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THE IMPACT OF COVID-19 LOCKDOWN ON AEROBIC CAPACITY IN FEMALE SOCCER PLAYERS

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Summary:

Aim. The purpose of this study was to evaluate changes in physical capacity caused by a 41-day significant reduction in training activity due to the COVID-19 lockdown. The 20 m shuttle run *(Multistage Fitness Beep test*) was used to determine physical capacity.

Methods. The examinations were performed on 23 female soccer players aged 15 to 23 years. The inclusion criteria were sufficient training experience and participation in competitions at the level of the Central Junior League and the First Women's League. On both dates of examinations, separated by a 41-day interval forced by the COVID-19 pandemic, maximal oxygen uptake was analyzed using an indirect method based on the *Beep Test*. The differences in VO2max on both dates for the combined groups were analyzed by Student's t-test for dependent samples.

Results. Calculations showed a highly significant reduction in VO2max (by 5.6 ml/kg/min). Furthermore, the absolute decrease in this variable was significantly related to baseline levels (r=0.760).

Conclusions. The re-education of physical activity enforced by the 41-day lockdown resulted in a significant loss of aerobic capacity. A greater decrease in VO2max was observed in female athletes with higher baseline levels of aerobic capacity. It seems advisable to develop special training programs for individual implementation in case the group training is impossible.

1. Introduction

Soccer players of both sexes at the competitive level must show very high aerobic capacity. The quantitative measure of this ability is the maximal oxygen uptake (VO2max) during exercise. The importance of VO2max as a physical attribute in this sport has been confirmed by the results of studies showing a close relationship between a team's average aerobic capacity and its place on the ranking list. Female national team members show the highest VO2max levels, whereas teams with lower aerobic capacity are ranked lower [1]. Therefore, regardless of gender, the structure of the sporting task in soccer requires training oriented to developing endurance, speed, and aerobic capacity to tackle the challenges posed during the entire match [2]. The physical requirements and training characteristics for elite female athletes were defined relatively early. During a match, they cover an

average of 10.3 km at a variable pace, with HR ranging from 171 to 205bpm depending on exercise intensity, and the distance covered depending on the VO2max values of 43.3 to 56.8 ml/min/kg [3]. During the annual training and competition cycle, fluctuations in the fitness levels measured by the anaerobic threshold levels are observed depending on the training load and competitive activity. The basic preparation period is from January to March, followed by the competitive period from March to June. After the break in the summer months, there is a shortened period of preparation for the autumn round of games (September to November). Some coaches monitor training effects before and after each of the two macrocycles using different exercise tests [4]. The direct measurement method is recommended as a gold standard to determine the levels of maximum oxygen uptake. Such measurement after 8-week training in 15 female athletes showed a significant increase in VO2max, on average from 43.2 to 46.2 ml/min/kg [5]. As can be seen, testing players for motor skills play an extremely important role in the training macrocycle. In the case of youth groups, knowledge of the physical and physiological abilities of athletes helps choose training loads to ensure that the transition from youth to adult soccer teams is as smooth as possible and does not pose a risk of chronic fatigue, known in coaching practice as overtraining. Today, biomedical science offers a wide range of methods to diagnose physical status, including early symptoms of overtraining. In addition to biochemical changes, one tool for detecting the risk of overtraining in an athlete is his or her decreasing performance in the maximal exercise test [6]. Among the various exercise tests, those designed to determine oxygen uptake attract much attention. The direct method consists in the analytical measurement of the chemical composition of exhaled air. Indirect estimation is based on the examination of the cardiovascular response and using empirical formulas. Indirect measurements performed in field conditions are not as precise as those in laboratory settings, but they are useful in coaching practice. The agreement of maximal oxygen uptake measurements obtained using both methods with different exercise (rowing ergometer, treadmill, step-test) has been studied and confirmed by many authors [7-11] but the direct measurement is considered the gold standard.

With the availability of many exercise protocols for the assessment of aerobic capacity levels, researchers and coaches have to decide which type of test to choose for their team so that the data obtained from the measurements can be best used for endurance training or diagnosis of fitness. Among the field tests, the Multi-Stage 20-m Shuttle Run has been widely used. A high correlation has been shown in athletes of both sexes between the VO2max in this test and the result of a 5km run [12]. Validation of the test-retest procedure showed very good reproducibility of the results [13]. This type of test has been used for cross-sectional studies of different age groups [14].

Given the validity of monitoring of training effects in field conditions and the demonstrated usefulness of a shuttle run exercise test, we attempted to investigate the change in VO2max in female soccer players on two planned days in order to identify the body's response to the applied physical load.

2. Material and methods

The study examined female athletes of the Resovia Sports Championship School. We measured 23 players, of which 14 competed in the age category of older juniors in the Central Junior Female League, and 9 at an adult level in the First Women's League, which, together with the training experience, constituted the inclusion criteria. The age of the participants ranged from 15 to 23 years. At the time of the measurements, all subjects were healthy and reported no contraindications to the examinations. A multistage shuttle run (*Beep test*) was used as the exercise test on both dates.

The examinations were performed in 2 rounds: in the final phase of the transition period (on 26 November 2020), and in the initial phase of the preparation period (on 9 January 2021). The test was conducted at the same time of day on both dates. Before the test, on the date I, subjects performed an exercise part to familiarize themselves with the procedure.

The 20m shuttle run is also termed an endurance shuttle run [5], or colloquially a *Beep Test*. It involves the participants moving between lines over a distance of 20 meters. The player must cross the end line before the beeper sounds. The speed of movement depends on the signal, the frequency of the signal increasing with each successive step (consequently encouraging participants to run faster). The stage at which the test subject is unable to cross the 20-meter line before the beep is an indicator of their fitness and the point at which the measurement should be stopped. The test is composed of 23 levels, each lasting one minute. The initial speed is 8.5 km/h and increases with each subsequent stage by 0.5 km/h. *Beep Test* is one of the most popular aerobic capacity tests. In 2018, it was used by British researchers to examine children and adolescents from 50 different countries around the world [6]. The following formulas are used to calculate VO2max (according to a study of the Japanese population by Matsuzaka et al. 2004) [7]:

a. For the age of 8-17 years: VO2max = 35.4 + 0.22 x L
b. For the age of 18-23 years: VO2max = 28.1 + 0.274 x L, where:

- L - total number of 20m sections covered.

Statistical analysis

To examine the differences between the results obtained for dates I and II, calculations were performed on the combined data from both groups, yielding a satisfactory sample size (n=23). Student's t-test for dependent variables at $p<0.05$ was used to compare the means for the two dates. The normality of distribution of both samples was tested using the Shapiro-Wilk test.

3. Results

After the examinations were conducted on the date I, the planned training program had to be discontinued due to restrictions caused by the COVID-19 pandemic. It was not until 41 days after the lockdown was lifted that we were given the opportunity to retest. There was no controlled training or physical activity monitoring of the female players during the lockdown period. Therefore, the second examination of capacity provided data that revealed the effect of reduced physical activity on the decrease in VO2max.

Table 1. Individual mean VO2max [ml/kg/min] in female players of different groups obtained on two test dates

VO2max before the COVID-19 lockdown		VO2max after lifting the lockdown (+41 days)	
Juniors	Adults	Juniors	Adults
49.26	54.678	41.81	46.5
50.8	50.02	43.1	43.96
51.46	47.554	44.03	45.88
48.16	42.896	40.64	41.56
51.68	54.678	46.78	46.34
47.72	46.732	38.39	43.18
46.84	42.348	40.52	39.8
45.08	42.896	39.77	41.11
37.96	46.732	37.57	43.45
48.38		39.42	
53		44.86	
47.28		41.73	
49.04		42.74	
47.72		40.81	

Individual results are presented in Table 1. The results of the statistical analysis are illustrated in Table 2. The distribution of the variables was normal in both samples.

The study showed a significant decrease in maximal oxygen uptake (by 11.7%). Larger decreases were noted in the players distinguished by a higher aerobic threshold on the test date I, with a significant linear correlation coefficient between a decrease and baseline VO2max (r=0.760). Consequently, the dispersion of results on the second test date expressed by the coefficient of variation (CV%) decreased.

4. Discussion

The aim of this study, which was to investigate changes in physical capacity after a planned training period, was not achieved for objective reasons. Nevertheless, valuable information was obtained on the effect of unplanned reduction in physical activity on aerobic exercise capacity in female soccer players.

The increase in VO2max during training may be caused by an increase in e.g. the number of mitochondria in cells, muscle capillaries, or stroke volume. However, discontinuation of the training led to a gradually decreasing VO2max. Such a phenomenon was found in elite female soccer players. After a period of 4 weeks of planned detraining during the transition period, when activity was reduced to two training sessions per week, a significant increase in body weight and a decrease in VO2max were noted [15]. Therefore, in the event of an unplanned reduction in the activity during the preparation period, the loss of fitness may reduce the benefits gained earlier.

An analysis of aerobic capacity in national elite female soccer players was carried out in 2018. Results depended on age category and field position [16]. The mean age of the participants was 20.72 years. Measurements were performed using the *Beep Test*. The mean score in the study group was 48.89 ml/kg/min. Compared to the female adult players, the VO2max levels in female athletes playing at the central level in Bosnia and Herzegovina were higher by 1.28 ml/kg/min (in the case of female older juniors by 0.72). An additional breakdown by field position was used after the examinations: female defensive players

Table 2. Results of statistical comparison of performance before (I) COVID-19 lockdown and immediately after the lockdown was lifted (II)

date	X SD	CV%	Me	Min max	t-function	p-value	Cohen's d
I	47.95 4.00	8.3	47.72	37.96 54.67	-10.03	>.000	1.65
II	42.35 2.63	6.2	41.81	37.57 46.78			

achieved on average VO2max of 48.06, midfields – 50.03, and forwards – 48.60. The high level of VO2max in female midfield players was due to the tasks performed by players in this position. The *National Game Model* published by the Polish Football Association provides the characteristics of players playing on particular positions [17]. In our opinion, from the point of view of the somatic motor profile, central midfielders should be characterized by a high level of endurance.

Another study [18] examined 23 healthy female soccer players with a mean age of 20.68 years. Aerobic capacity levels were evaluated using two tests: a modified 20 m shuttle run *(Multistage Fitness Beep Test)* and *Yo-Yo Test*. Modifications of the *Beep Test* consisted in increasing the distance between the lines to 40 m (thus extending the running time to 2 minutes), increasing the speed in the first three stages of the run from 1 km/h to 1.5 km/h, and adding a 30-second interval between successive stages. In the fourth and subsequent series, the speed increased by 1 km/h. At each speed (except for the last), the running time was 2 minutes. After the *Beep Test,* participants were asked to rest for 48 hours, after which a second measurement was taken, using the *Yo-Yo Test*. The mean score in the *Beep Test* was 48.19 ml/kg/min, while in the *Yo-Yo Test* – 47.17 ml/kg/min. With reference to the female athletes examined in our study, the results on the *Beep Test* differed compared to adult players (mean score: 47.61; difference: 0.58), while compared to junior players, the score was almost identical (48.17; difference: 0.02).

Young female athletes (12-15 years old) were subjected to performance testing. Over the season, VO2max levels changed from an average of 42.95 to 44.58 ml/kg/min. The athletes were tested using an indirect method (the Astrand test). Compared to the female juniors in our study, this result was worse compared to the 20 m shuttle run *(Multistage Fitness Beep Test)* by 5.22 at the beginning and 3.59 ml/kg/min at the end of the season. In contrast, 30-15 Intermittent Fitness Test scores were worse by 1.37 and 3 ml/kg/min, respectively. [19].

Soccer is a sport with a high risk of injury, while the relationship of aerobic capacity levels with the prevalence of injuries and illness in female soccer players has been the focus of subsequent studies in female soccer players [20]. Fifty-four adolescent female soccer players aged 13 to 18 years from local teams were examined using direct measurement. Each participant performed a progressive maximal exercise test. Measurement results were 58.6 ml/kg/min for participants from the first group and 54.6 for the participants in the second group. It is worth noting that the participants with lower aerobic thresholds in the pre-season were more likely to have injuries and illnesses. Comparison of the results after direct measurement with the VO2max results obtained during *Beep Test* and 30-15 IFT reveals significant differences in physical capacity between female older juniors examined in our study and the adolescent female soccer players from Wisconsin. When comparing VO2max reported by different authors using direct or indirect methods, one must take into account that different efforts and different methods lead to slightly different VO2max scores, as revealed by examinations of female soccer players. In the study, using laboratory treadmill test, Yo-Yo test, and direct measurements by means of portable measuring apparatus, the results were 55.0 and 49.9 ml/kg/min, respectively. The relative difference between these results is 10%, although maximum HR (190bpm) and post-exercise lactate levels were the same. Furthermore, maximal oxygen uptake estimated from HR measurements was several percent lower in both efforts compared to the values measured using the analytical system [21].

The mean VO2max results obtained on the test date I in our study are comparable to those mentioned above in the *Introduction* and *Discussion* sections in our paper. The negative effects of the COVID-19 pandemic on physical capacity demonstrated in our study have also been the subject of much recent research.

Study limitation

There are no individual data on physical activity during the 41-day interval of formal training and expected changes in body composition components.

Furthermore, this paper does not take into account the effect of the menstrual cycle on test results.

5. Conclusion

1. Unexpected disruption of the training program, in particular a reduction in training activity, results in a decrease in aerobic capacity after a few weeks that is greater for higher baseline levels.
2. In view of the risk of such situations, it is necessary to prepare individual training programs for each player for implementation in home settings.

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