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The effects of COVID-19 lockdown on jumping performance and aerobic capacity in elite handball players

AUTHORS: Roger Font[1,2,3], Alfredo Irurtia[4,5], Jose Antonio Gutierrez[6], Sebastià Salas[6], Enric Vila[6], Gerard Carmona[3]

[1] Sport Performance Area FC Barcelona, Barcelona, Spain
[2] National Institute of Physical Education of Catalonia (INEFC), University of Barcelona (UB), Barcelona, Spain
[3] School of Health Sciences, Tecnocampus, Pompeu Fabra University, Mataró, Spain
[4] INEFC-Barcelona Sport Sciences Research Group, National Institute of Physical Education of Catalonia (INEFC), University of Barcelona (UB), Barcelona, Spain
[5] Catalan School of Kinanthropometry, National Institute of Physical Education of Catalonia (INEFC), University of Barcelona (UB), Barcelona, Spain
[6] Medical Services FC Barcelona, Barcelona, Spain

Corresponding author:
Roger Font Ribas
Sport Performance Area FC Barcelona
Av. Onze de Setembre, s/n
08970 Sant Joan Despí
Barcelona, Spain
Ciudad Deportiva Joan Gamper
E-mail: roger.font@fcbarcelona.cat

ABSTRACT: The aim of this research was to analyse the capacity of a home-based training programme to preserve aerobic capacity and jumping performance in top-level handball players during the COVID-19 lockdown. Eleven top-level male handball players from the same team participated in the study. A submaximal shuttle run test and a counter-movement jump test were used to measure the players' aerobic fitness and lower limb explosive strength, respectively. A 9-week home-based training programme was followed during lockdown. Pre-test measurements were assessed before the pandemic on 29 January 2020 and ended on 18 May 2020. Moderate significant mean heart rate increases were found in the late stages of the submaximal shuttle run test after the lockdown (stage 5, 8.6%, $P = 0.015$; ES = 0.873; stage 6, 7.7%, $P = 0.020$; ES = 0.886; stage 7, 6.4%, $P = 0.019$; ES = 0.827). Moderate significant blood lactate increases were observed immediately after the submaximal shuttle run test following the lockdown (30.1%, $P = 0.016$; ES = 0.670). In contrast, no changes were found in jump performance. A structured home-based training programme during the COVID-19 lockdown preserved lower limb explosive strength but was an insufficient stimulus to maintain aerobic capacity in top-level handball players.

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INTRODUCTION

The first cases of coronavirus disease 2019 (COVID-19, caused by SARS-CoV-2) were detected in Wuhan, China, at the end of 2019 [1]. Subsequently, due to the effects of the virus and its easy spread, different countries opted to quarantine and isolate their citizens, confining them to their homes. In Spain, a state of alarm was declared on 15 March, which affected the entire population [2]. At the sporting level, all territorial, national and international competitions were suspended. In handball, the last matches were played on 7 and 8 March 2020 and all players had to stay at home at least until 4 May 2020 [3]. The different competitions did not resume again until August 2020 and only for elite teams (national and European competitions).

The importance in handball of certain levels of strength, speed and aerobic endurance to withstand training and competition is well known [4, 5, 6, 7]. It is also true that high intensity work is increasingly important due to the increase in the number of possessions in the game and the pace of play [5].

During this entire period of home confinement, the players had to work in their respective homes to avoid partially or totally losing previously acquired morphological and physiological adaptations through detraining or a decrease in training [8, 9, 10, 11, 12]. The difficulties of finding optimal spaces to train or having adequate training material and the uncertainty as to when competitions would resume generated frustration and demotivation in many athletes during this period [13]. Individualized work routines were planned to reduce this training handicap as much as possible, and to counter lack of motivation, poor nutrition and resting issues that may affect the athletes' ability to maintain proper habits and routines [10, 14, 15, 16]. In many cases material was provided to the players and group sessions were held by videoconference [10, 17].

Most of the current research on detraining is characterized by much shorter periods of time than that of this pandemic [11, 12]. However, there is a lack of information regarding the capacity of home training programmes to preserve general fitness levels (lower limb explosive strength and aerobic capacity) in top handball players during the COVID-19 lockdown. To the best of our knowledge, only one previous study [14] has investigated the effects of a given training programme in the aerobic capacity of elite handball players. Such studies might provide valuable insights about the real impact of home training programmes to prevent detrimental effects on the general fitness of elite handball players.

Accordingly, the aim of this research was to analyse the effectiveness of a home training programme to preserve aerobic capacity and lower limb explosive strength in top-level handball players during the COVID-19 lockdown.

MATERIALS AND METHODS

Design

A retrospective design was used to compare the change in submaximal shuttle run test and jump test performance. A 9-week home-based training programme was followed during lockdown. Pre-test measurements were assessed before the pandemic on 29 January 2020 and ended on 18 May 2020. The tests were conducted on the same day, first performing the submaximal shuttle run test in two groups of five and six players, respectively, and then the counter-movement jump (CMJ) test. The submaximal shuttle run and the CMJ tests were used to measure the players' aerobic fitness and lower limb explosive strength (both bilateral and unilateral), respectively.

Subjects

The study was conducted on 11 top-level male professional handball players from the same team throughout the same season. These were all international players with their respective national teams during the season in which they participated in this study. The players were three wings (26.3 ± 3.7 years; 185.3 ± 4.7 cm; 83.2 ± 6.5 kg), four backs (29.5 ± 7.0 years; 193.3 ± 5.1 cm; 98.3 ± 7.4 kg), three line players (27.9 ± 6.4 years; 195.0 ± 3.0 cm; 105.3 ± 9.2 kg) and one goalkeeper (27.9 ± 0 years; 190.0 ± 0 cm; 84.0 ± 0 kg). The data were obtained from the periodic monitoring of the players during training sessions. All players signed a contractual clause accepting their participation in research projects; therefore approval by an ethics committee was not required [18]. However, all players were informed about the purpose of the study, the known risks and possible associated hazards. The research was in accordance with the Declaration of Helsinki, and professional players gave informed consent prior to participation through their contracts.

Submaximal shuttle run test

To assess the aerobic capacity of the players, the multistage 20-metre shuttle run test [19] was performed up to stage number 8. The test consisted of running continuously between two lines placed 20 m apart at running speeds increased by appropriate intervals at a pre-recorded beep. Mean velocity started at 8.5 $km \cdot h^{-1}$ for the first minute (stage 1), increasing by 0.5 $km \cdot h^{-1}$ every minute up to 12 $km \cdot h^{-1}$ (stage 8).

During the test, heart rate (HR) was registered using a Garmin HR strap. The HR monitor was linked to the WIMU PRO system (Realtrack Systems, S.L., Almeria, Spain) and data were analysed thereafter using mean HR values for each submaximal shuttle run test stage.

One minute after the end of the test, players were pricked in the earlobe to analyse blood lactate levels [20, 21, 22]. The analysis was performed with a Lactate Scout + lactate analyser and Lactate Scout test strips (Nova Biomedical, Waltham, MA, USA).

Jump

The CMJ test was used to assess vertical jump performance as an indicator of lower limb explosive strength [23]. Players performed a fast flexion movement of the knee joint followed by a maximum-effort vertical jump, maintaining the hands-on-hips position until the final phase of the jump. A contact platform (Chronojump Boscosystem, Barcelona, Spain) was used to assess CMJ height. The hardware was connected to a computer which displayed the vertical jump height (cm) using free software (2.0.2., Chronojump Boscosystem Software, Barcelona, Spain). This type of technology has proven its reliability and validity in other types of research with vertical jump tests [24]. Players performed two bilateral CMJs and two unilateral CMJs with each leg. The best result of each test (height, cm) was recorded and used for further analysis.

Home training programme during COVID-19 lockdown

Each week during confinement, players received a structured training programme to follow at home. Basically, the home-based training programme consisted of five training days, from Monday to Friday, with a break over the weekend. During the first eight weeks, three strength training sessions were performed per week (on Mondays, Wednesdays, and Fridays) and two endurance-oriented sessions (on Tuesdays and Thursdays). During the last week (week 9), two strength training sessions and five endurance sessions (three outdoor running sessions and two stationary bike sessions at home) were performed. There was around a 40% reduction in workload volume between what the players actually did at home during the COVID-19 lockdown and what they would have performed under normal training and competition.

During confinement, players performed an average of 27 strength training sessions, including both individual sessions and online group sessions. All sessions conducted at home followed the medical recommendations derived from the COVID-19 pandemic [9, 25]. All sessions were preceded by a general warm up consisting of ~10 min of low intensity cycling (stationary bike), mobility and lumbo-pelvic stability exercises. In the first four weeks, strength training was endurance-oriented and over the last four weeks strength training was hypertrophy-oriented [26]. Individual hypertrophy-oriented training programmes were organized in super-sets in which a combination of low specificity level exercises (i.e., bilateral squat-based exercises) preceded slightly more specific exercises (more dynamic correspondence with

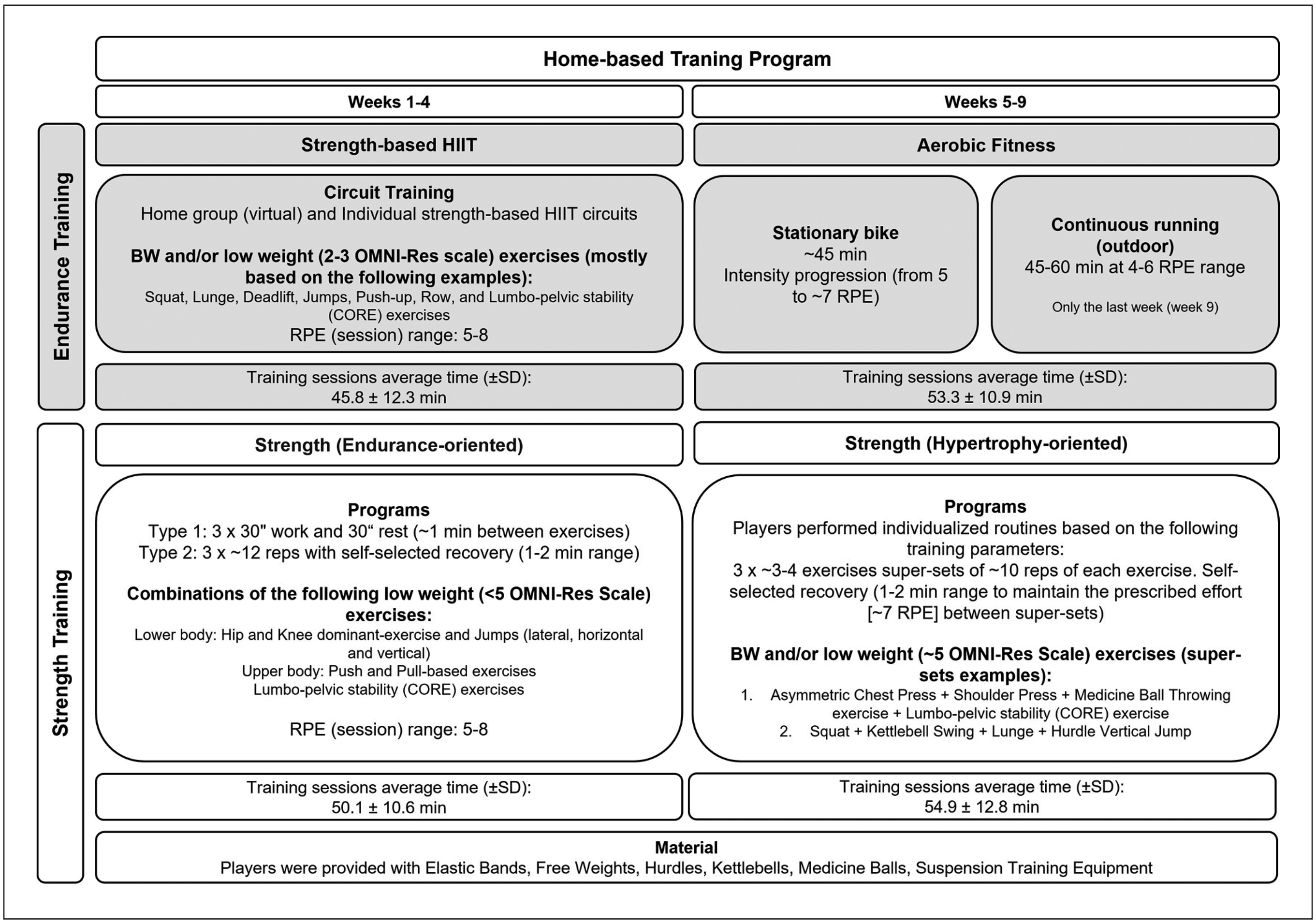

FIG. 1. Home training programme overview. BW, body weight; HIIT, high-intensity interval training; OMNI-Res Scale, Perceived Exertion Scale for Resistance Exercise; RPE, rating of perceived exertion.

handball-specific movements, i.e., vertical jump exercises) [26]. Regarding endurance training, players performed an average of 19 sessions. In the first four weeks, players performed individual strength-based high-intensity interval training (HIIT) circuits, and from the fifth week onwards they were prescribed general aerobic fitness training sessions based on continuous and progressive exercises. Both subjective ratings of perceived exertion (RPE) [27, 28] and the OMNI Perceived Exertion Scale (OMNI-Res Scale) for Resistance Exercise [29] were used to prescribe intensity during training sessions. See Figure 1 for a complete overview of the basic characteristics of the home-based training programme.

Statistics

Data were tested for approximation to a normal distribution using the Shapiro–Wilk test. A paired Student's t-test was used to evaluate differences in variables of interest (body mass, mean heart rate, capillary blood lactate concentration, CMJ height) from pre- and post-lockdown periods. Cohen's d was used to calculate the effect size (ES). Thresholds for ES statistics were trivial (ES < 0.20); small ($0.20 < ES < 0.59$); moderate ($0.60 < ES < 1.19$); large ($1.20 < ES < 1.99$); and very large (ES > 2.0) [30]. All data were reported as mean ± standard deviation and the level of significance was set at $P < 0.05$. All statistical analyses were conducted using SPSS version 23.0 (SPSS Statistics, IBM Corp., Armonk, NY, USA).

RESULTS

No significant differences (ES = -0.036, trivial) were found in body mass following the home training programme (Pre-lockdown: 99.0 ± 12.4 kg and Post-lockdown: 98.6 ± 12.7 kg).

Submaximal shuttle run test

Moderate, non-significant mean HR increases were observed in the early stages of the submaximal shuttle run test (aerobic capacity) (from stage 1, 108 ± 15 and 117 ± 11 bpm; stage 2, 127 ± 11 and 141 ± 21 bpm; stage 3, 133 ± 12 and 147 ± 20 bpm; stage 4, 140 ± 12 and 153 ± 19 bpm of HR mean values from before and after the home training programme, respectively) and moderate, significant changes were observed in later stages (from stage 5,

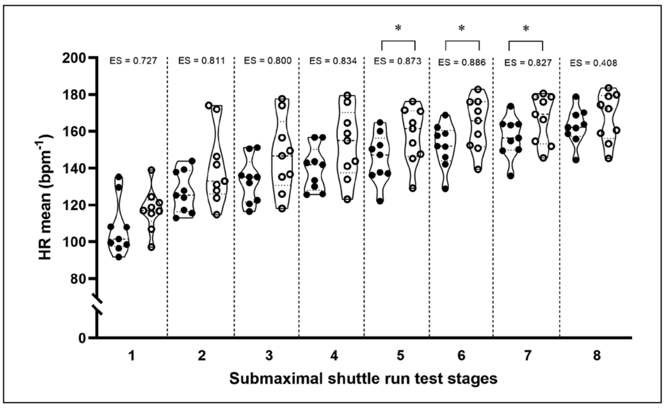

FIG. 2. Mean heart rate values from each multistage 20-metre shuttle run test. Black circles, pre-lockdown; White circles, post-lockdown. ES, Cohen's d effect size. *Significantly different at $P < 0.05$.

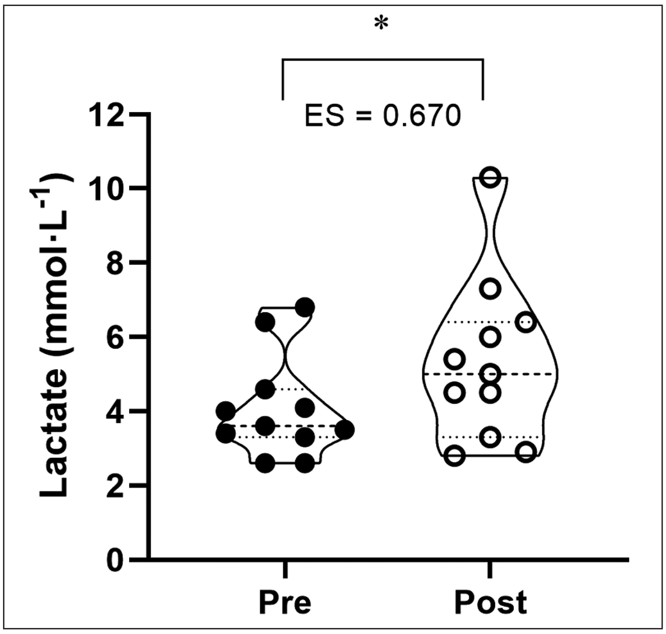

FIG. 3. Capillary blood lactate concentration. Black circles, pre-lockdown (Pre); White circles, post-lockdown (Post). ES, Cohen's d effect size. *Significantly different at $P < 0.05$.

145 ± 13 and 158 ± 15 bpm [$P = 0.015$]; stage 6, 152 ± 12 and 164 ± 14 bpm [$P = 0.020$]; stage 7, 157 ± 11 and 167 ± 13 bpm [$P = 0.019$] of HR mean values from before and after the home training programme, respectively) (see Figure 2). Finally, only small, non-significant increases were found in the last stage (stage 8, 163 ± 10 and 168 ± 13 bpm of HR mean values from before and after the home training programme, respectively). The results from this test were derived from 9 players due to HR band registration problems with 2 of the players from the sample.

Regarding lactate, moderate, significant increases (4.1 ± 1.4 and 5.3 ± 2.2 [$P = 0.016$] mmol/L mean values from before and after the home training programme, respectively) were found (see Figure 3).

Jump test

No changes were found in jump performance (41.8 ± 8.3 and 41.0 ± 7.0 cm of bilateral CMJ, 20.9 ± 7.3 and 22.3 ± 4.7 cm of unilateral CMJ [right], and 21.7 ± 4.4 and 22.4 ± 3.2 cm of unilateral CMJ [left] height from before and after the home training programme, respectively) (see Figure 4).

DISCUSSION

The aim of this research was to analyse the ability of a home training programme to preserve aerobic capacity and jumping performance in top-level handball players during the COVID-19 lockdown. The home training programmes followed by the players maintained lower limb explosive strength, measured as CMJ performance (jump height), but appeared to be insufficient to maintain aerobic capacity.

Aerobic capacity

Moderate, significant HR increases were observed in the last stages of the submaximal shuttle run test after the COVID-19 lockdown (see Figure 2). This might be indicative of a loss of aerobic capacity [31, 32]. It has been well established that detraining, due to training suppression or inadequate training, induces maximum HR increases (between 5% and 10%) [11]. Although this was not exactly the case during the lockdown scenario, the home training programmes probably failed to provide a sufficient stimulus to maintain aerobic capacity in elite handball players. This was also previously described by Fikenzer et al. [14], who found that endurance capacity, measured by the maximum mean velocity achieved in a multistage 20-metre shuttle run test, was diminished in most elite handball players from a given team due to the unspecific and inadequate stimuli provided by a home-based training programme during the COVID-19 lockdown. Dauty et al. [32] obtained similar results with the yo-yo test in young football players. The dependence on volume of endurance training responses [33] would explain the incapacity of home training programmes to maintain aerobic capacity in highly trained top handball players. In fact, the home training volumes were approximately 40% lower than those achieved during the regular season immediately before the lockdown. Moreover, our players only received running-specific stimuli during the last two weeks of the lockdown (see Figure 1), reinforcing the notion that the lack of training specificity also contributed, to some extent, to the loss of aerobic capacity [14, 32].

The moderate, significant increases in lactate after the COVID-19 lockdown were also indicative of a decrease in the players' aerobic capacity (see Figure 3) [11, 34]. Specifically, lactate increases are indicative of a reduction in the oxidative capacity of the

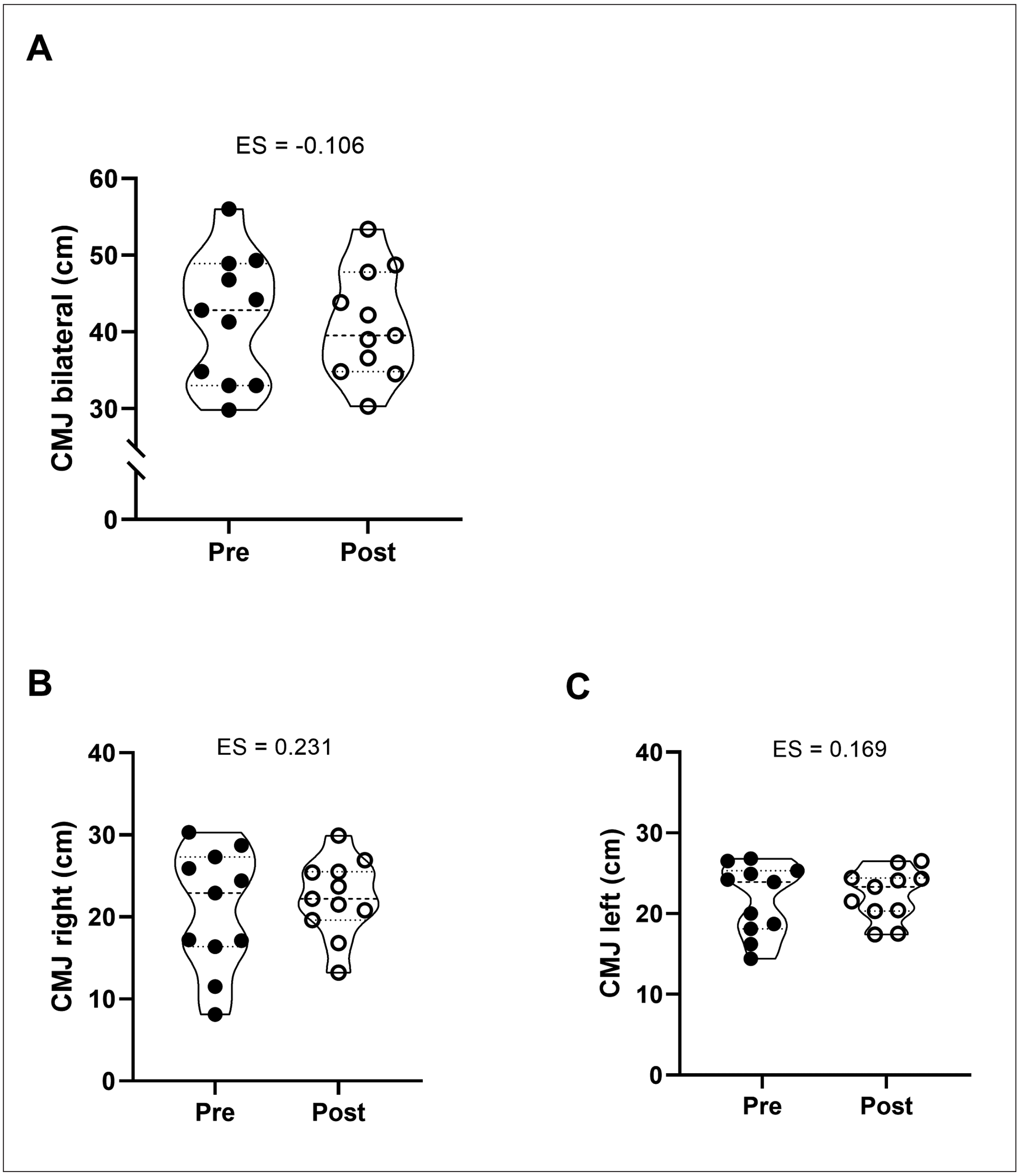

FIG. 4. Counter movement jump (CMJ) height. Black circles, pre-lockdown (Pre); White circles, post-lockdown (Post). ES, Cohen's d effect size.

muscle [11] and present a high correlation with endurance capacity in trained populations [35]. Together with HR values, these results confirmed that home-based endurance training was insufficient to maintain aerobic fitness in top-level handball players. However, it must be considered that since only moderate (ES) changes in aerobic fitness indicators (HR and lactate) were found after the lockdown, it seems reasonable to expect a rapid recovery of pre-lockdown values when players returned to on-court sport-contextualized training regimes.

Lower limb explosive strength

Regarding CMJ performance as an indicator of lower limb explosive strength [23], no changes were found between the two test periods (see Figure 4), showing that the training stimuli provided by the strength home-based training programme (Figure 1) were adequate to preserve jump capacity. Despite certain signs of detraining in neuromuscular-related qualities and peak power output, similar results have been previously reported in the literature about home training programmes' capacity to preserve jump performance (height) in professional football players [36, 37] and futsal players [38]. Specifically, Rampinini et al. [37] analysed fifty professional football players and found that 2–3 bodyweight or small weight strength training sessions per week at home during the COVID-19 lockdown preserved CMJ height despite a moderate (ES) loss in peak power output. Those authors [37] also obtained similar results following the transition period, where similar bodyweight training strategies were implemented. In this regard, it has also been observed in national level handball players that a 7-week interruption of the external weight-based strength training, where players only performed sport-specific training and bodyweight exercises, was enough to maintain jump performance (height) [39]. Therefore, and although a certain degree of loss in jump-related neuromuscular qualities might be expected, home-based lower limb strength training programmes, despite the differences in training contents and strategies (including equipment), seem to be capable of maintaining jump performance measured as CMJ height.

Limitations

An important limitation of this study was the impossibility of assessing the whole team after the lockdown because many players were in their respective home countries. Despite this limitation, 11 top-level handball players were analysed, all of whom were international players with their respective national teams. Finally, since the findings of this study come from 11 high-level handball players from a single team, caution is advised when generalising from these results, as different home training strategies in different team sport athletes might induce different adaptations.

Practical applications

A structured home-based training programme based on body weight and low weight exercises provides a sufficient stimulus to maintain jump performance (jumping height), an indicator of lower limb explosive strength, in top-level handball players. In contrast, the home-based training programme described did not succeed in preserving aerobic fitness in the cohort under study. Earlier implementation of aerobic fitness training strategies might have helped in the preservation of players' endurance capacity. However, since the loss in aerobic fitness indicators was moderate (ES), a rapid recovery of pre-lockdown values may be expected when players return to on-court sport-contextualized training regimes. Overall, the results of this study support existing general recommendations on the training approach during COVID-19 lockdown periods [40].

CONCLUSIONS

In conclusion, a structured home-based training programme during the COVID-19 lockdown preserved lower limb explosive strength but was an insufficient stimulus to maintain endurance capacity in top-level handball players.

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Disclosure statement

The authors declare no potential conflicts of interest.

Conflict of interest declaration

The authors declare no potential conflict of interest.

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