 months ago were included in the study. The study groups were composed of different individuals. The measurement is performed by connecting an electrode to one hand and one foot of an individual. The measurement takes about one minute, and nothing is administered to the patient, and the BIA shows the results digitally in real-time. This study was approved by Gaziantep University Medical School Medical Ethics Committee with the decision numbered 2016/276 (Date: 17 October 2016, Protocol Number: 276) and supported by Gaziantep University Scientific Research Projects Unit (TF.DT.17.11).

The BIA technique measures the whole-body impedance, that is, the body's resistance to an alternating current consisting of two components: resistance (R) and reactance (Xc). The resistance refers to the voltage drop caused by conduction through ionic solutions. Reactance refers to the delay of the current flow, which is measured as a phase shift, reflecting the dielectric properties of cell membranes and tissue interfaces. The most commonly used and clinically relevant impedance parameter obtained with BIA is the phase angle. In the past, the measurement of the phase angle has been applied to many clinical settings with evidence of good reliability as a marker of nutritional status and a predictor of poor clinical outcomes (17). However, changes in hydration and obesity have been shown to limit the reliability of phase angles in everyday clinical practice (18).

Statistical Analysis

Graph Pad Prism Software had been employed for statistical analyses. Differences between means were expressed by Student's t-test. All results were expressed as means \pm standard error of mean (SEM). Statistical differences were set at $p < 0.05$.

Main Points:

- It has been observed that Covid-19 disease significantly affected the percentage of healthy cells in the short term and in those who survived after disease.
- Covid-19 drastically changed the basal metabolism, body resistance, body cell mass and phase angle values in short-term.
- It has been found that these devastating effects of the Covid-19 are only short-term, and that whole-body composition parameters returned to normal in the long term.

RESULTS

Effects of COVID-19 on basal metabolism and body composition, and the ratio of damaged cells in the body after the disease were determined. Basal metabolic rate, lean body mass, body cell mass, total body fluid, intracellular fluid, and phase angle values were found to be statistically significantly increased in 3-6 months compared to that of the 1-3 months' range (Figure 1 and 2).

These results show that the basal metabolism and body composition parameters of the body become better, and the proportion of damaged cells decreases in time, after suffering COVID-19, reaching values close to normal levels in 1-3 months and much better levels in 3-6 months (Figure 1 and 2).

DISCUSSION

At the first encounter with a new pathogen, the energy requirements of the immune system of an individual increase significantly. For every 1 °C increase in body temperature, a more than 10% increase is seen in metabolic rate. Then, the activation of adaptive immunity leads to rapid and extensive cell growth, and the proliferation of virus-specific T and B lymphocytes, which intensifies energy metabolism in the cells according to their sizes (19).

Immune cells also need the energy to perform various special effector functions, such as migration, phagocytosis, etc. In total, the total energy cost of the entire immune system in a motionless state is approximately 20% of the daily average of the total metabolism rate at rest, whereas inflammation may lead to a 25-60% increase in energy consumption associated with the immune system (from mild inflammation up to sepsis) (20, 21). Physical fitness is necessary for our body to perform various daily activities properly and not to get sick easily. However, if the case of consumption of unbalanced foods, problems will arise and certainly increase the risk of becoming overweight. The level of energy needs is measured using the basal metabolic rate (BMR) method. Individual BMR is affected by some factors, such as body weight and gender (FAO, 2001). Basal metabolism is the minimum energy that an individual must have in order to maximize the basic functions of the body. Regarding the proper food intake, excess weight is triggered by unbalanced consumption of foods, such as high fat, plenty of carbohydrates, and low fiber, without a balanced expenditure of energy, such as physical activities. A person with a BMI (Body Mass Index) of more than 23 (23 - 24.9) is classified as overweight. On the other hand, according to the Asia Pacific criteria (P2PTM, 2018), a BMI value above 25 (> 25) is considered obesity. The WHO 2020 data show that more than 1.9 billion adults aged 18 and over were overweight, and more than 650 million of them suffered from obesity in 2016 (22).

Physical exercise is the best alternative natural treatment to increase body immunity against the COVID-19 virus. This virus is known to attack the immune system of the body. It is expected that physical exercise can increase immunity NSCA (2020). Performing outdoor sports carries a great risk of spreading COVID-19. However, it can still be performed by the protocol. An appropriate physical activity is necessary to increase immunity against COVID-19 (23).

Adequate physical activity will have a good relationship with the nutrients absorbed by the body. It has also been revealed that the immune function during obesity is associated with impaired immune response, which leads to excessive adiposity (24).

The physical activity and physical fitness performed are closely related to the bodyweight, which is associated with food intake. If the food intake into the body is not consumed through physical fitness and activity, it will probably result in obesity or overweight, which will negatively affect health (25). The habit of an individual to engage in physical activity is a method of improving his/her immune system or immunity. Performing a physical activity can promote a healthy lifestyle and promote healthy behaviours in society (27). As for the BMR values, the average calorie for the basal activities during the COVID-19 quarantine period is 1669 kcal/day for men and 1335 kcal/day for women. In a study on migrant workers, individuals were allowed to perform physical exercise during the quarantine period, and the average calorie burnout during the 14-day COVID-19 quarantine was found to be 2595 kcal/day for men, and 2031 kcal/day for women. The findings show that physical activity performed for immunity against bacteria and viruses also strengthens the body and will be important in protecting against viruses (26).

The immune system is an important factor against the physiological functioning of bacteria, viruses, and foreign substances through a complex and multi-layered mechanism. The human immune system has two parts, the adaptive and acquired immune systems. The immune system is also affected by nutrition, psychological factors, environment, physical exercises, or activities (27).

In cases of immediate danger (real or imaginary), the central nervous system can also have profound immunosuppressive effects through bioenergetic limitation. The psychomotor activity caused by acute psychological stress, sleep disturbance, pain, and anxiety can cause additional energy consumption of up to 30% of the basal metabolic rate (28). Fear of being infected by an “invisible virus”, feeling helpless and isolated in pandemic conditions can also contribute to immune dysregulation (28).

In general, the energetic, structural, regulatory, and psychological negative factors can critically limit the ability of the immune system to remove the infection. Gradual energy depletion leads to functional depletion of immune cells and, ultimately, cell death (lymphopenia). Similarly, disruption of immune function is characteristic in chronic infections, autoimmune diseases, and oncological diseases, but this occurs over much longer periods (29).

In the COVID-19, the inability of the adaptive immunity to take control of the infection quickly causes uncontrolled viral spread, which in turn leads to secondary pathological hyperactivation of innate immunity (cytokine storm), acute respiratory distress syndrome, acute injuries in the heart, kidney, and other organs. So far, there are only a few studies investigating the body composition and prognostic relationship in hospitalized COVID-19 patients (29).

One study found that a lower phase angle in the care unit increases the likelihood of severe COVID-19 (22). Another recent study reports that the low phase angle ($<3.95^\circ$), which was determined by BIA, is an important predictor of mortality regardless of age in hospitalized COVID-19 patients (median age 69, IQR 59-71) (23). On the contrary, in a retrospective study of 90 hospitalized COVID-19 patients (mean age 65 ± 14 years), a low phase angle was not found to be associated with longer hospitalization, or intensive care unit admission and death (24). In our study, the phase angle was associated with an increased risk of death at 60 days in a univariate model, but the statistical significance disappeared after the adjustments made for age and gender. The phase angle is directly associated with lean body mass (LBM) and body cellular mass (BCM) but is inversely proportional to extracellular water (ECW) and intracellular water (ICW) in healthy adults (13). Disease-related malnutrition is characterized by an early shift of fluids from the ICW to the ECW cavity, an increase in ECW/ICW, and simultaneously a decrease in BCM and phase angle (29).

The changes in the physical resistance of the body, body fluid mass, body fat mass, basal metabolic rate, and damaged cell rate in individuals who have survived this disease are also of great importance.

CONCLUSION

In this study, basal metabolism, physical resistance of the body, body fat mass, intracellular and extracellular fluid mass, and damaged cell levels were investigated in individuals who had survived COVID-19. If there are significant deviations from the normality, its course over time is important. Therefore, they were investigated in this study. Parameters such as basal metabolism rate, reactance (cell membrane resistance), total body water, intracellular water, lean body mass, body cell mass were found to be significantly increased in patients who had COVID-19 1-3 months ago compared to those who had COVID-19 3-6 months ago. The phase angle parameter, which indicates the ratio of damaged cells, was also found to be increased. An increase in the phase angle indicates a decrease in the number of damaged cells. A phase angle value of $6-8^\circ$ indicates very few damaged cells, $8-10^\circ$ indicate no damaged cell and $3-6^\circ$ indicate many damaged cells. This study shows that the parameters have improved over time, the physical resistance of the body has increased over time, and the proportion of damaged cells has decreased significantly.

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Conflict of interest: The authors declare that there is no conflict of interest.

Authors' contributions: Conception: CS, ŞK; Design: CS, ŞK; Materials: YG; Data Collection and/or Processing: YG; Analysis and/or Interpretation: CS, YG, ŞK; Writing: CS, YG, ŞK; Critical Review: CS.

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