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Title	The impact of COVID-19 lockdown on professional soccer players' body composition and physical fitness
Type	Article
URL	https://clock.uclan.ac.uk/id/eprint/40190/
DOI	https://doi.org/10.5114/biol sport.2021.109452
Date	2021
Citation	Parpa, Koulla and Michaelides, Marcos (2021) The impact of COVID-19 lockdown on professional soccer players' body composition and physical fitness. <i>Biology of Sport</i> , 38 (4). pp. 733-740. ISSN 0860-021X
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<https://doi.org/10.5114/biol sport.2021.109452>

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The impact of COVID-19 lockdown on professional soccer players' body composition and physical fitness

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ABSTRACT: During the COVID-19 lockdown, professional soccer players ceased their regular team training sessions and were provided with exercise programs to follow independently. This investigation assessed the impact of a 7-week COVID-19 lockdown and home-based individual physical training on professional soccer players' body composition and physical fitness. The study consisted of nineteen division 1 elite soccer players (age 27.68 ± 5.99 years, height 178.47 ± 5.44 cm) and compared the anthropometric and physical fitness parameters obtained post-transition period to those obtained post-COVID-19 lockdown. The statistical analysis indicated that body fat percentage was significantly higher after the lockdown period [$t(18) = -5.59$, $p < 0.01$, $d = 0.56$]. Furthermore, VO_{2max} [$t(17) = -11.54$, $p < 0.01$, $d = 0.57$] and running time [$t(17) = 3.94$, $p < 0.01$, $d = 0.76$] values were significantly higher after the COVID-19 lockdown than those obtained after the transition period. In addition, significantly higher level of performance was demonstrated on squat jump [$t(18) = -4.10$, $p < 0.01$, $d = 0.30$], countermovement jump [$t(18) = -7.43$, $p < 0.01$, $d = 1.11$] and sit and reach tests [$t(19) = -5.33$, $p < 0.01$, $d = 0.32$]. Concurrently, lower body strength was indicated to be significantly greater ($p < 0.01$) following the COVID-19 lockdown. The training protocol provided during the confinement, due to the COVID-19 outbreak, was effective in keeping physical fitness at a significantly higher level compared to the transition period. Coaches and trainers are encouraged to examine the effectiveness of this protocol, as it may help them develop effective periodization programs during the transition period. This protocol may aid in the development of effective periodization programs that require minimal equipment and can be followed in similar situations.

CITATION: Parpa K, Michaelides M. The impact of COVID-19 lockdown on professional soccer players' body composition and physical fitness. *Biol Sport*. 2021;38(4):733–740.

Received: 2021-06-04; Reviewed: 2021-07-18; Re-submitted: 2021-07-22; Accepted: 2021-09-18; Published: 2021-10-04.

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Key words:

Pandemic

Home training

VO_{2max}

Jumping performance

Strength

INTRODUCTION

The COVID-19 pandemic has led to severe and unexpected socio-economic problems and negatively impacted people's lives and health [1]. The coronavirus pandemic forced governments to implement drastic measures and impose a lockdown and social distancing [1]. Although the lockdown was necessary to curtail the spread of the disease, it disrupted many aspects of life, including sport and physical activity [2]. A nationwide lockdown implemented in March of 2020 resulted in the suspension of all organized sports, including professional soccer games. During the lockdown, professional soccer players ceased their regular team training sessions and were provided with exercise programs that they were encouraged to follow independently. Although the exercise routines were prescribed to the professional soccer players by the fitness coaches, it is uncertain how physical fitness was affected and whether the individualized programs were enough to maintain the physical condition of the players.

To an extent, the complete cessation or substantial reduction in training during the COVID-19 confinement can be compared to the transition period (off-season) that the soccer players undertake, but there are some differences as it has been unclear if or when the

players were going to return to play. Therefore, it was much harder to design a training program during the COVID-19 lockdown. Research affirms that the transition period results in moderately negative changes in body composition, sprint performance, and muscle power in male soccer players [3]. Furthermore, a comprehensive evaluation of soccer performance has highlighted a significant decline in VO_{2max} , cardiac output, and stroke volume during both short (less than 4 weeks) and long term (more than 4 weeks) detraining [4, 5]. Alongside the aforementioned changes in the aerobic energy system, the six-week transition period adversely affected the squat jump and countermovement jump performances [6]. Furthermore, the transition period has been found to increase the lower body fat of the elite professional soccer players [7], leading to undesirable negative changes in sprint times [8]. Nevertheless, the transition period is purported to enhance players' recovery from the physiological and psychological stress of the competitive season. On the contrary COVID-19 lockdown and the uncertainty of the season timeline has imposed an enormous psychological impact [9]. In addition to the psychological distress, a multilingual online survey of 5056

participants affirms that COVID-19 confinement led to impaired sleep quality that was related to sleep disturbances, daytime dysfunction, the use of sleep medications, and sleep latency [10].

Limited research indicated that home-based exercise training during COVID 19 lockdown was effective in improving aerobic fitness, even though a decline in players' competitive power level was evident [11]. Therefore, the effectiveness of the home-based exercise programs was questionable and imposed uncertainty to practitioners concerning the players' physiological status upon league restart. Furthermore, the rapid increase in training load following a 7-week lockdown could be detrimental to performance as well as increase the risk of injuries in professional soccer players [12]. Practical recommendations for the development of training sessions for soccer players returning to sport following lockdown indicate that a training program should include specific aerobic, resistance, speed, and flexibility exercises and should be based on the progressive overload principle [13, 14]. Furthermore, incorporating single-leg exercises in dynamic movements, proper landing, and leg and foot positioning is considered essential for injury prevention [13].

Therefore, this study aimed to assess the impact of COVID-19 lockdown and home-based individual physical training, which was created in line with the aforementioned recommendations [13, 14], on professional soccer players' body composition and physical fitness in comparison to the transition period.

MATERIALS AND METHODS

Subjects

The study consisted of nineteen division-1 elite soccer players (age 27.68 ± 5.99 years, height 178.47 ± 5.44 cm). Goalkeepers were excluded from the study as they did not follow the same exercise training as the in-field players during the COVID-19 lockdown. Furthermore, players diagnosed with COVID-19 at any point before the collection of data were excluded from the study. This observational study compared the same players' anthropometric and physical fitness obtained right after the 5-week transition period to those obtained after the 7-week COVID-19 lockdown. All the participants had medical clearance and a negative COVID-19 polymerase chain reaction (PCR) test within 48–72 hours before the testing. Fitness testing was conducted on two different testing days to avoid potential fatigue from subsequent testing and give enough time to sanitize the room surfaces and equipment between the players. Players were advised to abstain from any activity the day before testing, and measurements were obtained between 8:00 am and 13:00. Testing was part of the professional team's seasonal plan to examine the players' readiness post-COVID-19 lockdown, but players' participation in this study was completely voluntary. Each player was briefed on the procedures and signed an informed consent before data collection. Ethical guidelines were followed according to the Helsinki Declaration's ethical standards, and the study was approved by the University's ethics committee board and the National Committee on Bioethics. The researchers wore a face mask, face shield, gown, and

gloves during data collection and adhered to the guidelines for patients and testing personnel during aerosolizing procedures as indicated by the Centers for Disease Control and Prevention [15].

Training protocol

During the 7-week lockdown the players were provided with an individualized training protocol similar to the one they were instructed to follow during the 5-week transition period. Microcycles (each week) were identical in structure and included three strength/power training sessions per week and four cardiovascular sessions on alternate days. More specifically a player had to follow a strength training session on Monday, Wednesday, and Friday while cardiovascular sessions were recommended for Tuesday (sprints), Thursday (speed intervals), Saturday (tempo intervals) and Sunday (continues running for 45 min) (Table 4, Table 5). Each strength training session consisted of a ten-minute warm up that included low to moderate intensity aerobic exercises and a five-minute cool down that included stretching exercises.

Measurements and data collection procedures

Anthropometric measurements were recorded using a wall stadiometer (Leicester; Tanita, Tokyo, Japan) to measure the players' stature and a leg-to-leg bioelectrical impedance analyzer (BC418MA; Tanita) to measure body composition. All players were instructed to follow the standard BIA (bioelectrical impedance analysis) guidelines [16] before the measurements were obtained.

Cardiopulmonary exercise testing

In addition to the negative PCR test within 48–72 hours before the cardiopulmonary exercise testing, a comprehensive COVID-19 symptom and body temperature check were conducted immediately before the test. The players completed an incremental maximal cardiopulmonary exercise testing (CPET) until they reached exhaustion on a treadmill (h/p/Cosmos Quasar med, H-P-Cosmos Sports & Medical GmbH, Nussdorf-Traunstein, Germany). A breath-by-breath analysis was performed on the Cosmed Quark CPET (Rome, Italy) system. Laboratory conditions were kept constant, with the temperature at $22 \pm 1^\circ\text{C}$ and relative humidity at 50%. The players were tested utilizing the modified Heck incremental maximal protocol, which was previously validated for its reliability to test soccer players [17]. The test came to an end when the participant reached volitional fatigue or when there was no variation among the VO_2 levels while the workload increased. The $\text{VO}_{2\text{max}}$ was detected after having the results filtered to identify the highest value for an average of 10 seconds.

Sit and reach test

A sit and reach box (32.4 cm high and 53.3 cm long) with a 23 cm heel line mark was used to assess lower back and hamstring muscles flexibility. Players removed their shoes and placed the soles of their feet against the box while knees were fully extended. They were instructed to avoid fast and jerky movements while leaning forward

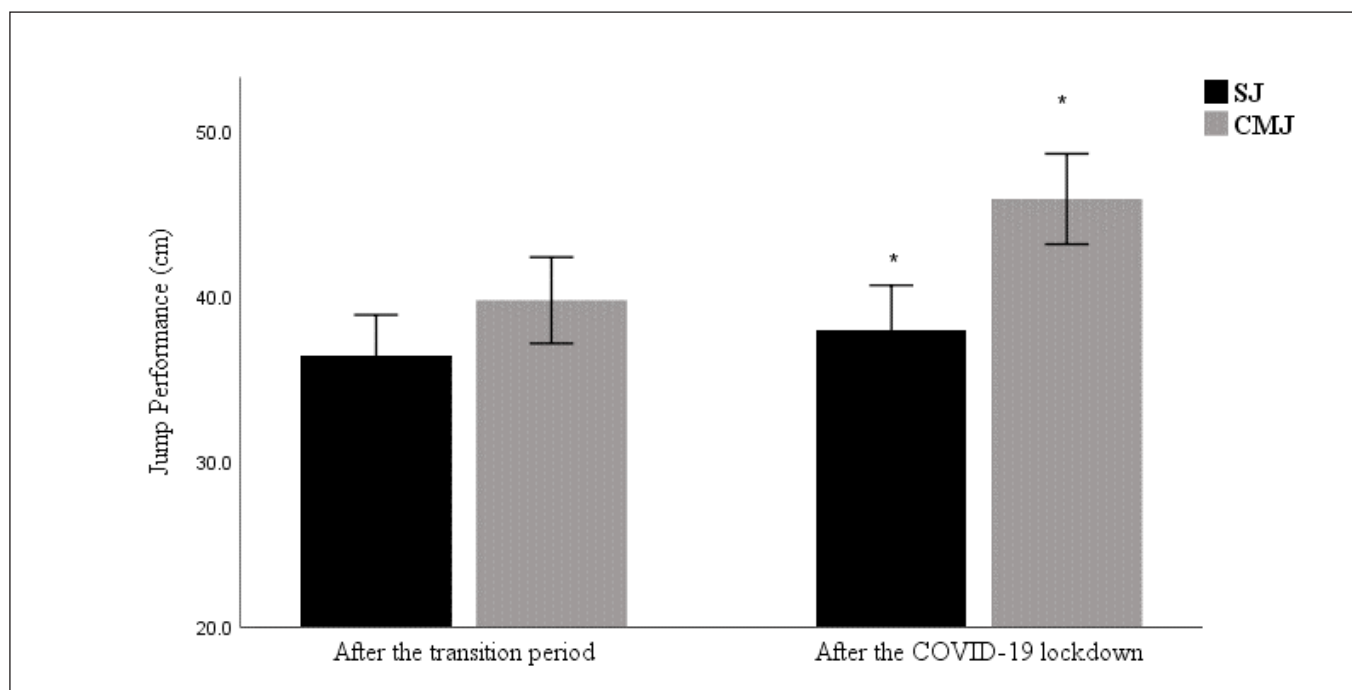


FIG. 1. Squat jump (SJ) and countermovement jump (CMJ) performance of soccer players following the transition period and the COVID-19 confinement.

with their hands on top of each other and palms facing downwards. The players performed 2 practice trials, and the 3rd trial was recorded to the nearest cm.

Lower body strength

The isokinetic knee strength was assessed utilizing the Humac Norm and Rehabilitation device (CSMI, Stoughton, MA, USA). Players performed a 10-min self-paced warm-up on a mechanically braked cycle ergometer (Monark 894 E Peak Bike, Weight Ergometer, Vansbro, Sweden) before the isokinetic testing. Once the players were appropriately positioned on the isokinetic device, they performed five sub-maximal repetitions of concentric knee flexion and extension for familiarization. Testing included three maximal concentric flexion and extension repetitions at an angle speed of 60°/s.

Vertical jump tests

Players' jumping performance was evaluated by the Optojump systems (Micro-gate, Italy). The system's bars were connected to a personal computer which instantly provided the measured outcomes. Measurements were obtained on a stable surface without the need for special preparation of the participants. They were instructed to stand between Optojump bars, and the first task was to perform a squat jump (SJ) with their knee joint bent approximately 100 degrees. The player had to descend into a semi-squat position and hold that position for approximately 3 seconds before takeoff. The task was repeated 3 times with 15-second intervals, and the maximum out of the

3 trials was recorded for the statistical analysis. Thereafter, each player performed 3 consecutive countermovement jumps (CMJ) with the same break between jumps. In the CMJ, the athlete started from a standing position and initiated a downward movement, followed by an upward movement leading to takeoff. In both cases, the hands were placed on the participants' waist, and swinging of the arms was not allowed.

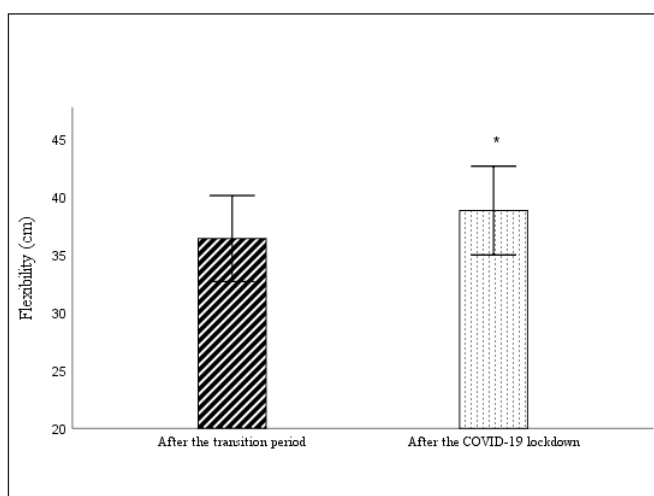


FIG. 2. Lower back and hamstring muscles flexibility of soccer players following the transition period and the COVID-19 confinement.

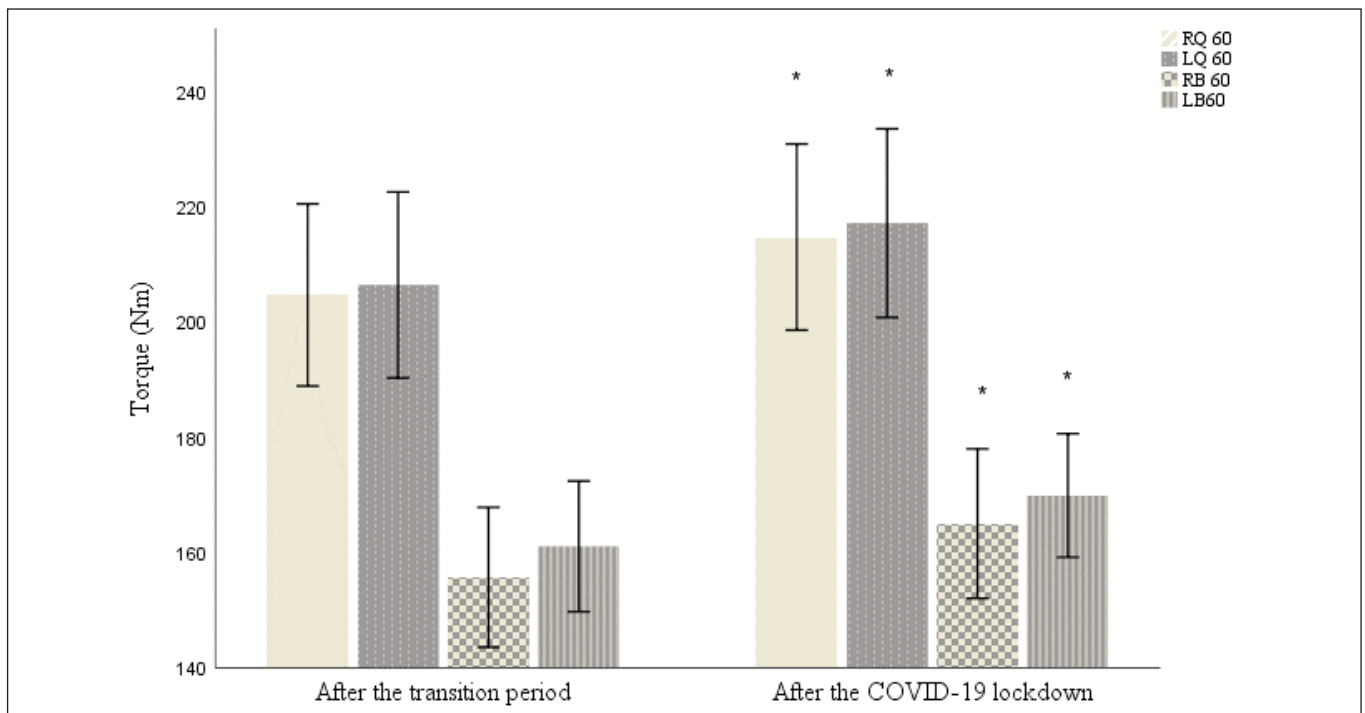


FIG. 3. Peak torque of lower body (right and left quadriceps and hamstring muscles) at 60 degrees/sec, following the transition period and the COVID-19 confinement.

TABLE 1. Anthropometric and body composition parameters of soccer players (n = 19)

	After the 5-week transition period	After the 7-week COVID-19 lockdown
	Mean ± SD	Mean ± SD
Age (years)	27.68 ± 5.99	
Height (cm)	178.47 ± 5.44	
Body Weight (kg)	74.51 ± 5.55	74.48 ± 4.93
BF%	10.72 ± 2.82**	12.28 ± 2.78**

BF%: Body Fat %. *P < 0.05, **p < 0.01.

TABLE 2. VO_{2max}, run time, squad jump, countermovement jump, and sit and reach of soccer players

		After the 5-week transition period	After the 7-week COVID-19 lockdown
	n	Mean ± SD	Mean ± SD
VO _{2max} (ml/kg/min)	18	55.36 ± 3.37	57.36 ± 3.60**
Run time (min)	18	17.03 ± 1.26	18.01 ± 1.32**
SJ (cm)	19	36.43 ± 5.14	38.03 ± 5.52**
CMJ (cm)	19	39.78 ± 5.42	45.92 ± 5.68**
Sit and reach (cm)	19	36.42 ± 7.71	38.84 ± 7.60**

VO_{2max}: Maximal Oxygen Uptake, SJ: squat jump, CMJ: countermovement jump. *p < 0.05, **p < 0.01.

TABLE 3. Lower body strength of soccer players

		After the 5-week transition period	After the 7-week COVID-19 lockdown
	n	Mean ± SD	Mean ± SD
RQ	19	204.79 ± 32.82	214.84 ± 33.55**
LQ	19	206.53 ± 33.52	217.26 ± 33.99**
RB (cm)	19	155.74 ± 25.20	165.05 ± 26.93**
LB (cm)	19	161.11 ± 23.56	169.95 ± 22.26**

RQ: Right quadriceps, LQ: Left quadriceps, RB: Right biceps femoris, LB: Left biceps femoris. *p < 0.05, **p < 0.01.

TABLE 4. Strength training routine for week 1

Weekly muscle strength and power training			
Week 1			
Day	Exercises	Sets	Reps
	10 min cardio Warm up before each training		
Monday	Knee tuck jumps	4–5	8
	Lateral waling lunges	4–5	6
	1-arm bench push ups	4–5	4
	Reverse Lunge/hops	4–5	5
	Nordic curl	4–5	6
	Elevated pushups	4–5	12–15
Wednesday	Elevated Lunge	5	8
	1-leg deadlift jumps	5	5
	Plyometric pushups	5	5
	1-leg squat	5	8
	Nordic curl	5	6
	Dips (triceps)	5	12–15
Friday	Continues circuit		
	Towel knee tucks	4	
	Burpee knee tuck jumps	4	
	Push up rotation	4	Work 30 s
	Wall sit	4	
	1-leg wall sit	4	Rest 20 s
	Long jumps, step back	4	
	Plank rotations	4	
	Hand release pushups	4	
	Body weight squats	4	

TABLE 5. Cardiorespiratory training for week 1

10 minutes warm up before each training session followed by light stretching						
Day 1 Sprints						
Sets	Meters	% intensity		Rest time (s)		
3	70	90		:45		
4	50	95		:45		
5	30	100		:60		
6	10	100		:60		
Day 2 Speed intervals						
Sets	Work (s)	Speed (km/hr)	% intensity	Rest time (s)	Speed (km/hr)	% intensity
1	:60	14	80	:60	8	50
2	:60	14	80	:60	8	50
3	:60	14	85	:60	8	50
4	:60	14	85	:60	8	50
5	:60	14	85	:60	8	50
6	:60	14	90	:60	8	50
7	:60	14	90	:60	8	50
8	:60	14	90	:60	8	50
9	:60	14	95	:60	8	50
10	:60	14	95	:60	8	50
Day 3 Tempo Intervals						
Sets	Work (min)	Speed (km/hr)	% Intensity	Rest time (min)	Speed (km/hr)	% Intensity
1	4:00	13	75	2:00	9	50
2	4:00	13	80	2:00	9	50
3	4:00	13.5	80	2:00	9	50
4	4:00	13.5	85	2:00	9	50
5	10:00	12	85	2:00	9	50
6	10:00	12	90	2:00	9	50
Day 4 continuous running						
45 minutes run at players own pace						

Statistics

SPSS 26.0 for Windows (SPSS Inc., Chicago) was used to analyze the results. Means and Standard Deviations were calculated for all the parameters. The homogeneity of variance and normality assumptions were verified using Brown and Forsythe's and Shapiro-Wilk tests, respectively. Means were compared using a paired-samples t-test. Cohen's d was utilized to determine the effect size. Effect sizes were interpreted as follows: small (0.2–0.4), medium (0.5–0.7) and large (0.8–1.4) [18]. For all statistical analyses, significance was accepted at $p < 0.05$.

RESULTS

The anthropometric and body composition parameters are presented in table 1. The body composition measurements demonstrated that body weight was not significantly different following a 5-week

transition and a 7-week lockdown period. On the contrary body fat percentage was significantly higher after the lockdown period (Table 1) [$t(18) = -5.59$, $p < 0.01$, $d = 0.56$ (medium effect)]. Furthermore, results indicated significantly higher VO_{2max} [$t(17) = -11.54$, $p < 0.01$, $d = 0.57$ (medium effect)] and running time [$t(17) = 3.94$, $p < 0.01$, $d = 0.76$ (medium effect)] values after the COVID-19 lockdown compared to those obtained after the transition period (Table 2). In addition, significantly higher level of performance was demonstrated on SJ [$t(18) = -4.10$, $p < 0.01$, $d = 0.30$ (small effect)], CMJ [$t(18) = -7.43$, $p < 0.01$, $d = 1.11$ (large effect)] (Fig. 1) and sit and reach tests [$t(19) = -5.33$, $p < 0.01$, $d = 0.32$ (small effect)] (Table 2, Fig. 2). Concurrently, lower body strength was indicated to be significantly greater following the COVID-19 lockdown compared to the end of the transition period (Table 3). More specifically right [$t(18) = -5.26$, $p < 0.01$, $d = 0.30$ (small effect)]

and left quadriceps [$t(18) = -4.38$, $p < 0.01$, $d = 0.32$ (small effect)] as well as right [$t(18) = -7.35$, $p < 0.01$, $d = 0.36$ (small effect)] and left hamstring [$t(18) = -5.46$, $p < 0.01$, $d = 0.39$ (small effect)] muscles demonstrated significantly greater values after the 7-week lockdown compared to those obtained after the transition period (Fig. 3).

DISCUSSION

The purpose of the study was to assess the impact of COVID-19 lockdown and home-based individual physical training, on professional soccer players' body composition and physical fitness in comparison to the transition period. Our results revealed that despite the massive challenges of the pandemic, the physical fitness of soccer players was significantly higher after a 7-week lockdown compared to the values obtained following a 5-week transition period.

The lower body strength of quadriceps and hamstring muscles was significantly greater following the lockdown period than the transition period. The values were within the normal range for professional soccer players [19], whereas after the 5-week transition period, quadriceps strength was at the lowest end of the normal range. Research indicated a mean decrease of 14.5% in strength after a detraining period of 7.2 weeks [20]. Furthermore, research demonstrated that athletes could maintain their strength levels for up to 3 weeks of detraining, but decay rates increase thereafter (between 5–16 weeks) [20]. Others indicated that strength could be maintained for up to 4 weeks of inactivity, whereas highly trained athletes' eccentric force, sport-specific power, and recently acquired isokinetic strength, may decline significantly [21].

The superior performance following the 7-week lockdown compared to the 5-week transition period was also evident for squat jump, countermovement jump, and sit-and-reach parameters. Research demonstrated significant reductions in squat jump and countermovement jump performance after six weeks of detraining [6]. The significant reductions in jump performance were evident on both professional [6] and semiprofessional soccer players [22], whereas 6 weeks of detraining did not affect the jump height of recreationally strength-trained men [23]. The aforementioned discrepancy may be attributed to the strength differences of the participants before the inactivity period indicating that athletes with high initial strength levels may experience a reduction in jump heights while the jump ability of individuals with lower strength levels may not be influenced by a period of inactivity [24]. An additional explanation for the observed reduction in jump performance following the transition period may be the negative impact of detraining on fast-twitch fibers that are associated with maximal strength and explosive power, which are in turn associated with SJ and CMJ measures [25].

From the cardiorespiratory perspective, VO_{2max} and run-time parameters were significantly higher following the COVID-19 lockdown than the transition period. Notwithstanding these findings, in both cases, the values were still below the average of 60 ml/kg · min, which is reported as a minimal satisfactory threshold for elite soccer

players [26]. Research affirms that detraining elicited reductions in VO_{2max} of professional [27] and semiprofessional male [28] players as well as elite female soccer players [29]. In addition, research indicated that players who followed a training program during the transition period demonstrated lower reductions in VO_{2max} values compared to those who did not follow any program [27]. Furthermore, adding high-intensity interval training during the 6-week transition period of semiprofessional soccer players could prevent reductions in VO_{2max} [30].

When considering the body composition measurements, while body weight remained stable following the transition and the lockdown periods, body fat percentage was significantly greater post-COVID-19 lockdown. The increase in body fat percentage may be associated with more unhealthy dietary choices during the lockdown, which was evident in the general population [32] or the reduced physical activity [27]. Research indicated that both body weight and body fat percentage increase following the transition period, but these negative gains are smaller for those who follow a training regimen than those who do not [27]. Despite the post lockdown increase in body fat percentage in this study, the rest of the fitness parameters were significantly better compared to the post-transition period. Furthermore, even though body fat percentage was significantly greater post-COVID than in the post-transition period, the values have remained within the expected range for professional soccer players [33]. Last but not least, research indicated that training-induced changes in physical performance can be achieved without body mass reduction after eight weeks of strength and injury prevention-oriented programme [34], which is in agreement with our findings. These findings suggest that the 7-week implementation of this training protocol which was created in line with the practical recommendations for the development of training sessions for soccer players returning to sport following lockdown [13, 14], can improve physical fitness without body mass reduction in soccer players.

Based on a key review study [3], the minimal effective dose for off-season training programs should include 2 sessions per week separated by 48–72 hours. More specifically, the review study suggested that the first training session should include one HIT session per week at 87–97% peak heart rate, while the second session should incorporate a combination of resistance and sports-specific exercises and plyometric training [3]. The program followed by the players in this study included a three times per week muscle strength and power training and four times per week cardiorespiratory training (week 1 training, tables 4 and 5).

Practical implications

While we do not have data to compare the body composition and physical fitness of the soccer players right before the COVID-19 lockdown, the training protocol provided during the confinement was effective in terms of keeping physical fitness at a significantly higher level compared to the transition period. Moreover, coaches and trainers are encouraged to examine the effectiveness of this protocol as

it may help them develop effective periodization programs during the transition period. Nevertheless, it should be noted that the COVID-19 lockdown occurred in March, prior to the completion of the season. The congestion of games that take place at the end of the season might have affected the performance levels of the players and, therefore, the results of this study. Research indicated that physiological and anthropometric parameters decline towards the end of the competitive period due to a number of factors, including but not limited to the increased number of competitive games [31]. Therefore, the performance levels of the players before the covid-19 lockdown might have been different from those before the transition period (after a complete season). Another limitation of the present study is the lack of pre-training examination of physical fitness and the lack of performance analysis during matches after the training protocol. Research on professional soccer players of LaLiga affirms that physical performance determined by running patterns is lower at the beginning of the season and progressively increases during the first 8–10 matchdays until a plateau is reached [35].

Despite the limitations of this study, we consider that it is still essential for coaches and trainers to utilize the individualized training protocol provided during the COVID-19 lockdown. This protocol may aid in the development of effective periodization programs that require

minimal equipment and can be followed in similar situations. In addition, it should be highlighted that this training protocol included exercises (such as Nordic curl) based on eccentric contraction that are essential not only for the increase in strength but also for the prevention of muscle injuries.

CONCLUSIONS

The program followed by the players in this study included a three times per week muscle strength and power training as well as a four times per week cardiorespiratory training. The specific training protocol was effective in keeping physical fitness at a significantly higher level than the transition period. Our results demonstrated that despite the massive challenges of the pandemic, the physical fitness of soccer players was significantly higher after a 7-week lockdown compared to the 5-week transition period. Furthermore, even though body fat percentage was significantly greater post-COVID than in the post-transition period, the values have remained within the expected range for professional soccer players.

Conflict of interest

The authors declare no conflict of interest.

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