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MONITORING THE DYNAMICS OF THE STATE OF A 64-YEAR-OLD MAN WITH COVID-19 BASED ON SMART WATCH DATA

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Abstract

Introduction: The variability of the clinical course of COVID-19 and the variety of the "geography" of its complications actualize the issue of monitoring and assessing the dynamics of the patients' condition for the most effective therapy and rehabilitation. Smart devices that track a number of physiological parameters allow you to monitor the health status and the course of the disease.

Case description: We present a case of a past viral infection (COVID-19) in the aspect of assessing the dynamics of the patient's condition and the effectiveness of treatment by resting heart rate and the total index of motor activity using smart watch. The patient was a 64-year-old man with a history of hypertension, atherosclerosis, type 2 diabetes mellitus and myocardial infarction. On certain days of viral infection, glucose levels, blood oxygen saturation, blood pressure and body temperature were measured. The patient was prescribed Ingavirin, Vitamins C and D, Doliprane, Azithromycin, Moxicin, Xarelto and Dexamethasone.

Results and discussion: It was revealed that the dynamics of the clinical course showed the strongest correlation with resting heart rate and total index of motor activity. Resting heart rate demonstrated a very high sensitivity, also changing in response to stress factors. Thus modern smart devices are able to provide information about the COVID-19 clinical course and the effectiveness of therapy.

Keywords: *COVID-19, smart watches, health monitoring, resting heart rate, total index of motor activity*

Introduction

Currently, with the development of technology and the miniaturization of circuit solutions, personal smart devices that monitor a number of physiological parameters are becoming widespread in clinical practice [*Lu L et al., 2020; Bayoumy K et al., 2021*]. The minimum standard capability of smart devices is the registration of heart rate by photoplethysmography and monitoring of physical activity by measuring the number of steps due to the built-in gyroscope and accelerometer. Initially, the purpose of smart trackers was to monitor physical activity and assess the level of fitness. Nowadays, Internet, telemedicine and wireless communication technologies allow the use of wearable individual smart devices for a wider range of tasks [*Rubel P et al., 2004; McAdams E et al., 2011; Lo Presti D et al., 2019; Naranjo-Hernández D et al., 2020*]. Thus, a number of projects (the Health ePeople study, the Stanford

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Azumio Activity Inequality study, the Google Baseline Project, MyHeartCounts, etc.) focus on assessing the possibility of preclinical detection of deviations in human functional parameters with the prospect of a global change in the paradigm of medical care from reactive to proactive [*McConnell MV et al., 2017; Tison GH et al., 2018; Dunn J et al., 2018;*]. Moreover, wearable smart devices can promote faster provision of medical care in hospitals, at home or in the field [*Rubel P et al., 2004; McAdams E et al., 2011*].

The variability of the clinical course of COVID-19 (from mild to critical), the variety of the "geography" of its complications, covering many organs and systems, including the respiratory, cardiovascular, nervous systems, etc. [*Kriz C et al., 2020; Russo V et al., 2020; Silva Andrade B et al., 2021*], the unstable protocol for the treatment of patients with COVID-19 actualize the issue of monitoring and assessing the dynamics of the patients' condition for the most effective therapy and rehabilitation and, as a result, the modernization of the treatment protocol.

We present a case of a past viral infection (COVID-19) in the aspect of assessing the dynamics of the patient's condition and the effectiveness of treatment by resting heart rate and the total index of motor activity using smart watch.

Case description

The patient was a 64-year-old man with hypersthenic type of constitution, a BMI of 36 and a history of hypertension, atherosclerosis and type 2 diabetes mellitus. In 2014, he suffered a myocardial infarction and two stents were placed in the coronary vessels. Since 2014, he has been taking oral Aspirin (81 mg), Zocardis (15 mg), Liprimar (10 mg) and Metformin (500 mg twice a day).

From October 19, 2020, in the first 3-4 days, the patient had non-specific signs of general malaise, namely, a slight dry cough, increased fatigability, performance decrement. On October 22 (day 4), the therapist prescribed Vitamins C and D, Ingavirin and Doliprane orally to prevent pain and high fever. All prescriptions of medication are presented in the lower part of Figure 1. Glucose levels, blood oxygen saturation, systolic and diastolic pressure, body temperature measured on certain days of viral infection are shown in the middle part of Figure 1. Throughout the disease, the patient was wearing smart watch, not removing it during a sleep.

From day 5 (October 23), worsening of all the above manifestations and moderate headache, muscle and joint pain, hyperhidrosis, asthenia and, as a result, a significant decrease in motor activity were observed. On day 7 the patient's temperature was 37.9°C and he suffered from a lack of appetite. However, there was no smell and taste impairment. On October 26, the doctor prescribed Azithromycin. The next morning the patient took a PCR test for SARS-CoV-2. At the test site, the patient had a short-term episode of a transient collaptoid state with an acute depression of muscle tonus, peripheral vasospasm, cold sweat, and a marked increase in heart rate. A PCR test for SARS-CoV-2 was positive (day 10). On October 29 (day 11) computed tomography (CT) of the lungs was performed at the clinic, where the patient had the second episode of a transient collaptoid state. According to the conclusion of multislice CT, the percentage of lung involvement was about 30-35% (Fig. 2).

As the October and November 2020 fell on the peak of the COVID-19 epidemic in Armenia, there were no places in specialized hospitals. The treatment was organized at home with the possibility of remote consultation with the doctor of the COVID clinic. From October 30 (day 12) the doctor increased the dose of Vitamin C to 1500 mg per day and prescribed the second antibiotic Moxicin (400 mg i.v.) and Xarelto (10 mg twice a day orally). On this day, oxygen saturation measured by a pulse oximeter was 86%. After connecting the oxygen concentrator, the saturation increased to 90-91%. The oxygen concentrator was used for short sessions (up to 25-30 minutes) 7-10 times a day. From November 6 (day 19), the patient received intravenous injections of Dexamethasone (8 mg) for 4 days, and then intramuscular injections with a gradual dose reduction until November 15.

Discussion

As a result of a retrospective assessment of all the parameters provided by smart watch, we have identified two of the simplest, but sensitive and correlated with the dynamics of the patient's condition: the total index of motor activity (TIMA), which is the number of steps per day, as well as resting heart rate (RHR), calculated in intervals in

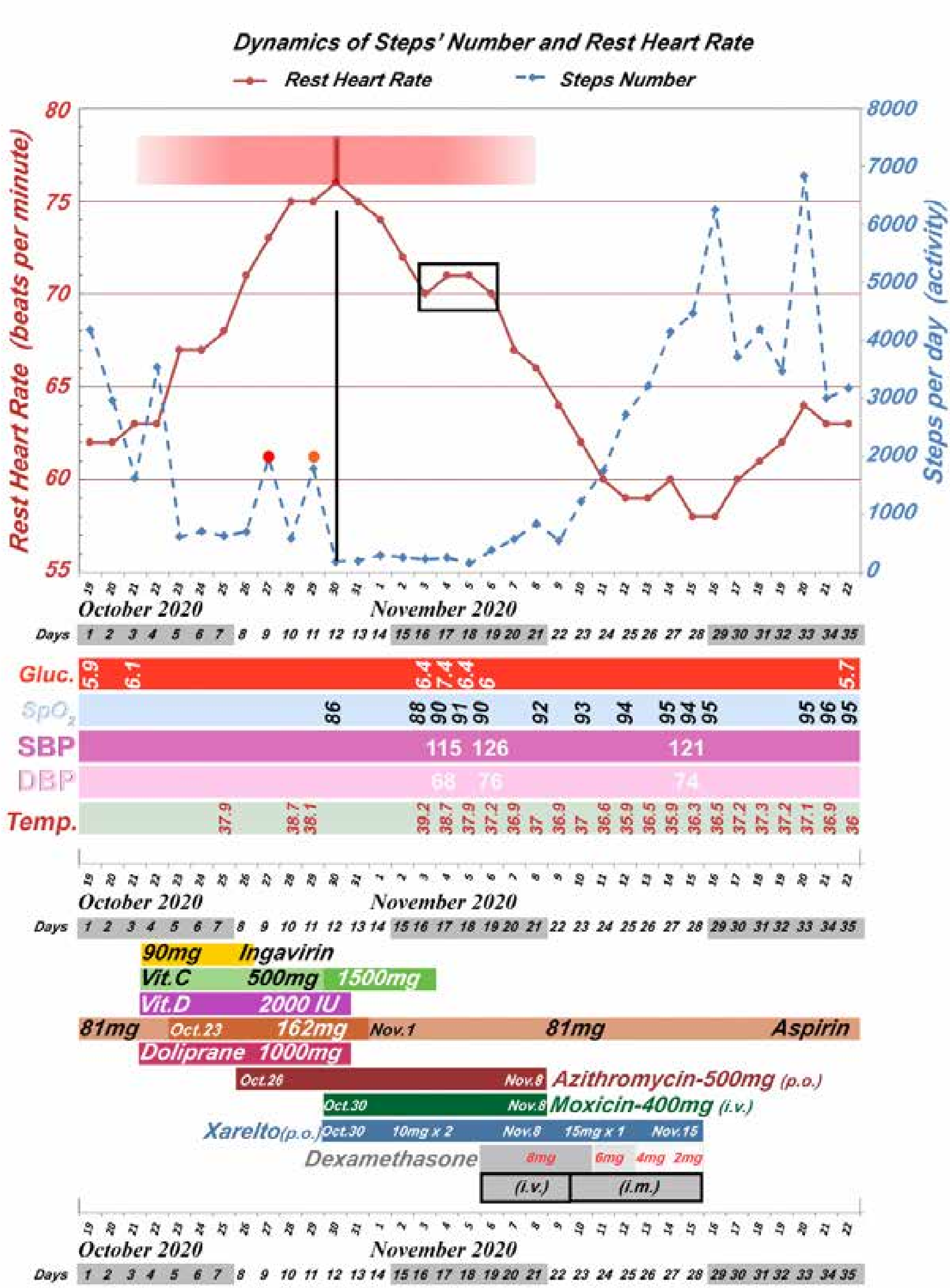

Figure 1. Synchronized imaging of the dynamics of resting heart rate, RHR and the total index of motor activity, TIMA (curves in the upper part of the figure), glucose levels (Gluc.), blood oxygen saturation (SpO_2), systolic (SBP) and diastolic (DBP) pressure, body temperature (Temp.) (middle part of the figure), and medications regimens (lower part of the figure) during COVID-19. X-axis: date (day, month) and day of disease, Y axis: on the left – RHR, on the right – TIMA. On the graph, a vertical line between the period of an increase (negative dynamics) and a decrease (positive dynamics) in RHR. The part of the curve, taken in the frame, corresponds to the psychological stress.

which motor activity is not recorded according to the accelerometer and gyroscope data.

The graph of the TIMA dynamics (upper part of Figure 1) shows a progressive decrease in the total number of steps per day to below 600 steps during the first 4-5 days already from the first day of observation (October 19). A sharp increase in this parameter on October 22, 27 and 29 is due to the forced relatively high motor activity: visits to the therapist (the 1st marked peak), diagnostic COVID center (the 2nd marked peak) and clinic for a lung CT scan (the 3rd marked peak). The described changes in motor activity were accompanied by a continuous increase in RHR values from 62 bpm (October 19) to 76 bpm (October 30) (Fig. 1).

At the same time, the heart rate (HR) increased inadequately (hyperreactivity) even in response to minimal physical activity, which is natural in conditions of marked dehydration and water-electrolyte imbalance. For this reason, and taking into account the possible decrease in systemic blood pressure in the conditions of a "cytokine storm" and

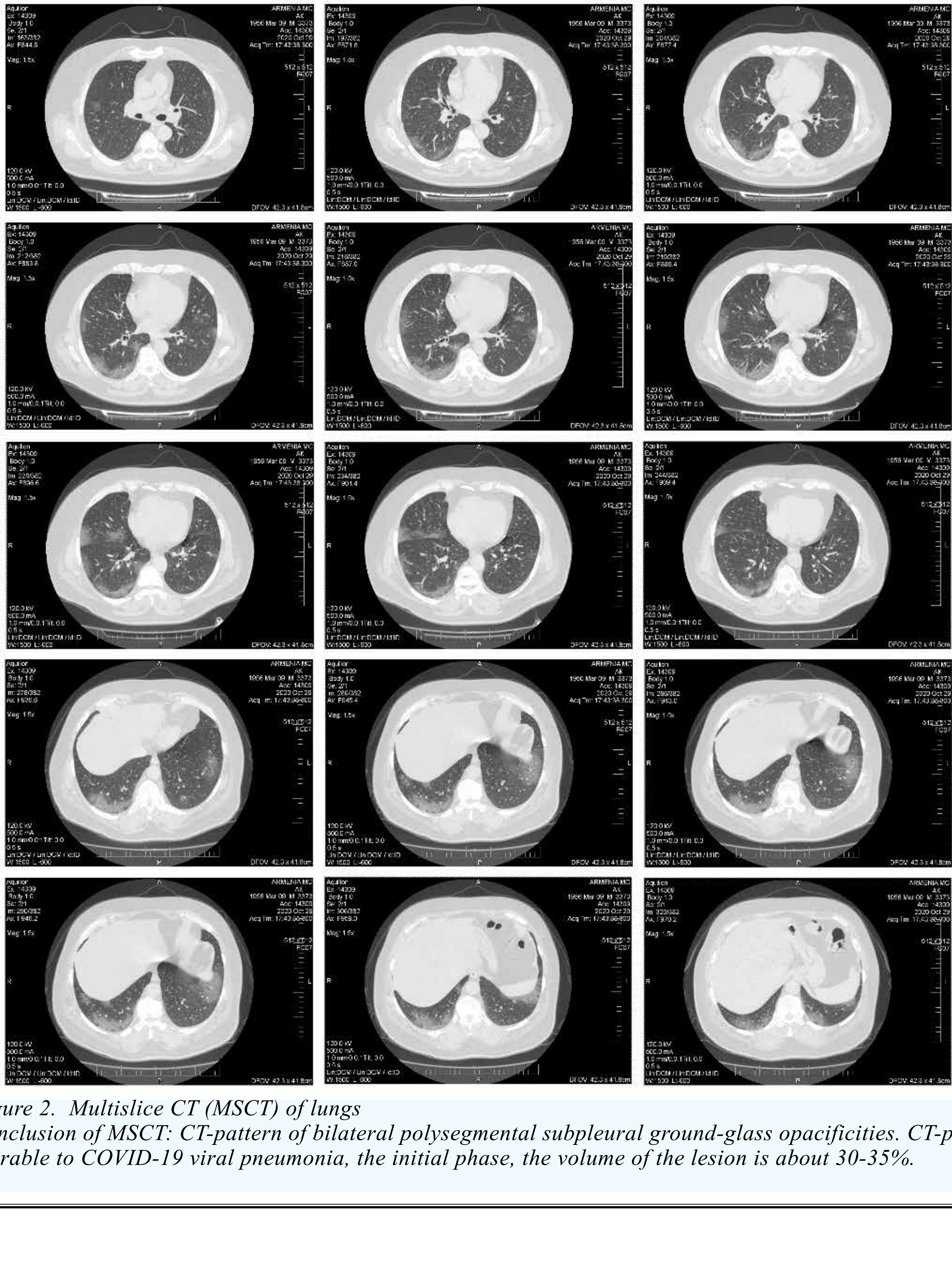

Figure 2. Multislice CT (MSCT) of lungs

Conclusion of MSCT: CT-pattern of bilateral polysegmental subpleural ground-glass opacificities. CT-pattern is comparable to COVID-19 viral pneumonia, the initial phase, the volume of the lesion is about 30-35%.

respiratory failure caused by the SARS-CoV-2 virus [*Russo V et al., 2020*], from October 30 (day 12), the amount of fluid taken per day was increased to compensate hypovolemia (water, juice and 1.5 liters of rehydron).

Although the RHR began to decrease from October 30, the TIMA fell below 300 steps per day and remained at this level until November 5. Positive changes in the TIMA have been observed from November 6. On November 14, the TIMA was over 4000 (Fig. 1). Results of clinical trials showed key role of Dexamethasone in treatment of COVID-19 [Tomazini BM et al., 2020; *RECOVERY Collaborative Group et al., 2021*]. It should be noted that in our case, intravenous injections of Dexamethasone mostly contributed to the recovery of motor activity.

During and after the COVID-19 course on certain days, weight and body fat percentage were measured by smart scale. Dynamic changes were assessed based on both average monthly and daily measurements (Fig. 3).

According to the average monthly values, the greatest changes were observed during October-No-

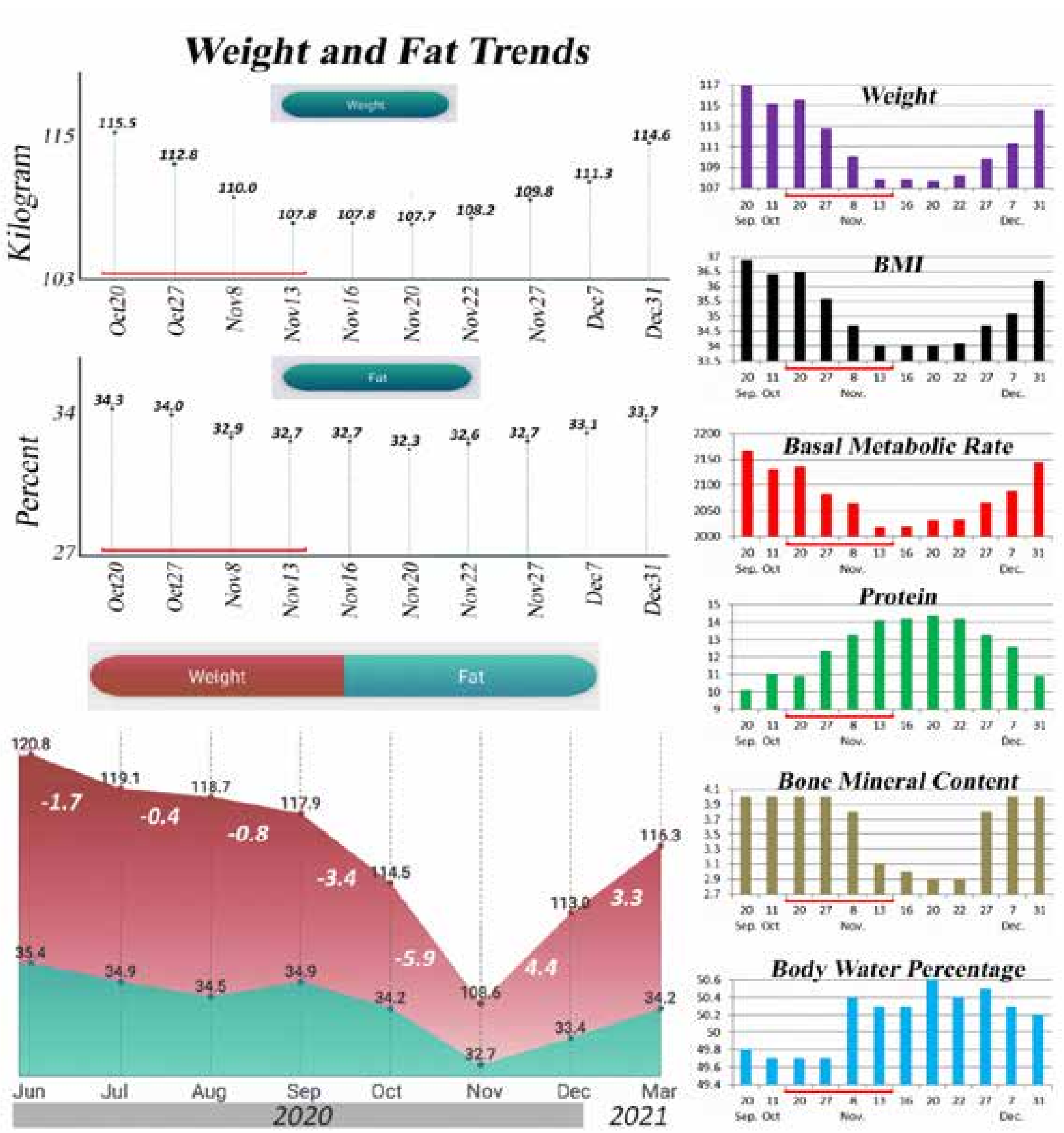

Figure 3. Dynamics of changes in weight (kg) and body fat (%) on certain days during the COVID-19 course (upper graphs on the left) and average monthly changes (lower graphs on the left). The graphs on the right show the dynamics of changes in the parameters measured by smart scales on certain days before, during and after COVID-19. Top-down: weight (kg), body mass index (BMI), basal metabolic rate, protein (%), body minerals content, body water (%). X-axis: date (day, month), Y-axis: parameter value. Red lines under the X-axes show measurements during the COVID-19 course.

vember (body weight loss was 5.9 kg, body fat percentage decreased by 1.5%) due to the prevalence of catabolic processes (Fig. 3, lower graphs on the left). During November-December, a gradual balancing of the metabolic imbalance was noted due to an increased anabolism (weight gain was 4.4 kg, body fat percentage increased by 0.7%). It should be noted that the viral infection developed from October 19 to November 12, that is, these average monthly weight changes are somewhat smoothed ("softened"). Real values can be estimated by daily measurements (Fig. 3, upper graphs on the left). Although the smart scale is not a certified medical device (non-medical grade), nevertheless, the trends of the measured and calculated parameters of the scale clearly correlate with the clinical observation data and the results obtained by the smart watch. This gives reason to rely on them when assessing parameter trends (Fig. 3, graphs on the right). The parameters of muscle bulk dynamics, showing significant rigidity are less convincing, which is probably the result of a "software bug" in calculating the parameter using smart scale.

During the COVID-19 pandemic, the results of a retrospective analysis of data from smart watches of the persons with history of COVID-19 have been published. These results indicate shifts in monitored parameters a few days before the onset of the first symptoms of COVID-19 [*Mishra T et al., 2020; Alavi A et al., 2022*]. We also found studies related to remote monitoring of patients with COVID-19 using telemedicine system [*Wurzer D et al., 2021; Sicari S et al., 2022*] and stories of OURA smart ring users covering the issue of assessing the course of COVID-19 [*Oura Team 2020; Oura Team 2020; Cronometer, 2021*]. But these publications don't cover the issue of assessing the effectiveness of therapy.

The reported case of monitoring the dynamics of the COVID-19 course based on smart watch data demonstrates the validity of using such devices to assess not only the patient's physical condition, but also the effectiveness of treatment. Two selected parameters, TIMA and RHR, allow assessing the physical activity of a person and the state of the regulatory mechanisms of cardiac activity, respectively. Naturally, both parameters depend on a number of factors and serve as nonspecific markers of processes occurring in various pathological conditions of both infectious and non-infectious nature: hormonal changes, intoxication, dehydration, electrolyte imbalance, asthenia, etc. Moreover, factors that modulate HR are BMI, body position, fitness, functional state, stress level, emotional state, medications, alcohol, food preferences, etc.

This observation also confirms the extremely high sensitivity of RHR. The descending area of RHR curve has an elevation on November 4-5 (outlined area, Fig. 1) associated with stress, which is the result of the news of the death of two very close people.

For more credibility of the presented data, reflecting a single case of assessing the dynamics of COVID-19, changes in RHR and TIMA within 30 days of the viral infection course in 2020 were compared with the dynamic shifts of these parameters in conditions of good health for a period of a similar duration in autumn 2017, 2019 and spring 2018 (Fig. 4). RHR had low variability during periods of well-being and in a particular case did not exceed 62-63 bpm. A different dynamics was observed during COVID-19. RHR was continuously increasing until the day 12. After the first injection

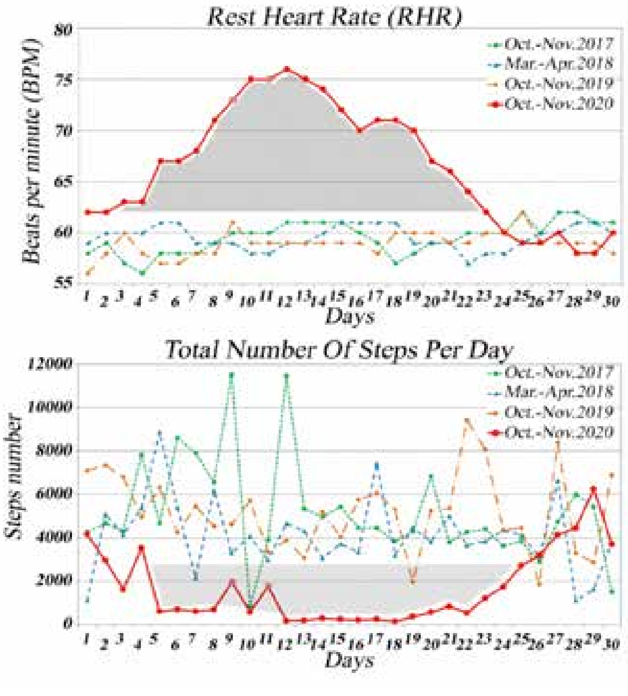

***FIGURE 4.** Comparison of resting heart rate (RHR) and the total index of motor activity (TIMA) dynamics for the 30 days of October-November 2020 corresponding to the COVID-19 period with periods of the same duration of the previous three years (2017-2019) measured by smart watch. X-axis: day of observation, Y axis: RHR (upper graph), TIMA (lower graph).*

TABLE 1.

Summary data of smart watch in the periods of well-being and during COVID-19.

	Days	Average	Max.	Min.	Max. - Min.	Std.
October - November 2017						
Steps per Day	30	**5,231.77**	**11526**	**852**	*10674*	*2,336.47*
RHR	30	**59.57**	**62**	**56**	**6**	**1.54**
Steps/RHR	30	**87.99**	**192.10**	**14.20**	*178*	*39.37*
March -April 2018						
Steps per Day	30	**4,140.20**	**8888**	**1120**	*7768*	*1,670.77*
RHR	30	**59.57**	**61**	**57**	**4**	**1.12**
Steps/RHR	30	**69.46**	**145.70**	**18.36**	*127*	*27.54*
October - November 2019						
Steps per Day	30	**5,206.30**	**9426**	**1858**	*7568*	*1,798.33*
RHR	30	**58.93**	**62**	**56**	**6**	**1.18**
Steps/RHR	30	**88.50**	**159.76**	**31.49**	*128*	*30.91*
October - November 2020						
Steps per Day	30	**1,691.67**	**6260**	**159**	*6101*	*1,623.66*
RHR	30	**66.60**	**76.00**	**58**	**18**	**5.77**
Steps/RHR	30	**27.25**	**107.93**	**2.24**	*106*	*27.72*

of Moxicin, this parameter began to decrease. During periods of well-being, the TIMA showed more significant fluctuations, since this parameter is affected by voluntary control of a person. However, during the COVID-19 course, the dynamics of the TIMA changed sharply. There was a marked decrease in the absolute value of TIMA with a simultaneous sharp decrease in variability.

Table 1 shows the average (Aver.), maximum (Max.) and minimum (Min.) values, as well as the standard deviation (SD) and range (Max.-Min.) of all three parameters for the results of a 30-day monitoring during periods of well-being (in 2017, 2018, 2019) and the viral infection (autumn 2020). The most pronounced changes in these parameters during COVID-19 are highlighted in blue, and the less significant changes are highlighted in gray.

Dynamic changes in RHR and TIMA have an inverse relationship. An increase in RHR and a decrease in TIMA correspond to declining health. At the same time, the TIMA shows some inertia, while the RHR changes practically without delay, due to which even transient stress factors have an impact on the parameter dynamics. The inertia of TIMA imposes some limitations on the assessment of its changes. We can talk about the dynamics of TIMA changes while maintaining the trend for 2-3 days.

CONCLUSION

Modern smart devices are able to provide information about the clinical course and the effectiveness of therapy. The dynamics of the COVID-19 clinical course showed the strongest correlation with resting heart rate and the total index of motor activity. A simple but sensitive parameter of resting heart rate reflects changes in homeostasis associated with various pathophysiological processes. The total index of motor activity is characterized by a pronounced variability in the norm due to voluntary control, but shows specific changes with deterioration in the health.

Thus, mobile wearable smart devices open up new prospects in the organization of medical care in extreme conditions (epidemics, pandemics) at home, contributing to the timely correction of treatment procedures to increase their effectiveness. Moreover, the mass wearing of such devices (this is already happening in the USA, Japan, China, South Korea, Western European countries etc.) and the accumulation of measured data on servers create new opportunities for assessing and early detection of the deterioration of the epidemiological situation in the country based on the "big data analysis" methods.

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