Tennis Home-Training during First Italy Lockdown COVID-19: A Pilot Study in Young Athletes

Running Title: Effect of Training at Home during Lockdown COVID-19

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Abstract
COVID-19 pandemic has imposed an Italy national lockdown between 9 March and 3 May 2020, limiting the ability of individuals to exercise/training outdoors. The aim of this study was based on the construction of remote-personalized-training protocols in tennis and examined the effects of a home-based intervention. Sixteen young athletes, divided into four groups in accord with the level of play and the pre-existing technical-tactical preparation, were trained by tennis-coach using simple equipment (i.e., balance board, medicine ball, steps). Physiological parameters (HR, SaO₂), the ability to execute technical gestures in conditions of stress/fatigue, development of adaptation and motor reaction skills, as well as eye-manual coordination; execution of movements at high speeds and precision, prevention of muscle and joint injuries, were monitoring. A questionnaire able to evaluate the subjective perception was administered. Athletes have demonstrated, by means of this latter, the beneficial effects of home-training during the lockdown. Concluding, the remote home-training, offered to athletes one option to maintain “normal” training practices, in view of a return to the tennis court. Furthermore, at today, in post-pandemic environments and behaviors, the results suggest that remote home-training intervention may help foster meaningful improvements in young athletes, strengthening intrinsic/subjective motivation.

Keywords Pandemic, Remote-Home-Training, Tennis, COVID-19, Lockdown

1. Introduction
In 2020, the World Health Organization (WHO) declared the Public Health Emergency of International Concern in January and Pandemic of coronavirus disease (COVID-19) in March. Since then, world people's lives changed radically. At the end of July 2021, the global situation counted 195,886,929 confirmed cases and 4,189,148 deaths, while in Italy there were, at the same date, 4,330,739 confirmed cases and 128,010 deaths (World Health Organization, WHO) [1]. COVID-19 had impact of on the life aspects of all people in every part of the world [2,3,4,5]. From March 9 to May 3, 2020, the government of Italy imposed a national lockdown,
restricting the movement of the population, except for necessity, work, and health circumstances. The “lockdown” measures, despite being widely approved by public opinion, were also described as the largest suppression of constitutional rights in the history of the republic (Costituzione Italiana) [6].

The lockdown restrictions have negative socio-psychological impacts both on mental and physical health (i.e., isolation, depression, anxiety, insomnia) and, as reported by Hawkley and Capitanio [7], long-term isolation creates stress, negative emotion, impaired cognition. Furthermore, Rodríguez-Rey et al. [8] in their study have reported that adverse psychological effects have occurred on Spanish people, and young people and women suffered more than the others. Moreover, during the COVID-19 lockdown, in southern Italy, a cross-sectional study confirms a negative impact on young and adults [9]. It has also been reported that physical inactivity during the COVID-19 pandemic lockdown was deleterious for the cardiovascular system [10], has increased sedentary behaviors [11], with poorer dietary choices and increased alcohol consumption [12,13].

The pandemic of coronavirus disease (COVID-19) leads to all Worldwide movement restrictions that have caused significant disruption to athlete's training and consequently sporting competitions [14,15,16]. Many athletes were not able to perform sport-specific training, due to movement restrictions [17], especially in children, adolescents, and young adults [18]. Many athletes have trained at home, often without specialist equipment or supervision [13,19].

In contrast, other athletes opportunistically used the ‘lockdown’ time during the pandemic in a positive way, to ‘upskill’ perhaps in preparation for their lives after sport [20,21]. Despite emerging evidence, demonstrating beneficial effects of home-training, the overall effectiveness of home-training for maintaining optimal levels of sport-specific conditioning remains unclear [22].

It is well known that sports practice has beneficial effects not only on the physical body but also on mental care [23, 24]. According to Garber et al. [25] and based on the recommendation of the American College of Sports Medicine, exercise improves physical and mental health and/or fitness in most persons without taking account of their training habits. It has also been reported that home-based tactics could include aerobic activities, balance and flexibility exercises, muscular strength and endurance training [26].

Recently, Loh et al. [27] have reported a positive effect of a home-based exercise program on social and emotional well-being among older patients with cancer and likewise, positive effects in people with chronic heart failure after individualized home-based physical program [28]. Moreover, it has been demonstrated that physical activity has beneficial effects in neurodegenerative diseases [29] and in older individuals to improve muscle mass and function [30,31].

Tennis is one of the most popular sports in the world, with 1.12% of the world's population (about 75 million) participating in tennis. Tennis is played at every level and at any age from 4 to over 80 years old. It is therefore considered a valuable sport for maintaining healthy physical activity levels in middle aged and older adults [32].

Tennis is a highly specific sport that requires specific spaces [33] and beneficial effects on the musculoskeletal function of tennis players respected to non-players are reported. It is a static and dynamic sport and it has many health benefits: it increases brain power, improves hand-eye coordination, reduces stress, decreases cardiovascular disease, increases fitness levels, leads to stronger bones and muscles [34]. Tennis playing requires cognitive control, visuo-spatial orientation and specific tennis motor skills for efficient decisions [35]. Furthermore, tennis players with enhanced decision-making skills can use movement-pattern information to determine shot selection, reduce their response delay times and, hence, improve their stroke performance [36].

The idea of this study was based on the construction of personalized training protocols, elaborated and differentiated according to different parameters, such as the level of play of the participants, the availability of space in one's home, the availability of equipment and tools suitable for training suited to their characteristics, as well as the technical-metabolic needs required for maintaining good physical-technical - tactics, with a view to a future return to activities on the court. Each student was allowed to train directly with tennis coaches, remotely, each in their own homes, adapting protocols to the technical material and environments available to the various athletes. Then, the aim of this study was to find a solution to fight this constant and forced motor decline in daily life, during the COVID-19 lockdown in 2020.

2. Materials and Methods

Subjects

This study was carried out during the Italian lockdown and it involved 16 volunteers’ young athletes, mean age 18.5±2.1 years (14 males: 18.4±2.2 years 2 females: 19 years) of a tennis club (Modena, Italy). Anthropometric measures: height, weight, and BMI were assessed and are reported in Table 1.

The athletes have been divided in four groups, according to the level of play and the pre-existing technical-tactical preparation. Different activities were carried out to satisfy the physical-technical-tactical demands of all those involved, adapting the workouts to their needs and characteristic (Table 2).
Table 1. Anthropometric parameters: height (cm), weight (kg) and Body Mass Index (BMI, kg.m⁻²) collected from the young athletes at pre (T1), during remote-personalized-home-training protocols (30 March - T2, and 20 April - T3) and at the end of the training (T4)

| Group | Athletes | Age | Height (cm) | Weight (kg) | BMI (kg.m⁻²) |
|-------|----------|-----|-------------|-------------|--------------|
|       |          |     | T1 T2 T3 T4 | T1 T2 T3 T4 | T1 T2 T3 T4 |
| A     | 1        | 16  | 167 167.2 167.5 167.9 | 60 61.2 61.5 62 | 21.5 21.6 21.9 21.9 |
|       | 2        | 19  | 178 178 178 178 | 76 76.5 75.9 75.7 | 24 24 23.7 23.7 |
|       | 3        | 17  | 171 171.2 171.2 171.2 | 65 66 66.6 66.6 | 22.6 22.6 22.6 22.6 |
|       | 4        | 16  | 179 179.4 180.1 180.1 | 73 73.5 74.4 74.5 | 22.8 22.8 22.9 22.9 |
| B     | 5        | 20  | 175 175 175.1 175.1 | 70 68 67.9 67 | 22.9 22.2 21.9 21.9 |
|       | 6        | 19  | 165 165 165.1 165.1 | 52 52.2 52.5 52.4 | 19.1 19.1 19.1 19.1 |
|       | 7        | 20  | 182 182 182 182 | 77 77.5 78 77.4 | 23 23 23.3 23.2 |
|       | 8        | 18  | 174 174 174.2 174.2 | 73.4 74 73.2 72 | 24 24.4 24.4 24.8 |
| C     | 9        | 18  | 175 175 176 176.3 | 71 71.3 73 73.5 | 23.2 23.2 23.6 23.6 |
|       | 10       | 20  | 182 182 182 182 | 75.5 76.9 77 77 | 22.6 22.9 22.9 22.9 |
|       | 11       | 16  | 169 169.5 171 171 | 60 61 61.7 62 | 21 21.4 20.9 21.2 |
|       | 12       | 24  | 177 177 177 177 | 73 74 75.1 75 | 23.3 23.3 23.9 23.9 |
| D     | 13       | 18  | 188 188 188.5 188.5 | 87 87.5 88 87.4 | 24.6 24.6 24.9 24.6 |
|       | 14       | 19  | 170 170 170 170 | 66 65 65 64.5 | 22.8 22.3 22.5 22.1 |
|       | 15       | 16  | 173 173.5 174 174 | 71 71 70.5 69.8 | 23.7 23.7 23.1 22.8 |
|       | 16       | 20  | 177 177 177 177 | 75 74.5 74.5 73.7 | 23.9 23.6 23.6 23.3 |

Table 2. Four groups of athletes (beginner, intermediate, and two advanced) in accordance to the level of play and the pre-existing technical-tactical preparation were done. Physiological parameters: HR: heart rate at rest; Theoretic HRmax (calculated by Tanaka formula: 208-0.7*age); HRmax (maximum 300mt speed test); and Reserve HR (calculated by: HRmax – HR at rest)

| Group | Athletes | Theoretic HRmax (Tanaka formula) | HRrest | HRmax (maximum 300 speed test) | Reserve HR (HRmax – HR rest) |
|-------|----------|---------------------------------|--------|---------------------------------|-------------------------------|
| A     | 1        | 196.8                           | 84     | 192                             | 108                           |
|       | 2        | 194.7                           | 94     | 193                             | 99                            |
|       | 3        | 196.1                           | 82     | 195                             | 113                           |
|       | 4        | 196.8                           | 79     | 194                             | 115                           |
| B     | 5        | 194                             | 75     | 192                             | 117                           |
|       | 6        | 194.7                           | 80     | 194                             | 114                           |
|       | 7        | 194                             | 71     | 190                             | 119                           |
|       | 8        | 195.4                           | 79     | 192                             | 113                           |
| C     | 9        | 195.4                           | 66     | 196                             | 130                           |
|       | 10       | 194                             | 69     | 192                             | 123                           |
|       | 11       | 196.8                           | 78     | 195                             | 117                           |
|       | 12       | 191.2                           | 73     | 190                             | 117                           |
| D     | 13       | 194.7                           | 76     | 192                             | 116                           |
|       | 14       | 196.8                           | 74     | 195                             | 121                           |
|       | 15       | 194                             | 68     | 194                             | 126                           |
|       | 16       | 195.4                           | 71     | 194                             | 123                           |
Table 3. Training program of the beginner group (A)

| WEEK                      | AIMS                                                                 | EXECUTIVE METHODS                  | EXERCISES                                          | DURATION AND REPETITIONS                                      | RECOVERY |
|---------------------------|----------------------------------------------------------------------|------------------------------------|---------------------------------------------------|--------------------------------------------------------------|----------|
| 1 2<sup>nd</sup> – 8<sup>th</sup> March 2020 | ankle, elbow, wrist extensor muscles strengthening; aerobic capacity; speed; motor reaction capacity; mobility of shoulder, low arts; lumbar spine | dumbbells; jump rope; tennis balls; stretching | extensions with dumbbells; isometry; shuttle circuits; free body; stretching exercises | 2-3 sets per exercise 10 repetitions per exercise 15 minutes total of stretching | 45sec – 1min |
| 2 9<sup>th</sup> – 15<sup>th</sup> March 2020 | body stretching; extensor/flexor lower body muscles strengthening; shoulder strengthening; tennis technique practice; core work | jump rope; tennis racquets; free body work | jumps with rope; stretching; forehand/backhand | 2 round 45sec per exercise | 45sec – 1min |
| 3 16<sup>th</sup> – 22<sup>nd</sup> March 2020 | lumbar spine & lower arts stretching; circuits training (cardio, tennis techniques circuit exercises; lower arts strengthening; aerobic capacity) | jump rope; tennis racquets; medicine ball | jumps with rope; stretching; forehand/backhand | 2 round 45sec per exercise | 45sec – 1min |
| 4 23<sup>rd</sup> – 29<sup>th</sup> March 2020 | cardio; abs workout; tennis techniques circuit exercises; flexibility and mobility | jump rope; tennis racquets; tennis balls | jumps with rope; stretching; forehand/backhand/abs | 2 round 45sec per exercise | 45sec – 1min |
| 5 30<sup>th</sup> March – 5<sup>th</sup> April 2020 | cardio; tennis techniques circuit exercises; lower body strengthening | medicine ball; tennis racquets; jump rope | jumps; tennis serve & slice; squats; abs; push-ups | 2 round 45sec per exercise | 45sec |
| 6 6<sup>th</sup> – 12<sup>th</sup> April 2020 | stretching; tennis serves; balance work; abs; tennis techniques circuit exercises; lower body workout | medicine ball; tennis racquets; balance board | push-ups; balance board isometry; tennis serve; abs | 2 round 45sec per exercise | 45sec |
| 7 13<sup>th</sup> – 19<sup>th</sup> April 2020 | lower body strengthening; abs workout; game tactical tennis sequence; | medicine ball; jump rope; tennis racquets; | crunch; squats; jumps; forehand/backhand | 2 round 45sec per exercise | 45sec |
| 8 20<sup>th</sup> – 26<sup>th</sup> April 2020 | cardio; shoulder work; abs workout; tennis serve & volley technique | medicine ball; tennis racquets; dumbbells; jump rope | jumps; side raises; abs crunches; frontal squat; serve | 2 round 45sec per exercise | 30sec |
| 9 27<sup>th</sup> April – 3<sup>rd</sup> May 2020 | balance work; cardio, lower body; mobility | jump rope; balance board | balance board isometry; jumps; crunches; squats | 2 round 45sec per exercise | 30sec |
Table 4. Training program of the intermediate group (B)

| WEEK                  | AIMS                                                                 | EXECUTIVE METHODS                           | EXERCISES                                     | DURATION AND REPETITIONS | RECOVERY |
|-----------------------|----------------------------------------------------------------------|----------------------------------------------|-----------------------------------------------|--------------------------|----------|
| 1 2nd – 8th March 2020| ankle, chest, triceps, low arts strengthening; aerobic capacity; motor reaction capacity; coordination; mobility | dumbbells; medicine ball; jump rope; tennis balls | extensions with dumbbells; squats; stretching; jumps | 3round 15sec per exercise | 45sec – 1min |
| 2 9th – 15th March 2020| cardio; stretching; forehand/backhand/serve; chest                | tennis racquets; technique circuit; rope jump | push ups; jumps; tennis circuit sequences exercises | 3round 15sec per exercise | 45sec – 1min |
| 3 16th – 22nd March 2020| lower body strengthening; stretching; shoulder; serve & volley; abs workout | tennis racquets; dumbbells;                      | push ups; squats; plank; tennis circuit techniques | 3round 15sec per exercise | 45sec   |
| 4 23rd – 29th March 2020| shoulder mobility; cardio; abs workout; forehand/backhand              | medicine ball; rope jump;                     | skip; jumps; mountain climber; throws with ball | 3round 15sec per exercise | 45sec   |
| 5 30th March – 5th April 2020 | tennis technique; abs workout; cardio; chest                              | medicine ball; rope jump;                   | full body crunch; jumps; ball frontal throws; plank | 3round 15sec per exercise | 45sec   |
| 6 6th – 12th April 2020 | cardio; biceps strengthening; serve & smash technique                            | elastic bands; jump rope;                   | smash/serve; pike walk out; jumps; squats; curls | 3round 15sec per exercise | 30sec   |
| 7 13th – 19th April 2020 | explosive force; serve & volley; balance; mobility; lower body strengthening | medicine ball; tennis racquets; jump rope; | burpees; jumps; serve & volley; balance isometry | 3round 15sec per exercise | 30sec   |
| 8 20th – 26th April 2020 | serve; forehand/backhand slice; cardio; aerobic power; abs workout                  | medicine ball; rope jump;                   | split step technique jumps; ball frontal throws; crunch | 3round 15sec per exercise | 30sec   |
| 9 27th April – 3rd May 2020 | volley; serve; abs; cardio; stretching                                | medicine ball; tennis racquets; jump rope; | plank knee up; jumps; throws                     | 3round 15sec per exercise | 30sec   |
Table 5. Training program of the advanced groups (C and D)

| WEEK | AIMS                                                                 | EXECUTIVE METHODS                      | EXERCISES                                                                                   | DURATION AND REPETITIONS | RECOVERY |
|------|----------------------------------------------------------------------|----------------------------------------|------------------------------------------------------------------------------------------------|--------------------------|----------|
| 1-2  | 2nd-8th March 2020 shoulder muscles strengthening; explosive force; core | dumbbells; medicine ball; tennis balls; balance board | shoulder press; squats; ball throws; balance board; stretching                           | 3 round 45sec per exercise | 45sec    |
| 2-3  | 9th-15th March 2020 cardio; stretching; low body strengthening; lumbar | elastic bands; jump rope; medicine ball | push ups; throws; squats; forehand/backhand with no racquets                               | 3 round 45sec per exercise | 45sec    |
| 3-4  | 16th-22nd March 2020 forehand; backhand volley; abs workout; core & lower | tennis racquets; jump rope              | jumps; wall squat; shoulder tap; plank                                                      | 3 round 45sec per exercise | 30sec    |
| 4-5  | 23rd-29th March 2020 types of forehand; abs workout; balance; calf     | tennis racquets; balance board         | frontal squat; plank jacks; isometry; calf roll backs                                      | 3 round 45sec per exercise | 30sec    |
| 5-6  | 30th March - 5th April 2020 cardio; backhand types; explosive force;   | tennis racquets; medicine ball; jump rope | jumps; explosive skip; squats; ball throws; burpees                                        | 3 round 45sec per exercise | 30sec    |
| 6-7  | 6th-12th April 2020 serve & slices; cardio; shoulder & up body         | elastic bands; medicine ball; jump rope; tennis racquets | jumps; high throws; plank to push up; side raises                                           | 3 round 45sec per exercise | 30sec    |
| 7-8  | 13th-19th April 2020 explosive force; top-spin forehand/backhand volley; | jump rope; tennis racquets; medicine ball; dumbbells | wall static squat; jumps; throws; lateral run with dumbbells                                 | 3 round 45sec per exercise | 30sec    |
| 8-9  | 20th-26th April 2020 low body explosive strengthening; cardio; abs; balance | tennis racquets; jump rope; medicine ball | skip; jumps; ball throws; planks; free dribbles with tennis ball                              | 3 round 45sec per exercise | 30sec    |
| 9-10 | 27th April - 3rd May 2020 low body strengthening; abs workout; cardio; motor | tennis racquets & balls; jump rope; medicine ball | jumps; frontal squat; throws; burpees; plank; crunches                                      | 3 round 45sec per exercise | 30sec    |
Briefly summarizing the temporal structure of the study, it is possible to say that the 4 groups, of 4 subjects each, had the opportunity to train, 2 times a week, for a total period of 9 weeks which covered approximately the entire duration of the national lockdown, from 2 March to 4 May 2020. The surveys were carried out at: 2 March (T1), 30 March (T2), 20 April (T3), 2 May (T4) 2020.

Tables 3, 4 and 5 describe the training program of the beginner group (A), the intermediate group (B) and the advanced groups (C and D). Each table describes the aims of the training for each week of the lockdown and the executive methods, the exercises, the duration and repetitions and the recovery time.

The training was obviously provided by a connection with "Video-Call" mode through the Zoom or Microsoft Teams platforms, with each group connected independently with the undersigned on their own dedicated weekly day.

The equipment included: Dunlop Fort All Court 3 & 4 tennis balls (“regular” type, used in tennis teaching from 14 years upwards); Balance Board (proprioception and balance training); Fitness elastic bands; Skipping Node; Medicine ball – 3 or 5 kg; Mat; Chairs; Weights (dumbbells) varying from 1 to 5 kg; Steps or, as alternative, stairs.

The equipment used to monitor some parameters related to training even during the performance of the activity were:

- Apple Watch series 4 (HR, FCmax, VO2 parameter monitoring)
- Electronic device (PC, Tablet, Smartphone) to periodically connect remotely to the training session (videocalls made through the Zoom platform or Microsoft Teams)
- Preset digital stop watch on Apple Watch series 4
- Finger Clips O2 saturation (SaO2)

Remote training protocols have been customized according to the level of play and the technical-physical-tactical characteristics of each athlete. There are three fundamental points to which a tennis-coach must pay particular attention:

I. Ability to execute technical gestures in conditions of stress and fatigue, as well as a strong development of adaptation and motor reaction skills, as well as eye-manual coordination;

II. Execution of movements at high speeds that require maximum precision at the same time;

III. Importance in the prevention of muscle and joint injuries.

The training evaluated parameters and the specific methodology are showed in Table 6 and 7.

| Table 6. Type of exercise and training evaluated parameters |
|------------------------------------------------------------|
| **TRAINING GOALS** | **GENERAL TRAINING** | **SPECIAL TRAINING** | **SPECIFIC TRAINING** |
| **Tactical and Technical skills** | | | Exercise with racket |
| • Technical-tactical memory | | | Work on the execution of technical tennis shots |
| | | | Short game tactical sequences |
| **Conditional skills** | | | |
| • Muscle strength and power | Weight resistance training | Interval training | Short game sequences (game tactics with quick movements) |
| • Sports speed and agility | Body-weight resistance training | High-intensity resistance interval training | |
| • Aerobic and muscle endurance | CORE training | | |
| | Functional step training | | |
| **Coordination skills** | | | Practice with tennis ball (i.e. throwing against the wall) |
| • Balance ability | Balance board training | Body balance training with tennis ball | Tennis technique and tactics |
| • Muscle reaction ability | Body balance training | Complex exercise with medicine ball | |
| • Eye-manual and hand-foot coordination | Jump rope | | |
| • Motor combination | | | |
| • Rhythm capacities | | | |
| • Motor-learning ability | | | |
Table 7. Specific methodology adopted for the athletes of the different groups.

| Type of Exercise                  | Time  | Type of Exercise            | Time |
|-----------------------------------|-------|----------------------------|------|
| Shoulder mobility                 | 10 minutes | Juggling with tennis ball    | 10 minutes |
| Balance exercise                  | 10 minutes | Static stretching           | 10 minutes |
| Dynamic flexibility               | 10 minutes | Cognitive task              | 5 minutes  |

**Group A - Beginner**

### PREPARATORY PHASE

| Exercises                        | Reps | Set | Rec | Load | Exercises                        | Reps | Set | Rec | Load |
|----------------------------------|------|-----|-----|------|----------------------------------|------|-----|-----|------|
| Air Squat                        | 15   | 4   | 1'  | BW   | Lunge                            | 15   | 4   | 1'  | BW   |
| Push up                          | 10   | 4   | 1'  | BW   | Chair dips                       | 10   | 4   | 1'  | BW   |
| Australian pull up               | 15   | 4   | 1'  | 30'  | BW                               | 12   | 4   | 1'  | 5+5 kg |
| Plank position                   | 30'  | 4   | 1'  | 30'  | BW                               | 20   | 4   | 1'  | 5 kg  |
| Hollow position                  | 30'  | 4   | 1'  | 30'  | BW                               | 7    | 4   | 1'  | 5 kg  |

### INTENSIVE PHASE

#### TRAINING 1

| Exercises                        | Reps | Set | Rec | Load |
|----------------------------------|------|-----|-----|------|
| Good morning (slow)              | 5    | 4   | 2'  | 5 kg |
| Front squat                      | 8    | 4   | 2'  | 5+5 kg |
| Military press                   | 12   | 4   | 2'  | 5+5 kg |
| Chest fly reverse                | 10   | 4   | 2'  | 5+5 kg |
| Australian pull up              | 20   | 4   | 2'  | BW   |
| Russian twist                    | 20   | 4   | 1'  | 30'  | 5 kg                           |

#### TRAINING 2

| Circuit Training                        | Time          | Round |
|-----------------------------------------|---------------|-------|
| 1' jump rope                            | In the shortest possible time | 4 rounds |
| 10 CMVJ                                  |               |       |
| 20 lunge                                 |               |       |
| 7 push up                                |               |       |
| 25 sit up                                |               |       |

**Specific tennis skills training**

| Training 2 | Time |
|------------|------|
| Forehand/backhand technique               | 10 minutes |
| Short games                                | 10 minutes |
| Tennis tactics                              | 10 minutes |

### Interval Training

| Training 1 | Time | Round |
|------------|------|-------|
| Step up    | 10' on 10' off | 6 rounds |
| Lateral step up | 10' on 10' off | 6 rounds |
### Table 5 Continued

#### Group B - Intermediate

| Training Phase | Training 1 | Training 2 |
|----------------|------------|------------|
| **PREPARATORY PHASE** | | |
| **1-3 weeks** | | |
| **Exercises** | **Reps** | **Set** | **Rec** | **Load** | **Exercises** | **Reps** | **Set** | **Rec** | **Load** |
| Air squat | 15 | 6 | 1' | BW | Lunge | 15 | 6 | 1' | BW |
| Push up | 10 | 6 | 1' | BW | Chair dips | 10 | 6 | 1' | BW |
| Australian pull up | 15 | 5 | 1'30" | BW | Dumbbell row | 12 | 6 | 1' | 5 + 5 kg |
| Plank position | 45° | 5 | 1'30" | BW | Sit up (Db) | 20 | 5 | 1'30" | 5 kg |
| Hollow position | 45° | 5 | 1'30" | BW | Turkish get up (Db) | 7 | 5 | 1'30" | 5 kg |
| **INTENSIVE PHASE** | | |
| **4-6 weeks** | | |
| **Circuit Training** | **Time** | **Round** | **Specific tennis skills training** | **Time** |
| Good morning (slow) | 5 | 4 | 2' | 5 kg | 10 wall ball | 12 minutes | AMRAP (As many rounds as possible) |
| Front squat | 8 | 6 | 2' | 5+5 kg | 12 burpees | 25 sit up |
| Military press | 12 | 6 | 2' | 5+5 kg | |
| Chest fly reverse | 10 | 5 | 2' | 5+5 kg | |
| Australian pull up | 20 | 6 | 2' | BW | |
| Chest fly | 10 | 5 | 2' | 5+5 kg | Specific tennis skills training | Time |
| Russian twist | 20 | 5 | 1'30" | 5 kg | Forehand/backhand technique | 15 minutes |

#### INTENSIVE PHASE

| Training 1 | | | Training 2 | | |
| Circuit Training | **Time** | **Round** | Specific tennis skills training | **Time** |
| 1' jump rope | In the shortest possible time | 6 rounds | Forehand/backhand Technique | 15 minutes |
| 10 CMVJ | | | Short Games | 15 minutes |
| 20 lunge | | | Tennis Tactics | 15 minutes |
| 7 push up | | | | |
| 25 sit up | | | | |

| **Interval Training** | **Time** | **Round** | **Step up** | **Time** | **Round** | **Lateral step up** | **Time** | **Round** |
| 10' on 10' off | 8 rounds | | 10' on 10' off | 8 rounds | |

#### Group C and D - Advanced

| Training Phase | Training 1 | Training 2 |
|----------------|------------|------------|
| **PREPARATORY PHASE** | | |
| **1-3 weeks** | | |
| **Exercises** | **Reps** | **Set** | **Rec** | **Load** | **Exercises** | **Reps** | **Set** | **Rec** | **Load** |
| Air squat | 15 | 8 | 1' | BW | Lunge | 15 | 8 | 1' | BW |
| Push up | 10 | 8 | 1' | BW | Chair dips | 10 | 8 | 1' | BW |
| Australian pull up | 15 | 6 | 1'30" | BW | Dumbbell row | 12 | 8 | 1' | 5+5 kg |
| Plank position | 60° | 6 | 1'30" | BW | Sit up (Db) | 20 | 6 | 1'30" | 5 kg |
| Hollow position | 60° | 6 | 1'30" | BW | Turkish get up (Db) | 7 | 6 | 1'30" | 5 kg |
The structuring of the activities basically followed two steps of investigations and one of re-elaboration:

A first phase of investigation in which proceeded to the detection (pre the lockdown due to COVID-19) of some parameters related to Heart Rate, using maximum shooting tests on the 300 meters, reproduced in the same way by all the participants in the project (i.e. environmental conditions, physical fatigue, rest). Information about the environments, tools and spaces already available within each their homes were asked.

In this second phase, following the investigations carried out on the family environments and on the physiological characteristics of each participating subject, coaches were able to start elaborating the different adapted activities and creating diversified groups.

A third phase of investigation in which it was administered a questionnaire (by phoning and video call) to each athlete who participated in. The questionnaire was structured as a Visual Analog Scale (VAS), able to evaluate the subjective perception. In fact, it has been reported that an ordinal scale based on subjective assessments, also used in the clinical and research fields, is a very commonly used tool for monitoring the subject’s evolution in physical therapy. Moreover, it is applicable in many circumstances and it is a good method of assessing an athlete’s response training [37]. The survey was tested with the following questions:

1. How is your general satisfaction respect to conceived/designed training protocol?
2. Did the proposed exercises have been clearly explained by the instructor?
3. Did the proposed exercises prove to be adequate for your group and play level, in view of an imminent return to the field?
4. Were the spaces that you have available sufficient and adequate for carrying out all the proposed activities?
5. Was the choice of training methodology (circuit work) effective and stimulating for you?
6. In general, do you feel adequately prepared for a possible return to the playing field in the coming weeks?
7. Do you feel adequately prepared for a possible return to the playing field in the coming weeks, from a physical point of view?
8. Do you feel adequately prepared for a possible return to the playing field in the coming weeks, from a technical point of view?
9. Do you feel adequately prepared for a possible return to the playing field in the coming week, from a tactical point of views?
**10. How do you rate this distance training experience?**

The questionnaire was administered to athletes at T1, T2, T3 and T4.

The athletes with age of majority, involved in this study gave written informed consent, obtained through use of e-mail, in respecting the ethical principles of the Declaration of Helsinki, when minors athletes the signed written parental consents were obtained.

**3. Statistical Analysis**

All data were collected using an online questionnaire and video monitoring at different time points, where due tabulated in a excel spreadsheet (Microsoft, Washington, WA, USA) and analyzed using GraphPad Prism 9. 0. 2 (GraphPad So ware Inc., San Diego, CA, USA).

Considering the low number of athletes, we performed also the descriptive statistics. Percentage changes, defined as [(post-pre)/pre]*100, were used for the analysis to assess home-training effects.

Anthropometric and physiological parameters, were analyzed by non-parametric test, Friedman and post hoc Dunn’s multiple comparison test was used to verify significant differences at the different time-points. Significant level was set at p<0.05. Data are reported as [mean ± SD].

**4. Results**

During the two months, the young athletes added some mm to their height. Statistic tests show the significant difference in groups A and C (p<0.01 and p<0.02 respectively), but post hoc does not show the significant difference among time-point (Figure 1a). However, between T1 and T4 + 8mm of growth in both groups were reported.

Also, a significant increase was observed in change of weight in group C at T4 respect T1 (71.8± 6.7 vs 69.8±6.8 kg, respectively, Figure 1b), while, not significant differences were observed in BMI (Figure 1c) among groups.

HRmax significantly decreased at T4 respect T1 in all groups (Friedman p<0.05), but only post-hoc test was significant in D group (188.6±5.9 vs 190.8±5.5), Figure 1d).

No significant differences in SaO2 were recorded, where the mean value was 99.2±0.5%.

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![Figure 1. Trend in four groups of: a) height, b) weight, c) BMI, and d) HRmax during the lockdown. *Significant difference within the group (p<0.01); In the figure, the legend with the colors of the four groups of athletes and their respective statistical significances in the same color as the groups](image-url)
At the end of the remote-home-training, the feedback received from athletes, by VAS was positive, reaching all the objectives.

In details (Figure 2), athletes reported:

1. General satisfaction respect to training protocol: group A 93.5%, B 94.7%, C 94.7%, D 91.2%.
2. Personal satisfaction for proposed exercises and clearness of explanation by the instructor: group A 99%, B 99%, C 99.5%, D 99.5%.
3. Consensus for the proposed exercises respect to the group and the play level, in view of an imminent return to the field: group A 99%, B 99%, C 94%, D 99%.
4. Consensus for the available and adequate spaces at home for carrying out all the proposed activities: group A 93%, B 96.7%, C 99.7%, D 93.5%.
5. Consensus respect the training methodology (circuit work): group A 98%, B 91%, C 99.7%, D 99.7%.
6. General evaluation on preparation respect to a possible return to the playing field in the coming weeks: group A 98.2%, B 99%, C 94%, D 99.2%.

7. Evaluation on physical preparation respect to a possible return to the playing field in the coming weeks: group A 89%, B 91.7%, C 88.2%, D 91%.

8. Evaluation on technical preparation respect to a possible return to the playing field in the coming weeks: group A 90%, B 92.2%, C 88.2%, D 92.2%.

9. Evaluation on tactical preparation respect to a possible return to the playing field in the coming weeks: group A 83.5%, B 87.5%, C 87.2%, D 87.7%.

10. General evaluation on the home-training experience: group A 100%, B 95%, C 100%, D 97.5%.

5. Discussion

It is widely known that physical activity and training have beneficial effects on physical, mental, and social health [18,19,23]; in particular, tennis and other rackets sports can be played by anyone at any level without distinction for age or sex [38]. The unexpected lockdown, due to the COVID-19 emergence, has destabilized all the population and especially the athletes, leading to decrease physical activity and the consequent well-being [39,40].

The current study reports the home-training perceptions of satisfaction of athletes during a “first lockdown in Italy in 2020”.

The lockdown could have some negative effects on mental, emotional health, stress, and training motivation as reported [38,39,40,41,42] This because athletes experience an uncertainty about their return to competition and their performance level [43]. COVID-19 not only completely changed our lives but also took us by surprise.Having been taken by surprise, from one day to the next, we had to reinvent ourselves in order to survive, trying to continue the work that had been abruptly interrupted and trying to lighten the days of the young athletes. For this reason, with the means available and technology (i.e., smartphone, tablet, ), we thought about this form of home-training.

It was not thought to be a success, as it turned out because the athletes may prefer the physical presence of their coach, as training at a medium-high level on your own isn’t psychologically easy. Meeting the hands-on needs of instruction was a challenge.

Not having any more available fields for carrying out training, the coach decided to elaborate and design training protocols as close as possible and corresponding to the technical-tactical-metabolic requirements of this sport, in order to make the experience as similar as possible to routine training, but obviously without using the ordinary surface and avoiding all direct interaction with other companions. We are aware that remote coaching had and has drawbacks and some limitations, but alas, it was and is the unique opportunity for both coaches and athletes during the COVID-19 pandemic, in particular during the first Italian lockdown in 2020.

The main question to solve was: how could it be possible to think of training perfectly correspondent to the characteristics that a tennis lesson must have and, at the same time, be adapted to each subject involved according to his/her age, level of play, equipment and spaces available at home?

The answer certainly required an initial analysis of the characteristics of the athletes who participated in the project and, secondly, investigations into the familiar environments and the tools available. Therefore, this project firstly “studied” the participants by monitoring different metabolic and physical parameters, including BMI, Heart Rate max, Heart Rate at rest, reserve Heart Rate, and then subjected them to some questionnaires in order to have a sort of “inventory” ready of the material with which start work on.

The study of the technical-metabolic characteristics of the subjects participating in the project was certainly accompanied by a preliminary investigation on the actual availability of the same and precisely on the space-time availability (rooms in the house, tools, and free days), for which also the participants had to show their approval and their commitment to get involved. The experience to practice distance training for an indeterminate time was accepted by the subjects involved as a chance to continue training despite the forced lockdown.

Boys and girls have decided to rely on this project totally, without time limitations and with the pure desire to savor relative normality, which represents an outlet, of emotion and fun, that is sport.

Recent research in the field of sports medicine has also raised concerns about the impact of coronavirus disease on athletes’ health. As reported in the literature [44,45] long-term detraining could bring a loss of endurance capacity and a loss of muscle strength and mass. These factors will significantly increase the risk of injury amongst athletes.

Lockdown period has presented absolutely unprecedented situation for all people and certainly a dramatic shift in teaching, and in the learning [46]. This was not the case only for the education (primary/higher) assessment practices, but also for all that is the recreational and sporting sphere.

The athletes involved in this study have demonstrated, by means of the questionnaire (VAS), the beneficial effects of home-training during the lockdown both on physical (e.g. HR measures might reflect (aerobic-based) adaptation and fatigue status, hence are able to represent the athlete's training status [47]) and mental well-being (Figure 3), even if, as we have been able to see from the answers, the greatest doubts remain on the technical and tactical preparation. However, our preliminary findings provide further insight compared to “outdoor” training methods.
5. Limitations

The authors are aware that the current study suffers from certain limitations as the sample size and the lack of any control group. However, we would like to emphasize that the coach-team consisted of 16 young athletes, and that everyone participated in the study. Athletes were divided into four groups according to the level of play and the pre-existing technical-tactical preparation, all have been included and analyzed in this pilot study. Given the scarcity of research including young athletes [48], and in particular tennis players, the sample size was been determined by accessibility. Because of the influence posed by this pandemic, it is important to use caution without generalizing when interpreting the data. As such, future researches in case of other blocking periods must extend the current findings.

Finally, we conclude that no measures were done when the athletes returned to the playing field after lockdown and that future studies may use a mixed approaches to confirm the current study’s which was suggested in previous studies [19].

6. Conclusions

In conclusion, we can say that the remote home-training, offered athletes one option to maintain both “normal” training practices, in order to avoid a risk of detraining in athletes in view of a return to the tennis court.

Anyway, further studies, with the use of implemented platforms could be more appropriate and yield novel training programs in sports. To date, COVID-19 pandemic represents a global crisis that has forced athletes young/elite/not and coaches into an unknown situation.

Author Contributions

Conceptualization, A.S., S.M.S.; methodology, A.S., R.D.D., S.M.S.; formal analysis, A.S., G.D.A., R.D.D., S.M.S.; investigation; A.S.; data curation, A.S., M.M., A.V., S.M.S.; writing—original draft preparation, A.S., M.M., R.D.D., S.M.S.; writing—review and editing, A.S., M.M., A.V., G.D.A., S.M.S.; visualization, S.M.S; supervision, S.M.S project administration: A.S., S.M.S. All authors have read and agreed to the published version of the manuscript.

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The study was conducted according to the guidelines of the Declaration of Helsinki.

Informed Consent Statement

Informed consent was obtained from all coaches involved in the study. Written informed consent has been obtained from the coaches to publish all data is available.
within the manuscript.

Data Availability Statement

All data is available within the manuscript.

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Conflicts of Interest

The authors declare no conflict of interest.

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