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Lessons from the COVID-19 pandemic: Insights into effective training strategies for physical development in football

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Abstract

Professional soccer players typically perform regular training sessions and match play for most of the yearly macrocycle with limited time focused on solely developing physical development. The COVID-19 outbreak in 2020 caused mass disruption to professional soccer but provided an opportunity for an alternative approach to training in attempt to develop professional soccer players physical fitness levels. In a non-randomised and non-controlled study, we aimed to assess the effectiveness of a 13-week remote based physical training programme on physical fitness levels in elite professional soccer players. Twenty professional soccer players undertook body composition assessments, a countermovement jump (CMJ) test, eccentric hamstring strength test and a submaximal 30–15 intermittent fitness test (IFT) pre- and post-remote based training programme. Body mass (79.3 ± 6.7 vs. 80.0 ± 7.3 kg), skinfold thickness (54.1 ± 14.8 vs. 56.7 ± 15.2 mm), maximum CMJ height (38.4 ± 3.4 vs. 40.9 ± 4.1 cm), eccentric hamstring strength (1035 ± 158 vs. 1009 ± 140 n) and percentage max heart rate reached in submaximal 30–15 IFT (81.3 ± 5.2 vs. $82.3 \pm 7.3\%$) were maintained (all $P > 0.05$) from pre- to post training programme, respectively. Although team-based soccer specific training load was removed, and the training programmes prescribed had an increased physical focus, fitness levels were maintained. This suggests that alternative modes of training can potentially be used in instances where team-based soccer specific training load isn't required or is unavailable, without negatively impacting physical development.

Keywords

Anthropometry, eccentric muscle action, hamstring strength, heart rate, soccer

Introduction

For 10–11 months of the year soccer players complete both team-based soccer specific training (team based tactical and technical drills as well as fitness and conditioning activities) and match play.[1–3] These demands often make it challenging to obtain the right balance of activity(s) to promote adaptations that improve performance,[4] maintain freshness for match play[5,6] and reduce injuries.[7] This provides practitioners with many restrictions on the training approaches for professional soccer players, limiting them to team-based soccer specific training. Removing these restrictions around the planning of routine soccer activity provides a unique opportunity to evaluate if different approaches to training have the potential to develop fitness capacities and lead to alternative planning strategies than those that are traditionally used in professional soccer. These "alternative" approaches (i.e. high-intensity interval training (HIIT) versus regular team-based soccer specific training and match play) may offer potential solutions to the difficulties of in-season training methods in subsequent seasons.

The 2020 coronavirus disease pandemic (COVID-19) had serious implications for global high-performance sport. Soccer in the UK had matches and training suspended

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indefinitely in March 2020. Consequently, players were required to train both remotely and individually for an extended period to offset the effects of the removal of team-based training and match play on players' health and performance.[8] This situation required key staff at clubs to change the usual training approach in terms of both the delivery strategy and content to limit detraining[9,10] and improve some physical capabilities.[2] Unlike traditional off-season programmes, there was an uncertainty around a return to training date, which meant players were kept in regular contact with key staff at the club. This provided a unique chance to evaluate non-traditional approaches to the physical development of players.

Previous research conducted pre and post the COVID-19 remote training period has identified significant reductions in professional soccer players physical fitness levels.[11–14] However, these studies were unable to provide details of individual remote based training programmes that were provided to players during this period. Therefore, the aim of this study was to assess a 13-week remote based training programme on elite professional soccer players fitness levels. We present a novel case study where the traditional approach to the training of soccer players was inadvertently altered to one that was remote in its operation and more fitness focussed in its content than traditional training programmes.

Methods

Experimental approach to the problem

Towards the end of the 2020 Scottish Premier League (SPL) soccer season (March 2020), games were suspended, and players were told to remain home until further notice due to the outbreak of COVID-19 (see Figure 1). Players (along with the public) were informed that they were allowed outside of their homes once per day for exercise and to otherwise remain home, when possible, thereby removing their exposure to team-based soccer specific physical activity. For teams within the SPL, this period lasted 94 days (~13 weeks) before players were allowed to re-enter the training ground. Throughout this period, players were allowed to return to their home nations (different restrictions in each country) and were told to reside there until they were instructed to return to the training ground. This period occurred during the second in season phase where players were regularly competing in training and match play. Table 1 provides an indication of 'typical loads' performed by players during each phase prior to the training programme commencement.

Due to the length of the period away from the club (around 8–9 weeks longer than a usual off-season), a comprehensive training programme was developed in the attempt to impact the fitness capabilities of players. Players received their programmes a week in advance and were advised how to accurately undertake them by the club's performance staff. They did not report any physical activity outside of their provided programme. The physical qualities were selected using a needs analysis and evaluated using a testing battery (see Figure 2). Examples of altered training sessions include limitations on resistance training equipment and for players who had a goal of reducing body fat. To overcome these issues, players were instructed to construct resistance training devices using household equipment and perform additional 30–45 min of cycling exercise per day, respectively. Additionally, the programmes were supported via remote communication to assist with compliance throughout the remote training period.

Participants

In a non-randomised and non-controlled study, twenty elite professional soccer players from a SPL club (mean ± SD, age 26 ± 4 years, height 182 ± 6 cm, body mass 79.2 ± 7.1 kg) took part in this study. Authors calculated a *priori* the statistical power of this study using G*Power (version 3.1.9.7, Heinrich Heine University Düsseldorf, Germany). A sample size of 15 participants was necessary to have sufficient power (0.82) based on alfa selected (5%) and a *moderate* effect size ($d = 0.8$). Participants from outfield positions were assessed (3 wide defenders, 5 central defenders, 4 central midfielders, 6 wide midfielders and 2 attackers). Participants were excluded from the study if they were

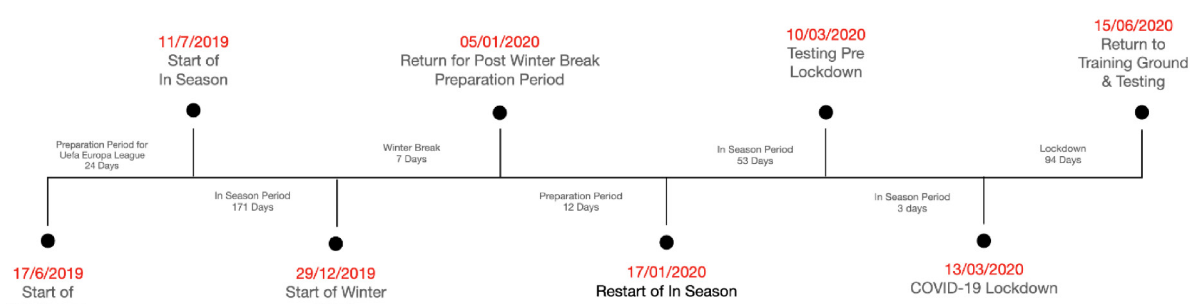

Figure 1. A timeline of the professional soccer teams season up until the project completion.

Table 1. An overview of the participants previous loading data from the start of their current season leading into the commencement of the remote training programme.

	Preseason phase 1 (June - July 2019)	In season phase 1 (August-December)	Preseason phase 2 (January 2020)	In season phase 2 (January – March)
Training Frequency/ week	8 ± 1.2	5 ± 2.1	6 ± 1.7	4 ± 1.3
Match Frequency/ week	1 ± 1.0	2 ± 0.8	2 ± 1.3	2 ± 0.7
Average Duration/ week (mins)	520 ± 63	390 ± 161	375 ± 163	328 ± 122
Average Total Distance/ week (m)	43623 ± 5035	33026 ± 11791	32418 ± 9297	27670 ± 10593
Average High-Speed Running (19.8–25.2 km/h)/ week (m)	1659 ± 420	1646 ± 932	1288 ± 232	1173 ± 499
Average Sprinting Distance (> 25.2 km/h)/ week (m)	246 ± 72	256 ± 166	220 ± 86	232 ± 128
Average High Intensity Accelerations (>3.0 m/s^2)/ week	18 ± 9.1	91 ± 55.7	98 ± 58.3	89 ± 34.9
Average High Intensity Decelerations (<−3.0 m/s^2)/ week	27 ± 3.4	67 ± 37.9	74 ± 41.3	72 ± 30.8
Lower Body Loading (sets/ week)	24 ± 2.3	9 ± 5.1	3 ± 0.8	4.5 ± 2.1
Upper Body Loading (sets/ week)	45 ± 4.6	42 ± 9.1	12 ± 3.6	38 ± 6.4

Data expressed as Mean ± SD.

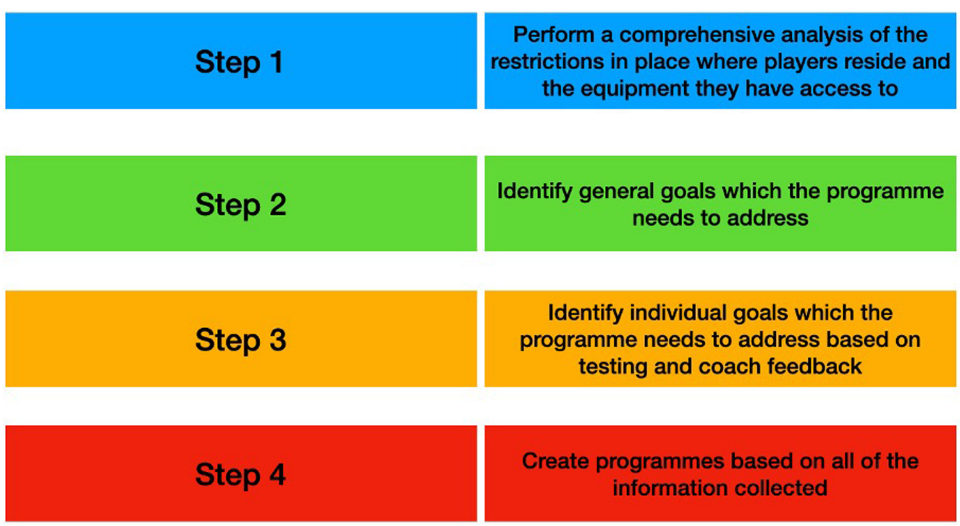

Figure 2. An overview of how training programmes were designed from weeks 6–13.

deemed to have undertaken <90% of the programme and weren't able to perform both the pre- and post-training programme testing protocols. Goalkeepers were excluded from the study as they undertook different training programmes in line with their individual needs and requirements. Participants were asked to remain professional throughout the testing period by maintaining a healthy lifestyle and regular remote based communication techniques with the club's performance staff allowed 'check ins' to ensure participants were adhering to best practise. Data was collected as part of routine testing already planned by the club. Consequently, the approval of an ethics committee was not required.[15]

Procedures

Participants entered the training ground at 09:30 am to perform body composition assessments. They were asked to consume the same breakfast on both testing days and consumed this immediately post body composition assessments. After breakfast (~1 h later) they performed (in order) the countermovement jump (CMJ), eccentric hamstring strength test and submaximal 30–15 intermittent fitness test (IFT). Tests were performed 3 days after the last competitive game or training session to limit fatigue and muscle soreness, with the pre-testing being 3 days before they were told to remain remote and not enter the training ground. Upon return, 94 days (~13 weeks) after they were told to remain home and after the training programme, participants entered the training ground and performed the tests again (in the same order and time of day), whilst following COVID-19 restricted protocols (i.e. full personal protective equipment for staff, social distancing procedures and sterilisation of equipment). Before both testing sessions participants were instructed to arrive at the training ground undertaking their usual sleeping habits and not consume caffeine until after the assessments. All tests were performed at the clubs indoor training facility where ambient temperature was controlled (~19°C). To avoid inter-observer variability, the same observer undertook each assessment both pre-and post Participants were familiar with testing protocols prior to this study commencement.

Body Composition. Participants underwent a body composition assessment 1–2 h after waking, upon arriving at the training ground, in a fasted state and prior to performing any exercise. They were advised to consume habitual nutritional intake in the days prior to assessment. Semi-nude body mass was measured by a digital scale (SECA, 876, Hamburg, Germany) to the nearest 0.1 kg. Skinfold thickness was measured by an International Society for the Advancement of Kinanthropometry (ISAK) Level 1 anthropometrist following the protocol established by ISAK.[16] Skinfold thickness was assessed at the ISAK 8-sites of measurement (triceps, biceps, subscapular, iliac crest, suprasinale, abdominal, anterior thigh and medial calf).[17] All landmark sites were firstly identified, marked and measured before any measurements were recorded, with each site being measured in succession to avoid experimenter bias and reduce the effects of skinfold-compressibility prior to repeating measurements for a second time.[18] The mean of the two first measures were used for analysis and a third measure was triggered if a 5% technical error of measurement (TEM) was exceeded and consequently, the median of the triplicate measurement was used for subsequent analysis as advised by ISAK. The inter-tester TEM ranged from 2.5% to 4.4% over both data collection periods, which is below the 5% standard required for ISAK level 1 accreditation.[19] The total skinfold thickness obtained from all 8 sites summated was used for analysis.

Jump Performance. After breakfast and ~1 h of rest, participants performed a CMJ on a ForceDecks FD4000 Dual Force Platforms (VALD Performance, Brisbane, Queensland, Australia). Force plate data were sampled at 1000 Hz and analysed via ForceDecks software. This devise is considered reliable assessment for CMJ height (CV = 3.3%).[20] Prior to commencing, participants performed a warmup according to methods outlined by Barker et al..[21] This warmup was standardised for each player and acted as a warmup for the eccentric hamstring strength test. Force plates were calibrated according to manufacturer's guidelines prior to both testing sessions and were zeroed prior to each participant stepping onto the plates. Participants were instructed to stand as still as possible prior to performance any jumps to determine body weight. The force-time curve was visually inspected to ensure limited movement occurred in the weighing phase, and a signal was provided by the software when an accurate bodyweight was taken. The participants were then instructed to perform the CMJ with equal weight on both force cells and their hands remaining on their hips throughout. Following 3-2-1 countdown, participants were instructed to drop to a self-selected countermovement depth, perform a maximal vertical jump, and land back onto the force plates. They were given 3 trials to obtain their maximum jump height in each test, with 15 s of rest between them (CV between the 3 trials was pre-testing = 3.7% and post-testing = 2.4%). Two members of the research team visually monitored each attempt to identify failed attempts. The maximum value from all 3 jumps was recorded in cm for analysis. Seventeen participants completed both pre- and post-assessments.

Eccentric Hamstring Strength. After a rest period of ~10 min from CMJ completion, participants underwent a Nordic hamstring exercise on a commercially available device with load cells (VALD Performance, NordBord, Queensland, Australia) to measure the bilateral eccentric knee flexors strength. This devise shows high to moderate test-retest reliability for bilateral peak force within the Nordic hamstring exercise (intraclass correlation coefficient = 0.83–0.90 and standard error of measurement 6–9%).[22] Participants knelt on a padded board, with the ankles secured immediately superior to the lateral malleolus by individual ankle braces that were attached to custom-made uniaxial load cells. The ankle braces and load cells were secured to a pivot, which allowed the force to always be measured through the long axis of the load cells. Participants performed 3 repetitions of the Nordic hamstring exercise, with a minimum 30-s interval between them. For a valid repetition, participants started from the initial upright position (kneeling, with the hip neutral and the torso upright), lay the torso to become horizontal to the floor by only using the knee joint (e.g. without altering the position of the hips or spine), in a slow speed and using eccentrically the hamstring muscles with maximum intensity and amplitude possible to avoid the acceleration and consequent torso fall. Participants were allowed to use their upper limbs to absorb the fall if they failed to avoid acceleration of the torso. A trial was deemed acceptable when the force output reached a distinct peak (indicative of maximal eccentric strength), followed by a rapid decline in force, which occurred when the participant was no longer able to resist the effects of gravity acting on the segment above the knee joint. Two members of the research team (same individuals on each test pre- and post) observed the movement to control for variability. If tests were deemed invalid, participants were told to restart testing >3 min after their last failed repetition. In line with previous research[23] and typical practises performed after off season periods within the club, force values were registered in every repetition and the bilateral peak value, measured in newtons (n) was used for analysis. Fifteen participants completed both pre- and post-assessments.

Aerobic Fitness. Participants performed the submaximal 30–15 IFT using the running protocol outlined by Buchheit.[24] The test began on level 10 and ran until completion of level 15. It lasted for a total duration of 8 min. During the last 30 s of level 15, the final 10 s maximum heart rate reached during the test was measured with heart rate monitors (Polar, Kempele, Finland) and taken from the global positioning system (GPS) software (Catapult, Vector, Australia). A detailed explanation of the processes taken to obtain data from GPS can be found elsewhere.[25] Global positioning systems were used as a heart rate system is integrated into the software. This system has previously been validated against the gold standard ($r = 0.99$) and take beat by beat measurements of heart rate.[26] Through internal research conducted over >4 years, this test has previously been found to have high levels of CV within this group of participants (2%) (unpublished data) and considered a reliable test by the investigation team. Similar submaximal tests that utilise heart rate as measures have been identified as valid and reliable measures to assess aerobic capacity.[27–29] At the beginning of the most recent preseason period in July 2019 maximal heart rate was obtained through a maximal 30–15 IFT. Fourteen participants completed both pre- and post-assessments.

Overview of the intervention in place

The intervention was designed by members of the research team after the lockdown period was announced. Therefore, it was difficult to accurately prescribe both resistance training and running load. Participants were asked to undertake resistance training with the weight and effort accounting to their ratings of perceived exertion. For running exercises, participants were told to run set distances within certain times (equating to a percentage of their maximal aerobic speed that was obtained in January testing). Participants were instructed to perform all running sessions outdoors and if possible, on a grass surface. They were instructed to perform resistance training exercises at home with the relevant equipment available to them. Participants were familiar with this type of work as it has been present in previous off-season and within season individual programmes.

For the initial 4 weeks (Stage 1), participants were instructed to undergo a generic off-season programme (see Table 2) designed to maintain force production,[30] avoid any significant detrimental body composition changes,[31] maintain VO2max[32] and maintain tendon stiffness.[33] Throughout weeks 6–13 (Stages 2 and 3) programmes were more specific to soccer (i.e. involving non-linear movements and some ball work) and individualised to each specific participant based on a needs analysis (see Figure 2) performed. In weeks 5 and 9 participants undertook a period of 'de-loading' where session frequency was reduced (see Table 2). In addition to the training programmes, participants were advised to adhere to a *low carbohydrate, high protein diet* of 3 $g.kg^{-1}$ carbohydrates, 2 $g.kg^{-1}$ protein and <1 $g.kg^{-1}$ fat. These guidelines were in line with that of[34] where favourable body composition alterations were made despite major alterations to habitual loading and activity.

In a conscious effort to maintain communication between the participants and staff members (both inter- and between-group), participants were allocated to specific staff members from the performance team. Each member of the club's performance team had a direct line to participants where they were able to train participants, communicate and feedback information to them remotely over video call (Zoom™, United States). At the conclusion of each week (or if needed at any point throughout), the club's wider performance team provided updates of each participant to the performance team over the video meeting platform. Staff monitored player adherence to the HIIT programme via a commercially available mobile phone application (STRAVA, California, USA) although due to difficulties within the technology, it was difficult to monitor player application. In addition, measures of internal load were attempted through wearable technology (WHOOP, Massachusetts, USA). However, due to the nature of data collection via these methods and the climate that participants and staff were working in at this time, these data sources were incomplete and not reported within this study. All the above was discussed in individual weekly meetings, providing both the staff member or the player to raise any ongoing or upcoming issues and overcome with an action plan accordingly.

Statistical analysis

The Shapiro-Wilk test and visual inspection of Q-Q plots were used to assess normality distribution of data. Students paired *t*-tests to determine any change from pre- to post-test for all variables. All data are presented as mean ± standard deviation (SD). Alpha level was set to 0.05. The Statistical Package for the Social Sciences (SPSS, Version 26, IBM, Armonk, NY, United States) was used for statistical analyses. Effect sizes (Cohen's d) with precision of estimated by the 95% confidence intervals

Table 2. An overview of the 13-week training programme and the transition through different phases for principles of training and exercise selection.

	Lower Body Resistance		
Goal	**Recover, Regenerate and Maintain**	**Muscle Hypertrophy**	**Strength**
Weeks	1–4	6–8	10–13
Frequency/ week	1–2	2	2
Rep range	4–6	4–8	3–6
Sets/ session	14–19	28	28
Ratings of Perceived Exertion	8–9	8–9	8–9
Exercise selection	Rear Foot Elevated Split Squat Leg Press Eccentric Copenhagen's Romanian Deadlifts Nordics	Back Squat Romanian Deadlifts Rear Foot Elevated Split Squat Nordics Eccentric Copenhagen's Feet Elevated Hip Lifts	Back Squat/ Trap Bar Deadlift Romanian Deadlift Rear Foot Elevated Split Squat Nordics Eccentric Copenhagen's Barbell Hip Thrust
	Upper Body Resistance		
Goal	**Recover, Regenerate and Maintain**	**Gradual Rebuild**	**Muscle Hypertrophy**
Weeks	1–4	6–8	10–13
Frequency/ week	1–2	2	2
Rep range	6–10	4	8–15
Sets/ session	13–18	24	32
Ratings of Perceived Exertion	7–8	7–9	7–8
Exercise selection	Dumbbell Bench Press Single Arm Dumbbell Row Pull Ups Dumbbell Shoulder Press	Barbell Bench Press Bent-Over Row Landmine Press (Half Kneeling) Pull Ups Single Arm Dumbbell Row Incline Dumbbell Bench Press	Barbell Bench Press Bent-Over Row Landmine Press (Half Kneeling) Pull Ups Single Arm Dumbbell Row Incline Dumbbell Bench Press
	Core Strength		
Goal	**Recover, Regenerate and Maintain**	**Gradual Rebuild**	**Continuation**
Weeks	1–4	6–8	10–13
Frequency/ week	1–2	2	2
Rep range	4–10 or 30–45s	15s	15s
Sets/ session	18–24	20	20
Exercise selection	Swiss Ball Mountain Climbers Pallof Press (Half Kneeling) Side Plank Swiss Ball Deadbugs Alternating Shoulder Taps Overhead Pallof Press (Half Kneeling)	Front Plank Left Side Plank Reverse Plank Ride Side Plank	Front Plank Left Side Plank Reverse Plank Ride Side Plank

(continued)

Table 2. (continued)

Running Based Conditioning			
Goal	**Recover, Regenerate and Maintain**	**Rebuild Fitness**	**Continual Loading**
Weeks	1–4	6–8	10–13
Frequency/ week	2–3	4–5	4–5
Volume of Training	Low	Moderate	High
Intensity of Effort (%)	Moderate (70%)	Mod-High (70–80%)	High (>80%)
Maximal Aerobic Speed (%)	65–120	85–140	85–140
Complexity of Tasks	Low	Moderate	High
Average No. of Sessions/ week	2.5	4.3	4.3
Duration/ session (minutes)	49	51	52
Average Distance/ session (m)	8300	5669	5451
Average High-speed distance/ session (m)	270	762	490

Note: Weeks 5 and 9 were de-loading weeks. Players were instructed to perform 2 pitch based running sessions, 1 lower body, 1 upper body and 1 core resistance training sessions. External load from running based conditioning was calculated using both commercially available smartphone applications (Strava, California, USA) and estimated based off the players maximal aerobic speeds.

(95% CI)[35] were calculated to provide an estimate of meaningfulness of comparisons between pre- and post-test results. The thresholds for effect sizes statistics were as follows: <0.2, trivial; 0.2–0.6, small; 0.6–1.2, moderate; 1.2–2.0, large; >2.0 very large.[36]

Results

Testing data

A full overview of the training programme results for all fitness assessments pre- and post-training programme can be found in Figure 3(a-e). Participants were prescribed a training programme which included HIIT aimed to improve aerobic capacity, although this produced no difference for percentage max heart rate reached in the submaximal 30–15 IFT pre and post training programme ($P = 0.63$, $ES = 0.15$, 95% CI 0.361, 0.695). CMJ performance and eccentric hamstring strength after lower body resistance training led to no significant difference for either fitness assessment ($P = 0.06$, $ES = -0.67$, 95% CI 0.115, 1.165; $P = 0.46$, $ES = 0.18$, 95% CI 0.261, 0.768, respectively). Alongside the programmes provided to participants, they were advised to adhere to a *low carbohydrate, high* protein diet in an attempt to limit fat mass gain and increase lean mass. There was no significant difference between pre and post training programme for skinfold thickness ($P = 0.07$, $ES = 0.18$, 95% CI 0.012, 0.842) or body mass ($P = 0.13$, $ES = 0.11$, 95% CI 0.094, 0.746).

Discussion

The aim of the current study was to examine the effects of a 13-week individual remote physical fitness programme on adaptations in elite professional soccer players. The individual remote physical fitness programme administered was able to maintain fitness adaptations that were present at the point of evaluation during the in-season period. This data would seem to suggest that different strategies to both the content and the delivery of training may provide alternative approaches to supporting the physical capabilities of players. Given that HIIT training can lead to aerobic adaptations,[37] and resistance training can improve explosive power[38] and eccentric strength,[39] we highlight that these interventions were able to provide an alternative strategy of training when team-based soccer specific training load was removed.

A key physical component of professional soccer match play is aerobic fitness.[40] In attempt to improve aerobic fitness adaptations, players undertook HIIT over the 13-week training programme (see Table 2). We found no reductions in aerobic fitness after the 13-week training programme (see Figure 3(a)), demonstrating that this approach was potentially effective in maintaining the aerobic fitness of the participants. Given that the training programme started after an abrupt end to the competitive in-season (see Figure 1 and Table 1), aerobic fitness was likely already well developed, and the training programme administered was not at a volume or intensity to elicit further adaptations. Indeed, performing HIIT versus regular small-sided games provides no additional benefit for aerobic performance.[41] Therefore, the HIIT performed in the current study could be a useful method to 'substitute' team-based soccer specific training load. To elicit positive aerobic adaptations to increase fitness levels, an increase in training volume may be required throughout the remote training period.[14] Nevertheless, performing HIIT as an alternative to regular training and match play seems to be able to

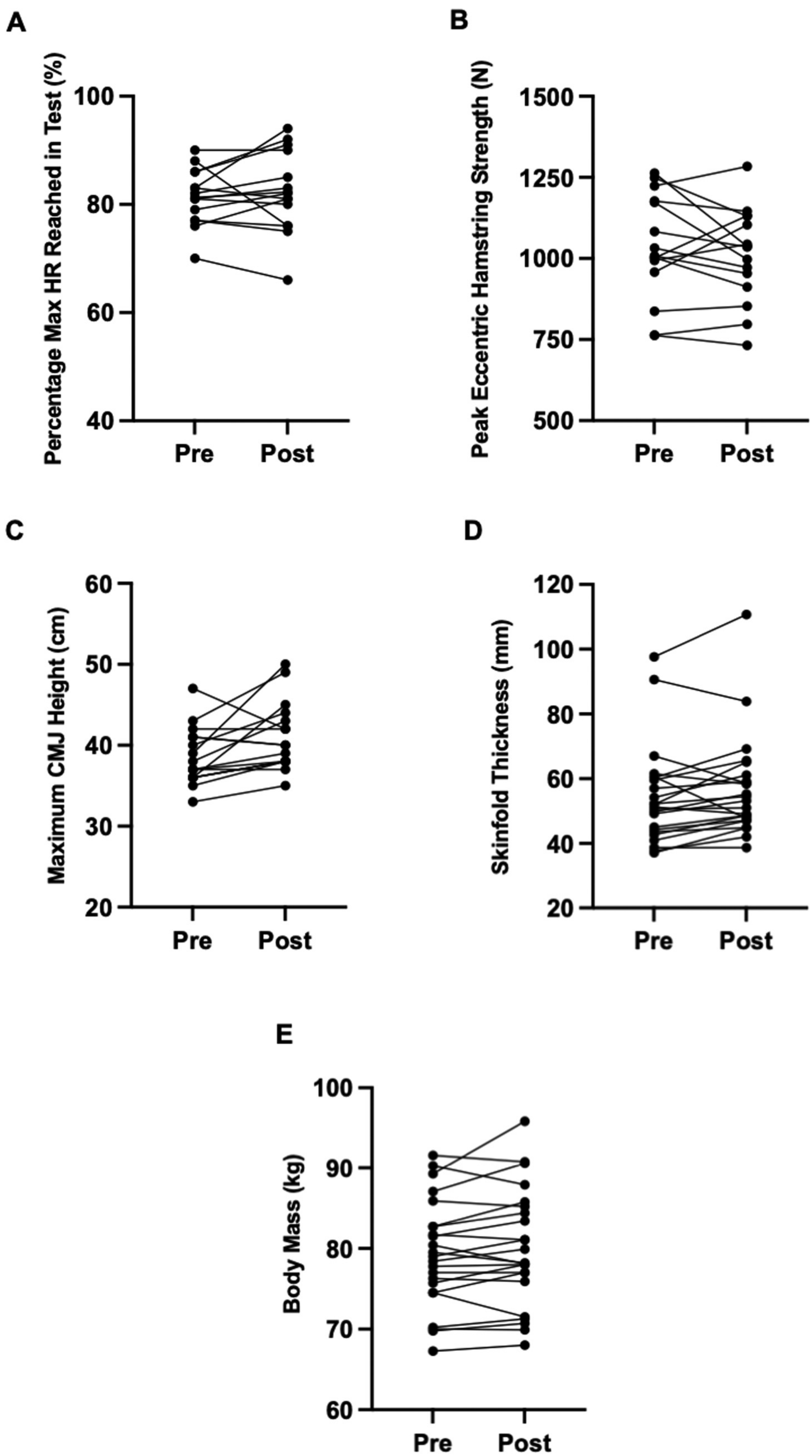

Figure 3. Mean ± SD for fitness assessment pre and post 13-week remote training period. A) percentage max heart rate reached in 30–15 IFT, B) peak eccentric hamstring strength in N, C) CMJ height in cm, D) skinfold thickness in mm and E) body weight in kg.

maintain or improve aerobic fitness levels in a volume related manner.

Considering that resistance training is an important aspect for developing neuromuscular function in soccer players,[30] we employed progressive lower body resistance training as part of the overall programme (see Table 2). Although the lower body resistance load was set to high session volume (in terms of the number of sets and reps performed each session) and intensity (in terms of load lifted), the programme was only able to maintain in season adaptations in both CMJ height and eccentric hamstring strength (see Figures 3(b) and 3(c)). These data provide evidence that regular soccer training and match play can potentially stimulate neuromuscular function adaptations and the initiation of a resistance training programme when this is removed can only maintain levels of neuromuscular function. Indeed, when soccer training and match play is performed with regular exposures to small-sided games and near maximal sprints, there can be positive effects on CMJ height,[42] eccentric hamstring strength[43] and fascicle length.[44] However, when the exposure to regular soccer training is removed, in addition to no resistance stimulus being performed eccentric hamstring strength was reduced by 14.1% after 49 days[11] and CMJ height reduced by 3.4% after 63 days.[12] Therefore, it is evident that professional soccer players require either regular soccer training and match play or a comprehensive resistance training programme to maintain within season neuromuscular function. Further research is required to utilise different testing procedures at various velocities to assess neuromuscular function for different training modalities.

Although negative body composition changes are usually associated with remote training away from the club in professional soccer players (i.e. in the off-season),[12,45–47] we were able to maintain skinfold thickness and body mass over the intervention period (see Figures 3(d) and 3(e)). Indeed, we are limited to these two methods of analysis, which has limitations in being able to determine body site locations of lean mass loss and/ or gain. Taken alongside other results of this training programme, it would seem necessary that the training and nutritional programme was able to maintain all levels of fitness that were assessed, maintaining lean muscle mass, and limiting fat mass gain. Given that we are now more aware of typical energy expenditures when traditional training is replaced by differing forms of cardiovascular and strength-based training,[34,48] we have been able to maintain the already high levels of muscle mass and low body fat through more precise nutritional guidelines. This gives further rationale for players to undertake structured training and nutritional programmes in tandem. Additionally, maintaining regular communication with players over video calls can raise and resolve issues in real-time and this could be a useful tool to keep players on track of both training and nutritional goals.

We present some extremely novel data with regards to an elite professional soccer team, though our data and methods are not without limitations. Firstly, the study design is not randomised and there was no control group, meaning practical applications cannot be generalisable. However, research conducted in the applied setting is often difficult to undertake and such study designs aren't possible due to the competitive nature of elite sport. In addition, the findings of this study are related to only 1 team, albeit many other soccer teams were in the same situation, more work is required to ascertain if this is transferable to other teams. This study was also limited to just 4 methods to assess fitness, more methods of assessment are required to develop a deeper understanding of the adaptive response to the training programme. We were also unable to monitor internal and external training load performed continuously and accurately, rather than prescribed from both HIIT and resistance training perspective. This could potentially lead to issues with application and correct undertaking of the prescribed remote based physical fitness programme. In addition, although players were told to wait >4 h prior to their next training session (i.e. resistance training after HIIT) in an attempt to limit any concurrent training adaptations,[49] this was not controlled and could potentially impact results. Lastly, due to the period when this study was being conducted, we were unable to assess fitness levels at various points within the programme. This could allow us to gain an understanding of potential detraining and retraining effects throughout the programme after the cessation of team-based soccer specific loading.

Whilst we were able to maintain in-season adaptations within the present study, opportunities to train outside of the usual environment remains a unique opportunity. Future research should be performed to determine the dose-response of different training programmes in already high-level soccer players with highly developed fitness capabilities. In addition, it should look to identify specific areas of programme design based off baseline testing levels. Periods such as the traditional off season, winter breaks or periods of injury seem viable opportunities to assess this relationship and explore 'alternative' training approaches further.

Practical applications

The findings of this study highlight that 13-weeks of an individual remote physical fitness programme can potentially maintain fitness adaptations in professional soccer players. Such data emphasises to practitioners that alternative modes of training can provide players with a sufficient stimulus to maintain in-season fitness levels. This approach to training can potentially be used to complement in-season training (i.e. when time off is prescribed to players) or used throughout periods of non-habitual loading (i.e. off-season, international breaks, winter breaks).

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