Peer-to-peer online video feedback with pedagogical activity improves the snatch learning during the COVID-19-induced confinement in young weightlifting athletes

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Abstract
The lack of training caused by the COVID-19 pandemic could have significant consequences on the performance and health of athletes. The aim of the present study was to test the effects of two innovative distance education methods on improving motor skills in weightlifting. We randomized 35 children (aged 10 to 12) into groups of peer-to-peer online video feedback with a pedagogical activity (P-VF-PA), peer-to-peer online video feedback only (P-VF), and control group (CONT). Learners underwent a test one week before (T0) and one day after (T1) an eight-session training intervention and a retention test session a week later (T2). Kinovea was used to measure the kinematic parameters of the snatch performance. After the distance learning sessions, the training with the P-VF-PA method improved most of the kinematic parameters compared to the P-VF method, and the advantages derived from its application persisted in the retention test (e.g., the difference between the right side and left side distances of the bar trajectory Diff-Tr (T1 vs. T0: 42.32 ± 41.33%, Hedges’ g = 1.16, p < 0.01; T2 vs. T0: 37.82 ± 37.57%, Hedges’ g = 1.37, p < 0.05)). In conclusion, distance motor learning based on the P-VF-PA method improved performance and technical knowledge of the snatch in 10–12 years weightlifters.

Keywords
Coaching, error correction, kinematics, motor learning, technical knowledge

Introduction
The COVID-19 pandemic has affected sports systems worldwide, leading to the near-total closure of sports halls and physical education (PE) facilities as a measure to curtail the spread of the contagious disease.¹ The limited participation in physical activities, resulting from sports complex closures and the suspension of PE classes during the COVID-19 pandemic, has substantially reduced the physical performance² and the feeling of well-being.³ Meanwhile, screen time⁴ and social media usage⁵ have significantly increased. Even though the excessive use of screen-based devices and social media platforms during the quarantine period has been shown to be associated with negative physical and mental health outcomes,⁶–⁸ there are a few recent studies that have called for the incorporation of those technologies into the distance teaching/learning process.⁹,¹⁰ In other words, the current challenges should present not only obstacles but also opportunities for innovation in distance learning.

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The outbreak of the COVID-19 pandemic has accelerated the ongoing pedagogical transformations, and conventional
learning models are thereby being questioned. With social distancing and uncertainty about the timing of the re-opening of sports halls and PE facilities, there is a pressing need for more flexible approaches to motor learning. Innovative knowledge and skill delivery models have been suggested to engage athletes and PE students through varying degrees of technology-mediated active learning formats and, thus, partially abandoning the conventional “passive” model where the teacher or coach is the transmitter of information, and the student or athlete is a passive receiver. The use of technology-mediated active learning methods has become common in sport and exercise pedagogy. Indeed, the active participation of the learner in the learning process improves performance compared to the traditional one-way knowledge transmission model where content is passively delivered to learners.

The use of video technology has recently added a further dimension to the active learning experience. It has been revealed that allowing learners to control the delivery of video feedback can improve information processing during the movement execution and can increase technical knowledge levels. More interestingly, using such a multimedia-mediated strategy for motor learning purposes increases self-efficacy, technical performance, and intrinsic motivation. Researchers have also shown that video feedback can empower athletes to watch their performance at their adequate pace, through pausing, rewinding, and slowing down the video-based content to learn at a rate that matches their needs. However, Souissi et al. declared that beginners are not able to detect all the technical errors in their snatch movements displayed in the video feedback. Therefore, for a more fruitful motor learning experience, Souissi et al. suggested that the integration of a pedagogical activity (in the form of a comparison of the videotaped performance against key images of the task) during the video feedback viewing helps the learner to further detect and correct technical errors.

During COVID-19 confinement periods, where social distancing is obligatory, the coach or PE teacher may lack sufficient time to provide corrective feedback to learners during a distance learning session. For this reason, a combination of digital technologies and peer-assisted learning strategies could be an effective means to help learners receive audio feedback from their peers more frequently than a coach could provide. Indeed, audio technology has been shown to enhance feedback provision compared to written feedback during distance teaching.

Expert raters (i.e., instructors) would provide better feedback than learners. However, properly conducted peer-to-peer feedback has been reported to be beneficial to both the learner providing the feedback and the learner receiving it. More interestingly, peer feedback can be equally effective or, in some cases, more effective than comparable levels of teacher feedback. While peer assessment offers a solution to assist the instructor, it challenges the quality of the learning process.

The investigation of distance peer-to-peer video feedback in sport and physical activities learning seems to be absent in the literature. Therefore, it has become necessary to fill this research gap. The aim of the present study was to examine the effects of two strategies of distance peer-to-peer video feedback on the correction of technical errors of the snatch during COVID-19-induced confinement and to assess the persistence of the improvements in young athletes after a one-week rest period. We hypothesized that peer-to-peer online video feedback with a pedagogical activity (P-VF-PA) would be more appropriate for the technical error correction during distance learning of the snatch movement in young athletes. Additionally, the P-VF-PA group was expected to increase their technical knowledge level after eight training sessions during the post-test and retention test.

### Methods

#### Participants

Initially, 60 individuals were identified as potential participants for this study. Later, 25 were excluded, of which 22 failed to meet inclusion criteria and three did not provide an informed consent form. Eventually, 35 healthy young athletes (10–12 years old) volunteered to participate in the present study. All participants started to practice weightlifting at the same time (the same school system) and had six months of prior training in the sport of weightlifting. Descriptive characteristics of the study sample are shown in Table 1. Prior to the commencement of the experiment, parents/guardians of the students received an informed consent letter containing detailed information about the study procedures. By signing the letter, they approved the participation of their dependents in the study. The experimental protocol was approved to comply with the guidelines of the 2013 Helsinki Declaration by the local Research Ethics Committee (CPP: N°0126/2020).

Each of the participants were included in this study if: (i) he/she had no history of musculoskeletal, neurological, or orthopedic disorders and had no history of lower extremity and back/spine injury or surgery during the six months prior to testing (these might have affected their physical ability), (ii) had no visual or cognitive problems, (iv) he/she must

| Table 1. Descriptive characteristics of the participants. |
|---------------------------------------------------------|
| Groups | P-VF-PA (n = 12) | P-VF (n = 12) | CONT (n = 11) |
|--------|-----------------|---------------|---------------|
| Age (years) | 11.22 ± 0.6 | 11.44 ± 0.83 | 11.27 ± 0.64 |
| Height (m) | 1.46 ± 0.06 | 1.47 ± 0.08 | 1.47 ± 0.05 |
| Body mass (Kg) | 40.6 ± 6.2 | 40.6 ± 5.6 | 41.3 ± 5.9 |

P-VF-AP: peer-to-peer online video feedback with pedagogical activity; P-VF: peer-to-peer online video feedback; CONT: control group.
be competent enough to use the technological tools employed in the study, and (v) he/she must have two smartphones, a computer, a messenger application, and an internet connection.

Before the experiment, participants were randomly assigned to either: Peer-to-peer online Video Feedback with Pedagogical Activity (P-VF-PA = 12) group, Peer-to-peer online Video Feedback (P-VF = 12) group, or a Control group (CONT = 11).

All groups were requested to list any activities or sports they had practiced in conjunction with the experiment, and they listed similar activities (e.g., electronic games and walking).

Procedure
The present experiment included two different sessions. Participants performed three test sessions; a pretest and a posttest a week before (T0) and one day after (T1) the eight-session training period, and a retention test session (T2) a week after the completion of the practical intervention. The test sessions were focused on (i) technical evaluation of the snatch movement through measuring kinematic parameters and (ii) technical knowledge level evaluation. All test sessions were performed in the afternoon between 1 p.m. and 3 p.m. Participants from each group completed eight weightlifting training sessions, interspersed by a period of 48 h. Each learning session was composed of two sets, and each set comprised 12 snatch repetitions.

Prior to the pretest, participants filled out a questionnaire that generally asked about the availability of the technological equipment needed for the experiment (i.e., computers and smartphones) at their homes. Testing procedures strictly respected the COVID-19 health protocol set forth by the World Health Organization.

The pretest session was administered to all participants a week before the start of the experiment. Participants were randomized into three homogeneous groups. Before initiating learning activities, the Kinovea software (version 0.8.15) was installed on the computer of each participant of the two experimental groups. In addition, the Zoom mobile application and a videotaped demonstration by an expert were installed on the smartphones of all participants of the three groups. Three days prior to the start of the intervention, all participants were familiarized with the general environment, equipment, and experimental procedures in order to minimize the learning effect during the study. Participants from all groups performed two distance-learning sessions of the forward roll under the supervision of the teacher in order to assess their technological skills. All participants showed strong capacities to use the different technological tools employed in the present study. A day before the first distance learning session, a 5 kg bar and two 21-cm high supports were delivered to participants’ homes. Throughout distance learning sessions, participants from each group maintained the specific training mode assigned to them.

Test procedures
Technical performance. The snatch was performed with a 5 kg lifting bar that was placed on two 21-cm high supports inside a weightlifting hall. Two landmarks on the vertical plane for the ends of the barbell served to convert the displacement measurements into centimeters. Two Sony (HXR-MC2500, Tokyo, Japan; HD: 50 frames per second; 50 Hz frequency) digital cameras were fixed on the right and left sides 5 m distant from the athlete and 1.5 m elevated from the ground (Figure 1). Two markers were placed on the edges of the bar.

The video treatment was performed with the Kinovea software to measure the horizontal and vertical displacements of the bar. Puig-Díví et al. have shown that the Kinovea software is a reliable and valid tool for motion analysis.
Hoover et al.\textsuperscript{29} and Stone et al.\textsuperscript{30} determined the important kinematic factors that interfere in the success of the snatch technique, namely: the horizontal (rearward) displacement of the bar in the first pull with respect to the starting position ($Dx_2$), the bar looping extent in the catch phase ($DxL$), the bar horizontal displacement between the receiving position and the reference line ($DxT$), the bar horizontal displacement between the first and the second pulls ($DxV$), the maximum bar vertical displacement at catch position ($VTR$) and the difference between the left- and the right-side distances of the bar trajectory in an absolute value (Diff Tr) (Figure 2).

The trajectory of the barbell during the snatch takes an S-shaped pattern: the bar is moved toward the lifter’s body upon the first pull and the transition phase. Then, it is pushed away from the lifter’s body by simultaneous hip and shoulder flexions and knee joint extensions.\textsuperscript{31,32}

The optimal bar path for a proper weightlifting technique has been determined with particular emphasis on horizontal vertical displacement reduction. These parameters can increase power while saving energy.\textsuperscript{20,33}

\textit{Technical knowledge level}. A video sequence displaying the snatch performance of a novice child who made eight errors was played to all athletes. Errors were previously depicted by three weightlifting coaches. This sequence was slowed down (to 25% of actual time) on the Kinovea software. Athletes were allowed to pause the video to detect the maximum number of pretest errors. Eight attempts to announce the errors were required and recorded by the coaches. The scoring scale ranged from 0 to 8 as follows: 1 point for each existent error detected and 0 point for each declaration of a non-existent error. The same sequence was replayed during the post-test and retention test.

\textbf{Learning session}

At the beginning of each distance learning session, participants were asked to perform a 15 min warm-up that included rope exercises, stretching exercises, and squat movements. During the practice, at the beginning of each 12-trial block, participants were asked to view the video demonstration of the snatch technique along with a detailed description of the success criteria (i.e., using audio-visual content). When the viewing was completed, participants were required to complete 12 trials of the snatch skill. For both experimental groups, all of the snatch movement trials were recorded during each learning session using a smartphone placed on a chair at a distance of 3 m. Also, those participants were informed that they would be allowed to get extrinsic feedback only three times, intercepting exactly the 12 skill trials. Each participant in three groups was required to watch their video feedback in slow-motion mode. Pause, play, rewind, and forward options were available at the convenience of the learner. During the video viewing, each learner had to concentrate on the content in an attempt to identify errors committed during the skill performance. The participants of each group received the following video feedback modes:

Peer-to-peer online Video Feedback with Pedagogical Activity (P-VF-PA): participants of this group were divided into two sub-groups. Each sub-group is made up of six participants. The first sub-group carries out the block of 12-trials. Learners were provided with key images of the snatch technique including visual cues presented on a paper in order to help them in the error detection and the feedback provision processes. Before watching his/her video feedback, each participant must transfer the snatch sequence to his/her homolog (having the same characteristics: weight, age, sex, and technical skills) in the second subgroup. During the visualization, the two peers try to detect the maximum number of errors then they exchange their evaluation and correction of the movement via voice message (verbal feedback) on the Facebook Messenger application, then switch roles.

Peer-to-peer online Video Feedback (P-VF): similarly, participants in this group were divided into two subgroups. Each participant sent his/her video feedback to his/her correspondent from the second sub-group before the video
viewing. Just after viewing, participants had to exchange their audio feedback through the messenger application and then switch roles.

Control group (CONT): Participants \((n = 11)\) in this group practiced the snatch exercise and did not receive any type of feedback.

All distance learning sessions were controlled by the PE teacher through the Zoom video-conferencing application. In addition, the parents of participants reported that their children did not practice any weightlifting exercises outside of the training sessions.

**Statistical analyses**

Statistical analyses were obtained with the Statistica 10 software (StatSoft, Cracow, Poland). Data are presented as mean and standard deviation (mean \(\pm\) SD). The G*power software\(^{34}\) served to calculate the required sample size. Values were set at 0.05 for \(\alpha\) and at 0.95 for power. Based on a study by Souissi et al.\(^{20}\) and discussions between the authors, the effect size was estimated to be 0.63. The sample size was set at 12 participants for each group. The Shapiro–Wilks test was used to check the normality of distribution.

To compare differences between the pre-, post-, and retention test values for the P-VF-PA, P-VF, and CONT groups a 3 \(\times\) 3 \((\text{group} \times \text{time})\) repeated measures ANOVA was conducted. The effect sizes were calculated as partial eta squared \((\eta_p^2)\) to estimate the meaningfulness of significant findings. When appropriate, the significance of differences between means was tested using the Bonferroni post-hoc test and the effect sizes were calculated as Hedges’ \(g\).\(^{35}\)

The significance level was set at \(p < 0.05\) for all analyses.

The Intraclass Correlation Coefficient (ICC = \(r\)), Coefficient of Variation (CV), and Confidence Interval (CI) were calculated for each kinematic parameter at a 95% CI to assess the strength of association between collected data at three repetition times of the snatch in all groups at pretest. Levels of test-retest reliability were interpreted according to the rating scale proposed by Landis and Koch\(^{36}\): 0.0 \(\leq r < 0.2\) was considered poor, 0.2 \(\leq r < 0.4\) fair, 0.4 \(\leq r < 0.6\) moderate, 0.6 \(\leq r < 0.8\) substantial, and 0.8 \(\leq r < 1\) almost perfect. Based upon ICC and CV results, it was confirmed that test-retest reliability was substantial to almost perfect for all kinematic parameters (least \(r = 0.83\) (95% CI = 0.76–0.88); highest \(r = 0.93\) (95% CI = 0.84–0.94), \(p < 0.001\); CV% ranged from 3.42% to 6.12%).

**Results**

**Technical performance**

Descriptive statistics presented as mean \(\pm\) SD are summarized in Table 2. Based upon follow-up comparisons there were no significant differences between groups at baseline testing for age, height, weight, body mass index, and all kinematic parameters \((p < 0.05)\). Based on the results of the ANOVA (group \(\times\) learning) of the mixed model (Table 2) with repeated measurement of the second factor, a significant learning effect was confirmed for most kinematic parameters: \(\text{Dx2} (F(2,64) = 3.61, \eta_p^2 = 0.10), \text{DxV} (F(2,64) = 6.84, \eta_p^2 = 0.18), \text{DxL} (F(2,64) = 4.68, \eta_p^2 = 0.13),\) and \(\text{VTR} (F(2,64) = 8.68, \eta_p^2 = 0.21),\) (ii) a significant group effect for \(\text{DxV} (F(2,32) = 4.05, \eta_p^2 = 0.20), \text{Dxl} (F(2,32) = 4.97, \eta_p^2 = 0.24)\) and \(\text{Diff-Tr} (F(2,32) = 6.1, \eta_p^2 = 0.27),\) and (iii) a significant effect of a group-by-learning interaction for \(\text{DxV} (F(4,64) = 3.33, \eta_p^2 = 0.17)\) and \(\text{Diff-Tr} (F(4,64) = 4.23, \eta_p^2 = 0.21).\)

For P-VF-PA group, based upon post-analysis, it was determined that there were lower values at \(T_0\) compared to \(T_0\) for \(\text{Dx2} (27.79 \pm 50.81\%, \text{Hedges’ } g = 1.03, p < 0.05, 95\% \text{ CI} = 0.06–7.37), \text{DxV} (29.52 \pm 33.71\%, \text{Hedges’ } g = 1.12, p < 0.05, 95\% \text{ CI} = 0.15–9.03), \text{DxL} (20.85 \pm 38.17\%, \text{Hedges’ } g = 1.18, p < 0.05, 95\% \text{ CI} = 0.08–10.36), \text{Diff Tr} (42.32 \pm 41.33\%, \text{Hedges’ } g = 1.16, p < 0.01, 95\% \text{ CI} = 1.11–9.96)\) and at \(T_2\) compared to \(T_0\) for \(\text{DxV} (33.76 \pm 32.88\%, \text{Hedges’ } g = 1, p < 0.05, 95\% \text{ CI} = 0.2–9.07)\) and \(\text{Diff Tr} (37.82 \pm 37.57\%, \text{Hedges’ } g = 1.37, p < 0.05, 95\% \text{ CI} = 0.67–9.51).\) In the P-VF group, the \(\text{DxV}\) values were significantly less at \(T_1\) versus \(T_0\) \((31.61 \pm 29.7\%, \text{Hedges’ } g = 0.61, p < 0.05)\).

In addition, based upon post analysis, it was determined that there was a significant inter-group difference between the P-VF-PA and \(\text{CONT}\) at \(T_1\) for the \(\text{Diff-Tr}\) parameter \((p < 0.05, 95\% \text{ CI} = -13.07 \text{ to } -9.98)\) and at \(T_2\) for the \(\text{DxV} (p < 0.05, 95\% \text{ CI} = 0.36–8.91), \text{DxL} (p < 0.05, 95\% \text{ CI} = -12.34–0.15)\) and \(\text{Diff-Tr} \) parameters \((p < 0.05, 95\% \text{ CI} = -12.16 \text{ to } -0.06)\) and compared with the P-VF group at \(T_1\) only for the \(\text{Diff-Tr} (p < 0.05, 95\% \text{ CI} = -11.67–0.15).\)

**Technical knowledge level test**

The technical knowledge level at \(T_0\), \(T_1\), and \(T_2\) for all groups is presented in Figure 3. Based upon the results of the \((3 \text{ groups} \times 3 \text{ times})\) ANOVA, there was a significant time effect \((F(2, 64) = 18.68; \eta_p^2 = 0.37),\) (ii) a significant effect of the interaction time \(\times\) group with \((F(4, 64) = 4.89; \eta_p^2 = 0.23),\) and (iii) a significant effect of the group with \((F(2, 32) = 8.5; \eta_p^2 = 0.34)\).

At baseline (\(T_0\)), within-group comparison revealed no significant difference between the P-VF-PA, P-VF, and \(\text{CONT}\) groups for technical knowledge level \((p > 0.05)\). For the three groups, based upon post-analysis, it was determined that there was a significant increase in the technical knowledge level at \(T_1\) vs. \(T_0\) \((p < 0.001, \text{Hedges’ } g = 2.15, 95\% \text{ CI} = -3.44 \text{ to } -1.06)\) and at \(T_2\) vs. \(T_0\) \((p < 0.001, \text{Hedges’ } g = 1.72, 95\% \text{ CI} = -3.02 \text{ to } -0.64)\) for P-VF-PA group and \((p < 0.05, \text{Hedges’ } g = 1.24, 95\% \text{ CI} = -2.44 \text{ to } -0.06)\) for the P-VF group at \(T_2\) compared to \(T_0\) only. In addition, the post-hoc test showed a significantly higher technical knowledge level for the P-VF-PA.
Table 2. Kinematic parameters (mean ± SD) were recorded before and after training in the three groups.

| Kinematic variables | P-VF-AP | P-VF  | CONT  | Anova |
|---------------------|---------|-------|-------|-------|
|                     | T0      | T1    | T2    | T0    | T1    | T2    | T0    | T1    | T2    | learning × Group (p) | Learning Group (p) |
| DX2 (cm)            | 10.24 ± 3.64 | 6.53 ± 3.54* | 6.9 ± 4.91 | 10.06 ± 3.84 | 9.78 ± 3.53 | 8.95 ± 3.35 | 9.5 ± 3.62 | 9.38 ± 3.58 | 9.18 ± 3.84 | 0.12 < 0.05 0.36 |
| DXV (cm)            | 12.66 ± 4.13 | 8.07 ± 4.04* | 8.02 ± 5.02* | 13.36 ± 4.26 | 10.82 ± 4.06* | 8.89 ± 4.11 | 12.82 ± 4.1 | 13.28 ± 3.31 | 13.84 ± 4.39 | <0.05 =0.002 <0.05 |
| DXT (cm)            | 16.65 ± 5.58 | 12.3 ± 5.28 | 13.94 ± 3.98 | 15.4 ± 5.21 | 15.47 ± 4.42 | 16.06 ± 3.8 | 16.7 ± 4.16 | 16.05 ± 4.55 | 15.28 ± 15.28 | 0.17 0.13 0.52 |
| DXL (cm)            | 19.06 ± 4.61 | 13.84 ± 4.19* | 15.06 ± 4.32* | 18.71 ± 4.69 | 16.51 ± 4.72 | 16.01 ± 3.31 | 20.01 ± 3.9 | 19.94 ± 4.29 | 19.93 ± 5.1 | 0.19 <0.05 <0.05 |
| VTR (cm)            | 14.94 ± 4.62 | 11.57 ± 4.78 | 11.8 ± 4.15 | 13.35 ± 4.46 | 12.6 ± 3.19 | 11.94 ± 4.06 | 15.95 ± 5.12 | 15.23 ± 5.24 | 15.02 ± 4.12 | 0.42 < 0.001 0.24 |
| Diff Tr (cm)        | 13.27 ± 4.18 | 7.74 ± 5.25* | 8.18 ± 3.15* | 12.83 ± 3.66 | 13.5 ± 4.14 | 12.72 ± 4.12 | 13.96 ± 4.36 | 14.76 ± 4.86 | 14.29 ± 3.9 | <0.01 0.08 <0.01 |

P-VF-AP: peer-to-peer online video feedback with pedagogical activity; P-VF: peer-to-peer online video feedback; CONT: control group; Dx2: the horizontal displacement from the start position to the start of the second pull; DxV: the horizontal displacement from the second pull position to the forward position; DXT: the horizontal displacement from the start position to the catch position; DxL: the horizontal displacement from the most forward position to the catch position; VTR: the vertical displacement from the maximum height to the catch position; Diff Tr: the difference between the right-side and left-side distances of the bar trajectory in absolute value. P-values were adjusted for multiple testing by the Holm–Bonferroni method. * = significant difference compared with T0 (p < 0.05). # = significant difference compared with CONT (p < 0.05). € = significant difference compared with P-VF (p < 0.05).
group compared with (i) the CONT group at T1 ($p < 0.001$), Hedges’ $g = 1.67$, 95% CI = 0.51–3.61) and at T2 ($p < 0.01$, Hedges’ $g = 1.6$, 95% CI = 0.28–3.37) and (ii) The P-VF group at T1 ($p < 0.01$, Hedges’ $g = 1.66$, 95% CI = 0.24–3.26).

**Discussion**

The aim of this study was to determine whether a distance learning method where video-based peer feedback was coupled with a pedagogical activity (P-VF-PA) would be effective in improving motor skill learning in weightlifting. In addition, we compared the effect of this method with a similar method where no pedagogical activity was involved (P-VF) and a control condition without any type of feedback on the snatch technical performance in young athletes. After eight learning sessions, technical performance, in terms of the barbell trajectory, was significantly improved using the P-VF-PA strategy compared to the P-VF method; this benefit persisted in the retention test after a week. Results of comparisons between the learner groups showed that the technical performance of the P-VF-PA group was better (i) for the Diff-Tr kinematic parameter at T1 and at T2 for DxV, DxL, and Diff-Tr parameters compared with the CONT group and (ii) for Diff-Tr at T1 compared with the P-VF group.

Thus, it appears that P-VF-PA was an effective method for promoting rapid improvements in the snatch technical performance within a distance learning context. The P-VF-PA group showed a larger decrease at T1 and T2 in several horizontal displacement parameters. As noted in the results section, the P-VF-PA group showed a significant improvement at T1 for the horizontal displacement of the first pull (Dx2: $-27.29\%$). In fact, the adoption of a correct starting position (in which the shoulders and knees of the learner are slightly in front of the bar, the shins are in contact with the bar, and the hands are extended) is an important first step in establishing better bar kinematics.

Furthermore, in the P-VF-PA group, the horizontal displacement of the bar from the most forward position to the catch position (DxL) decreased by 20.85% at T1. In addition, the horizontal displacement between the first and the second pulls (DxV) improved at T1 and T2 by 29.52% and 33.76%, respectively. The minimization of the barbell’s horizontal displacements is considered the most important indicator of an effective technique. In this study, it is interesting to note that a change in the overall bar path reduced the differences in the trajectory distance between the right and left sides of the barbell. Indeed, there was a significant decrease in asymmetry at T1 and T2 ($-42.2\%$ and $-37.8\%$, respectively) for the P-VF-PA group. A possible reason for these improvements might be that the pedagogical activity the learners had experienced while viewing the video feedback may have assisted them in concentrating on all the details of the movement and this, in turn, may have facilitated the detection of errors. On top of that, the mutual evaluations between the peers may have contributed to a significant increase in error detection rates and/or consolidated the information concerning the evaluations, leading to higher levels of procedural knowledge associated with the snatch technique. There is a growing body of empirical evidence that properly conducted peer-to-peer feedback is beneficial to both the learner providing the audio feedback and the learner receiving it. Ashton and Davies reported that to increase the efficacy of peer feedback during distance learning, a variety of interventions must be integrated. The previous studies recommended guided pedagogical support systems to train students in general assessment and peer feedback skills.

For the P-VF group, only the horizontal displacement of the bar between the first and second pull (DxV) was improved (i.e., $-31.6\%$). Peer-to-peer feedback without pedagogical support may disrupt the automatic control process after a rest period (retention test). Still, a practice involving P-VF may produce some improvements in the snatch technique in weightlifting during the posttest. These findings align well with those of Trabelsi et al., who confirmed a positive effect of peer-to-peer feedback on learning the long jump technique in PE classes. Concerning the Dx2, DxL, DxT, VTR, and Diff-Tr parameters, the obtained results showed no change. These results are coherent with those of Souissi et al., who suggested that this result may be explained by the fact that learners who have little prior knowledge are not capable of grasping relevant information from the total amount of information displayed in the video.

In light of the present study’s findings, it could be concluded that the P-VF-PA is an efficient method, during distance learning, for correcting the patterns of complex movements executed within a short time window. It was clear that the peer-to-peer online video feedback with the
introduced pedagogical tool significantly improved snatch learning in young weightlifting athletes. With the active participation of the learner in the inverse learning strategy, skills are built to reach an efficient individual technical pattern, and not the stereotypical reproduction of a static representation of the action imposed by the instructor. The error-monitoring system, involved in the P-VF-PA method, tracks the outcomes of the movement execution and detects deviations from the expected performance results.

To the best of our knowledge, this is the first study to investigate whether distance peer-to-peer interaction strategies mediated by online technology can help learners improve their sport skills. However, a possible limitation of the study could be that the errors were identified through a qualitative analysis conducted by the learner during learning sessions rather than quantified. Collecting quantitative data could have further explicated the root causes of the improvements observed in participants’ performances of the snatch movement. Also, the maximum speed of the bar should be assessed in order to measure the finer intricacies of improved technical performance.

The results of the P-VF-PA method may greatly influence the methods of coaching and teaching complex movements during PE classes (face-to-face or distance) in the future. They may also be considered for research in different fields such as sport psychology and distance physical therapy in emergency conditions; but this will only be possible by continuing to bridge the gap between qualitative and quantitative data collection and analysis.

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