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Research article

THE IMPACT OF LIMITED MOVEMENT DURING THE COVID-19 PANDEMIC ON THE LEVEL OF PHYSICAL ACTIVITY AND MORPHOLOGICAL CHARACTERISTICS

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Abstract. *The aim of the study was to determine the impact of two months of relative motor inactivity caused by restriction of movement during the period of the Covid-19 pandemic on changes in the level of physical activity and morphological characteristics of the respondents. The study was conducted on a sample of 48 female students aged 20±0.6 years. Data for the selected variables for assessing the level of physical activities and morphological characteristics were collected with standardized instruments at two time points. A comparative analysis of the average values for assessing the level of physical activity reveals a significant negative impact of eight weeks of relative motor inactivity. The energy expenditure in all three types of physical activities (light, moderate and vigorous), and consequently the total expenditure, expressed in the Metabolic Equivalent Task, significantly decreased during the period of inactivity. Statistically significant differences were found only for hard work and total work during the week ($p < 0.001$), while there were no significant differences in light and moderate physical activities. The analysis of average values for the assessment of selected morphological variables proved that the period of inactivity caused the deterioration of morphological characteristics. Statistically significant negative changes occurred in all five monitored body dimensions of the respondents. During the experimental treatment of inactivity (ETI), body mass, the Body Mass Index, body fat percentage and waist size increased significantly ($p < 0.001$). At the same time, the lean component decreased significantly ($p = 0.007$).*

Key words: *Lockdown, Relative Motor Inactivity, Energy Expenditure, Body Status*

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INTRODUCTION

Physical activity (PA) is defined in theory as any movement derived from skeletal muscle activation that requires energy expenditure and complex behavior including sports and other physical activities (Plasqui & Westerterp, 2007), but at the same time also defined as the promotion of positive childhood behavior that can lay the foundation for overall health (U.S. Department of Health and Human Services, 2010).

A number of studies dealt with the engagement of students in sports and recreational activities in order to determine the amount and structure of their movement during the average week. In most of these studies, the International Physical Activities Questionnaire (IPAQ) was used as an instrument to collect data. Almost all studies (De Vahl et al., 2005; Romanov et al., 2014; Sullum et al., 2010; WHO, 2018b) reported very low levels of PA for students. This data is associated with poor fitness and majority of respondents stated that exercise presents a great effort for them (Pantelić et al., 2010).

In recent years, there has been growing interest in the physical activity and nutrition of children and youth (including students), as evidenced by numerous studies (Lopez-Sanchez et al., 2020; Basterfield et al., 2011; Boreham & Riddoch, 2001; Janssen & LeBlanc, 2010; Pate et al., 2002; Suder & Chrzanowska, 2015; Tolfrey et al., 2000; Trost et al., 2001). These studies looked at the problem of PA and health, proved that low levels of physical activity greatly affected the increased risk of obesity and decreased physical ability. Obesity can be classified using a number of methods, each of which has its pros and cons (Norgan, 2007; Wilson et al., 2019). The Body Mass Index (BMI) is correlated with the PA and student sedentary behavior. Higher BMI is associated with higher levels of sedentarity and lower levels of PA (Cooper et al., 2015; Jago et al., 2020; Schwarzfischer et al., 2019).

The World Health Organization (WHO) on 11 March 2020 declared a pandemic caused by the SARS-CoV-2 virus. In order to protect the population from infection in the Republic of Serbia, on 15 March 2020 a state of emergency was declared. A key safety, health measure, the “lockdown" limited the free movement of people, which had an impact on the regular physical activities of students. Studies have shown that, in different countries, student PA levels (walking, moderate, high, and total PA) were reduced during the Covid-19 pandemic (Lopez-Valenciano et al., 2021; Barkley et al., 2020).

The aim of the study was to determine the impact of two months of relative motor inactivity caused by restriction of movement during the Covid-19 pandemic and their impact on changes in the PA level and morphological characteristics of the respondents.

METHODS

Study Design

An experimental longitudinal study with non-probabilistic appropriate sampling, which would monitor changes in the physical characteristics and levels of physical activity of young women, under the influence of aerobic exercise, was supposed to start in early March 2020. However, due to the introduction of a state of emergency that lasted almost two months (until 6 May, 2020) schools and colleges were closed. As the sample of this study consists of female students, the implementation of the experiment was stopped due to lockdown. Initial measurements were already carried out, which resulted in using collected data to analyze changes in the PA level and physical characteristics of the same respondents,

which occurred during the two-month limited movement. Therefore, instead of the originally planned application of the experimental exercise factor, the forced experimental inactivity factor was applied due to the Covid-19 pandemic.

The research draft was re-created as a field experiment that monitored the impact of physical inactivity on the subjective assessment of the PA level and changes in morphological characteristics during the period of lockdown.

During the process of collecting empirical data, the self-assessment of the PA level, the IPAQ questionnaire was distributed to the respondents at the beginning and end of the state of emergency. At the same two time points, variables for assessing morphological characteristics were measured (body mass, BMI, percentage of fat, lean body mass and waist size). All data were collected using standardized instruments whose metric characteristics were checked in previous studies.

Sample

The study was carried out as an experimental study with a suitable sample formed by the voluntary participation of female students of the Academy of Applied Studies Belgrade, in Belgrade. The study was conducted on a sample of 48 female students, moderately physically active, aged 20 years (±6 months). Moderate physical activity as the dominant kind was used for the homogenization of the sample, because there were no students belonging to the category of highly active, and students whose energy expenditure was less than 600 MET-minutes/week (Metabolic Equivalent Task - MET) were not expected to quickly change their attitudes in relation to the PA and exercise.

Before the start of the experiment, the purpose of the study was explained to the respondents along with the measurement protocols. Each of them gave their written consent to participate in the research. All procedures were carried out in accordance with the provisions of the Helsinki Declaration on work with people (WMA, 2013).

Variables and instruments

Each respondents was registered with the following four variables for assessing their PA level: light (low intensity PA), moderate (moderate intensity PA), vigorous (vigorous intensity PA) and total work (sum of light, moderate, and vigorous). The energy expenditure in all four forms of physical activity (light, moderate, vigorous and total work) is expressed in MET.

To assess the PA level on a weekly basis, a standardized IPAQ questionnaire was used, distributed to the respondents at the beginning of the experiment and after eight weeks. This study used a shorter version of the questionnaire published on the website of the Association for Sports and Sports Medicine (USMS, 2020).

The IPAQ has good metric characteristics confirmed in several studies (Craig et al., 2003; Hallal & Victoria, 2004; Hagströmer et al., 2006). It is the world's most widely used physical activity questionnaire (Van Poppel et al., 2010). The IPAQ measures the frequency, duration and intensity of physical activity in four areas of life: (1) work, (2) travel, (3) housework, and (4) free time. The results are expressed in MET, where one MET is equivalent to metabolic consumption at rest. According to international standards (Ainsworth et al., 2011; IPAQ group, 2005) PA can be broken down into three categories: (1) low PA (less than 600 MET per week), (2) moderate PA (from 600 to 3.000 MET total or 480 MET heavy PA) and (3) high (more than 3.000 MET in total or 1.500 MET heavy

PA). For the calculation of the PA index, IPAQ guidelines were used (Ainsworth et al., 2011) according to which the heavy PA is worth 8 MET, moderate PA 4 MET, light about 3 MET. Moderate walking (a walk) for example corresponds to a value of 3.3 MET.

Each respondent had assigned values for the following five variables for the evaluation of morphological properties, in the beginning (the initial measurement) and after the lockdown (the final measurement): body mass, BMI, the percentage of fat in the body composition, the lean body mass of the body and waist size.

To measure body mass (BM), percentage of body fat, and lean body mass (LBM) bioelectric impedance was used and the electronic portable scale "Tanita" (model BC-543). BMI was calculated as the ratio of body mass and square of body height, i.e. BMI = kg/m^2 (Blackburn & Jacobs, 2014; Keys et al., 1972). Waist size (WS) was recorded to evaluate abdominal fat mass. It was measured with a flexible strip with a measurement accuracy of 0.1 cm at the level of the middle distance of the lowest point on the rib arch and the highest point on the iliac crest of the pelvic bone. In addition to the variables that are monitored, body height was measured using a telescopic instrument (model SECA 220). Data were expressed in centimeters with an accuracy of 0.1 cm. This measurements were taken only once and were only used to calculate the BMI.

Statistical analysis

For each variable, at both time points of the experiment, the arithmetic mean (Mean) and standard deviation (SD) were calculated. The significance of the differences between the average values of the PA level before and during the limited activities and the average values of the variables for the assessment of morphological characteristics before and during the limited activities was checked by the T-test for dependent samples (Paired Samples Test). For the data related to the level of nutrition, which were assessed using BMI, a frequency distribution was made that enabled contingency analysis, i.e. the application of the Chi-Squared test. The SPSS 21.0 statistical program (IBM Corporation, USA) was used for the complete statistical analysis. All the conclusions were realized at the 0.05 level of significance ($p < 0.05$).

RESULTS

The comparative analysis of average values of PA levels before and after ETI (Table 1) revealed a significant negative impact of two months of inactivity. The energy expenditure, expressed in MET-s, in all three types of physical activities, for light (265.75 to 224.17), moderate (745.29 to 679.33), and vigorous (1067.09 to 788.17), and consequently on the total expenditure (2066.76 to 1712.50), decreased significantly during the period of limited movement. Statistically significant differences were found only for vigorous ($p < 0.001$) and total work ($p < 0.001$) during the week, while there were no significant differences for light ($p = 0.492$) and moderate ($p = 0.854$) PA. These data suggest that ETI did not have a proportional effect on changes in different PA levels, as the corresponding graph shows (Figure 1).

Table 1 The average PA values before and after the ETI

	Before ETI		After ETI		Paired Samples Test	
Work (MET)	Mean	SD	Mean	SD	t	p
Light	265.75	± 344.11	224.17	± 345.84	0.693	0.492
Moderate	745.29	± 470.11	679.33	± 441.00	0.854	0.397
Hard	1067.09	± 537.93	788.17	± 306.39	4.195	< 0.001
Total	2066.76	± 597.75	1712.50	± 637.83	4.204	< 0.001

Abbreviations: MET - metabolic equivalent task, ETI - experimental treatment of inactivity, SD - deviation from the mean value, t - T-test, p - significant

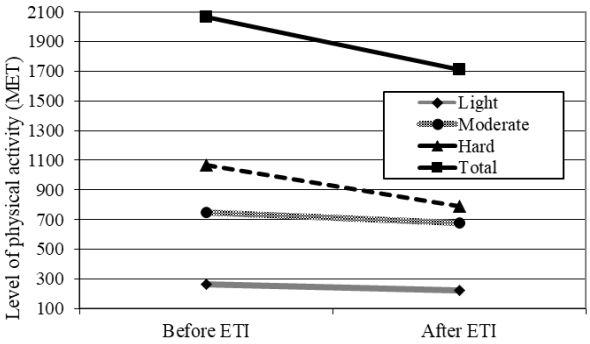

Fig. 1 Changes in the PA level before and after ETI

By comparing the average values of monitored body dimensions before and after ETI (Table 2), a significant negative impact of eight weeks of inactivity was observed. During ETI, the average values of the monitored variants increased significantly: BM (61.10 kg to 62.52 kg), BMI (21.71 kg⁄m^2 to 22.21 kg⁄m^2), body fat percentage (26.72% to 27.73%), and WS (77.92 cm to 79.25 cm), while LBM was reduced (42.47 kg to 42.13 kg). Inactivity had the greatest impact on BM ($p < 0.001$), BMI ($p < 0.001$), body fat ($p < 0.001$), and waist size ($p < 0.001$), but significance was not absent in the impact on LBM ($p = 0.007$), and as LBM was reduced, decreasing values were registered for the lean body component (Figure 2).

Table 2 The average values of variables for the assessment of morphological characteristics before and after ETI

	Before ETI		After ETI		Paired Samples Test	
Variable	Mean	SD	Mean	SD	t	p
BM (kg)	61.10	± 8.09	62.52	± 8.45	-6.713	< 0.001
BMI (kg/m^2)	21.71	± 2.56	22.21	± 2.65	-6.622	< 0.001
Body Fat (%)	26.72	± 5.56	27.73	± 5.29	-1.214	< 0.001
LBM (kg)	42.47	± 2.69	42.13	± 2.91	2.829	0.007
WS (cm)	77.92	± 6.58	79.25	± 7.01	-5.212	< 0.001

Abbreviations: BM - body mass; BMI - body mass index; LBM - lean body mass; WS - waist size; SD - deviation from the mean value; t - T-test; p - significant

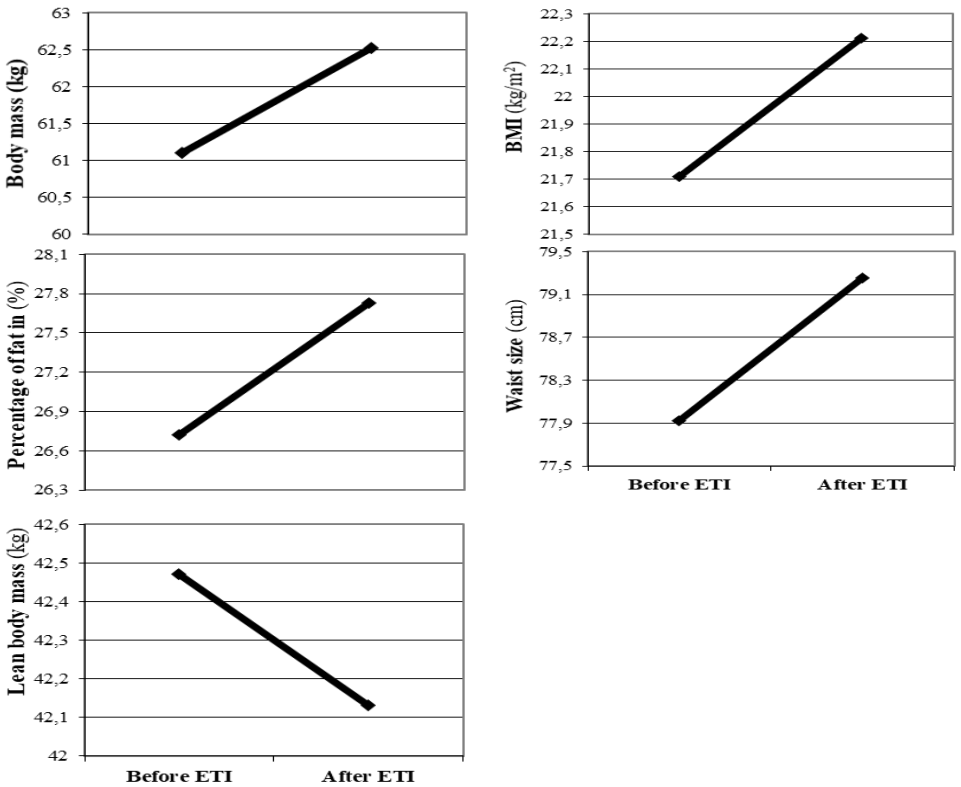

Fig. 2 The average values of variables for the assessment of morphological characteristics (body mass, BMI, body fat percentage, lean body mass and waist size) before and after ETI

Empirical frequencies (Table 3 and Figure 3) show that the sample is dominated by female students with normal body weight. Almost the same distribution of frequencies was obtained both before and after ETI (before ETI 81.3%; after ETI 87.4%). The only observed difference refers to the decrease in the number of underweighted respondents (before ETI 10.4%; after ETI 4.2%), who due to gained kilograms during inactivity, moved into the group of persons with normal body weight.

Table 3 Distribution of test subjects in relation to nutritional status before and after ETI

	Before ETI		After ETI	
Nutritional status	Number	Percentage	Number	Percentage
Underweight	5	10.4%	2	4.2%
Normal weight	39	81.3%	42	87.4%
Overweight	3	6.3%	3	6.3%
Obesity	1	2.1%	1	2.1%
Total	48	100%	48	100%

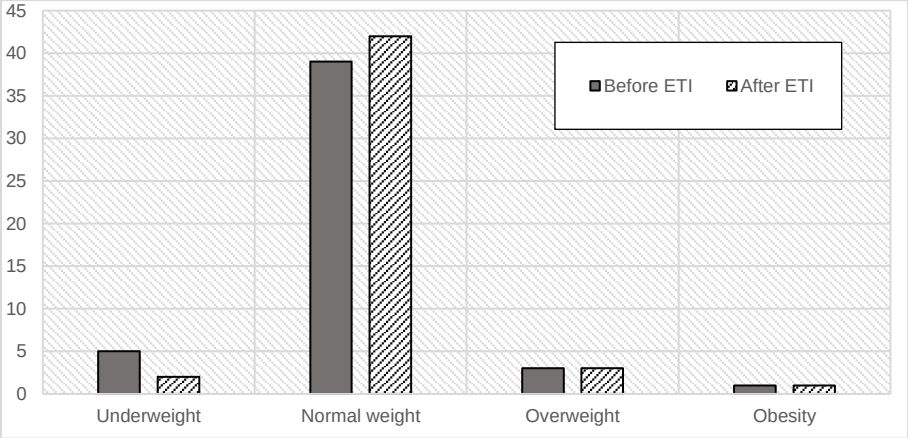

Fig. 3 Distribution of test respondents in relation to nutritional status before and after ETI

DISCUSSION

Based on the data collected with the IPAQ instrument, the level (extent and structure) of PA during one week before and during the last week of the limited movement was determined. The data are expressed in MET and represent an index of the energy consumption of the respondents, both total and separate consumption in individual PA of different intensity (light, moderate, and vigorous). The movement habits and morphological characteristics of the test respondents deviate from the average values that apply to the student population and were obtained in previous research. The respondents from the sample had a higher level of PA even before the ETI (the level of PA determined during the formation of the sample – before the start of the experiment, the respondents were categorized as persons with moderate PA) compared to the data obtained for the student population in previous research (De Vahl et al., 2005; Romanov et al., 2014; Sullum et al., 2010; WHO, 2018b). Most researchers have previously reported that in the student population, regardless of the country of origin of the sample of respondents, overweight is represented on average by 18-22%, and obesity by 3-5% (ACHA, 2016, 2019; CDC, 2019; Rutkow et al., 2016; WHO, 2018c). In the sample, the percentage of respondents who have weight problems was significantly lower (6.3% overweight and 2.1% obese). These findings can also be explained by the nature of the material that the respondents studied during their time at university. Given that they were all enrolled in a study program with a large number of medical-health subjects, it is obvious that they had access to more information about healthy lifestyles than the average student (including information about nutrition and regular PA).

A comparative analysis of average values of PA levels revealed a significant negative impact of two months of inactivity. The energy expenditure in all three types of physical activities (light, moderate, and vigorous), and consequently the overall consumption, decreased significantly during the "isolation" period. Gallè et al. (2020) and Barkley et al. (2020) concluded that all sedentary behaviors significantly increased and all PA significantly decreased during the period of restraint. The largest decrease of 26.14% was recorded for

PA of the highest intensity (vigorous) as shown by other studies in which the decrease for this type of intensity ranged between 2.9 and 52.8 % (Ács et al., 2020; Barkley et al., 2020; Gallè et al., 2020; Gallo et al., 2020; Romero-Blanco et al., 2020; Sañudo et al., 2020; Alarcón Meza & Hall-López, 2021). The reduction for light PA was 15.65%, and the smallest was for moderate PA – 8.85%, which was significantly less than 30% (Gallo et al., 2020). This difference in the reduction of moderate PA can also be explained by the fact that the sample consisted of moderately active respondnets, whose activity trends remained relatively similar. The total PA index decreased during two months of inactivity by 17% which is different from the 28.6% (Ács et al., 2020) and 50% (Gallè et al., 2020) reductions. The decrease in total PA in the mentioned studies is significantly higher for several reasons: in our sample, a small decrease in moderate PA has already been explained, which as such affected the overall balance, a higher percentage of our female students spend time in Belgrade only during their studies, and during the ban on movement resided in environments where the restrictions were much milder and the third reason, unlike in other countries, in Serbia the lockdown measures were somewhat more relaxed.

Statistically significant differences were found only for vigorous activities and total weekly energy expenditure, while there were no significant differences in light and moderate PA.

Vigorous PA primarily involves sports and recreational activities that require leaving the house and going places where there is organized exercise (fitness centers, gym tracks, public parks, sports fields, swimming pools, etc.). As a state of emergency was introduced during the Covid-19 pandemic, which entailed limited freedom of movement, the closure of all sports and recreational facilities, and a ban on public gatherings, the scope of these most intensive activities was significantly reduced. On the other hand, light and moderate work was mostly related to household chores (cleaning, vacuuming, work in the garden or yard, etc.) and performing daily duties (going to work, shopping, etc.). The respondents had to perform this type of daily work during the "lockdown" period as well, which explains the absence of significant differences between light and moderate work. This shows that most people cannot meet the recommended health minimum of physical activity just by doing housework. The modern way of life, especially in urban areas, encourages hypokinesia in view of the proximity of commercial facilities for the supply and use of numerous technical aids in households that reduce energy expenditure to a minimum. In such living conditions, a modern man who cares about his health obviously has an increasing need for additional physical exercise.

Comparative analysis of the average values of variables for the assessment of morphological characteristics (body mass, BMI, body fat percentage, lean body mass and waist size) confirms the significant negative impact of two months of inactivity.

The average values of four of the five monitored body dimensions, which are taken as indicators of nutrition, increased statistically significantly. Body mass at the level of the complete sample increased on average by almost 1.5 kg, BMI by 0.5 kg/m^2, fat percentage in total body mass by 1%, and waist size by 1.4 cm. At the same time, lean body mass, which is used in anthropometry to estimate the share of muscle in the total body mass, decreased. It is an indirect indicator that the total muscle mass decreases during the absence of higher intensity PA.

The level of nutrition of the respondents was assessed using BMI, the values of which are aligned with the BMI values (21.77 kg/m^2) obtained in the study of Ghimire (2022). The frequency distribution showed that the sample was dominated by female students with a normal body weight. Both before and after the phase of inactivity, there were over 80% of

them. The number of normally weighted respondents even increased (87.4%), which is a consequence of the increase in the body weight of three female students who were underweighted before the inactivity, and during the two-month experimental treatment they moved to the group with normal body weight. Although the overall changes were not statistically significant, these data indirectly point to the fact that resting for too long and the absence of more serious PA negatively affects a person's physical status. The number of obese, as well as overweight respondents, did not change during the inactivity experiment, which most affected the actuality that almost the same frequency distribution was obtained before and after two months of inactivity of the respondents. Therefore, despite the increase in body mass and the percentage of fat tissue, there was no serious deterioration in nutritional status. These data can be explained by the already mentioned fact that the research sample was formed by female respondents whose body composition and PA level (the condition for the sample is moderate physical activity) is above the average for the student population determined in previous research (CDC, 2019; WHO, 2018c; Ghimire et al. 2022).

CONCLUSION

A negative impact of limited freedom of movement on the estimated PA level was observed. It was found that the estimated PA level was significantly reduced, especially manifested through vigorous and total work. It was proven that insufficient movement caused deterioration of the monitored morphological features. The following were recorded and statistically confirmed: a significant increase in body mass, BMI, percentage of body fat and waist size, and a decrease in lean body mass.

Previous studies provide evidence of the benefits of exercise. The significance of this study is that, under changed circumstances, it was possible to prove, and it was proven, that a two-month period of inactivity produces negative consequences, and that previously reported sedentary behavior patterns of young people may later have implications for their overall health.

In this sense, it can be stated that this study also contributed to the confirmation of the negative impact of the pandemic caused by the SARS-CoV-2 virus on the lives of young people. This, among other things, speaks in favor of the general population observation that people's lifestyle during the pandemic period was predominantly focused on the close family circle, as well as virtual social life, and that physical activities and physical exercise experienced a significant reduction, and therefore more intensively highlighting the value of physical exercise and affirming outdoor activities should be one of the priority tasks of the kinesiology profession in the coming period.

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UTICAJ OGRANIČENOG KRETANJA TOKOM PANDEMIJE COVID-19 NA NIVO FIZIČKE AKTIVNOSTI I MORFOLOŠKE KARAKTERISTIKE

Cilj studije bio je utvrditi uticaj dvomesečne relativne motoričke neaktivnosti izazvane ograničenjem kretanja tokom perioda pandemije Covid-19 na promene nivoa fizičke aktivnosti i morfoloških karakteristika ispitanica. Istraživanje je sprovedeno na uzorku od 48 studentkinja starosti 20±0.6 godina. Podaci za odabrane varijable za procenu nivoa fizičkih aktivnosti i morfoloških karakteristika, prikupljeni su standardizovanim instrumentima u dve vremenske tačke. Uporedna analiza prosečnih vrednosti za procenu nivoa fizičke aktivnosti otkriva značajan negativan uticaj osmonedeljne relativne motoričke neaktivnosti. Energetska potrošnja u sva tri vida fizičkih aktivnosti (lak, umeren i težak rad), a posledično i ukupna potrošnja, iskazana u Metabolic Equivalent Task, značajno se smanjila tokom perioda neaktivnosti. Statistički značajne razlike utvrđene su samo za težak rad i ukupni rad tokom nedelje ($p < 0.001$), dok su kod lakih i umerenih fizičkih aktivnosti signifikantne razlike izostale. Analizom prosečnih vrednosti za procenu odabranih morfoloških varijabli dokazano je da je period neaktivnosti prouzrokovao pogoršanje morfoloških karakteristika. Kod svih pet praćenih telesnih dimenzija ispitanica dogodile su se statistički signifikantne negativne promene. Tokom eksperimentalnog tretmana neaktivnost (ETN) značajno su se povećali ($p < 0.001$): telesna masa, Body Mass Index (BMI), postotak telesne masti i obim struka. Istovremeno, bezmasna komponenta značajno se smanjila ($p = 0.007$).

Ključne reči: *Lockdown, relativna motorička neaktivnost, energetska potrošnja, telesni status*