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The Beneficial Effect of Combining Feedback, Observational Learning and Motor Imagery on Football Pass Performance

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ORIGINAL ARTICLE

ABSTRACT

The aim of this original research was to investigate the effect of a combination of feedback, action observation of a model, and motor imagery on passes accuracy in non-expert football players. All the participants performed a pre-test, 5 week-intervention sessions, and a post-test similar to the pre-test. The task consisted of passing toward a target located at 20-meters in an outdoor football field. During each session, the participants, divided into Control (i.e., physical practice only), Feedback, Model, Imagery, and Feedback plus Model plus Imagery (FMI) groups, performed 3 blocks of 4 trials. After each block, they received or not feedback by the coach, watched a clip or a video of a skilled peer model touching the target, and finally realized a mental task or motor imagery. The main results of this study revealed that the FMI group increased the performance from the pre- to the post-test, whereas the performance of all the other groups remained stable across the experimental conditions. The current study showed the beneficial effect of combining the observation of a model, the motor imagery, and expert feedback after physical practice, especially in the case of a short learning session in non-expert football players.

Keywords: Feedback, observation, motor imagery, soccer, motor learning

INTRODUCTION

According to Schmidt (1991), motor learning is a process of acquiring, completing, and using motor information, knowledge, experience, and motor programmes. Motor learning is a change resulting from practice, which can be facilitated by the use of feedback (Schmidt & Lee, 1999), mental practices as action observation, or motor imagery (Eaves, Riach, Holmes, & Wright, 2016).

Feedback and Motor Learning

Landin (1996) evoked that the use of external (e.g., verbal) feedback provides important information, enhances attention, and facilitates task performance by indicating vital form characteristics that may not be available to the performer's vision (Janelle, Champenoy, Coombes, & Mousseau, 2003). In a study, Buekers (1995) observed that a group of football players receiving extrinsic feedbacks, in a head-shooting task, had better performance than the participants of the control group that had no feedback. In addition, the use of positive feedback and correction concerning prior trials permit greater outcome scores in easy badminton skills (Tzetzis, Votsis, & Kourtessis, 2008). However, it is important to note that the use of feedback may have both beneficial (i.e., enhancing goal attainment and guide) and detrimental effects: It may lead to dependency and prevents the processing of intrinsic feedback (Schmidt & Lee, 1999). In order to limit these negative effects, authors suggested the use of summary feedback given after a certain number of trials (Schmidt, Lange, & Young, 1990) and after a delay of a few seconds (Swinnen, Schmidt, Nicholson, & Shapiro, 1990) to allow the processing of the intrinsic information. In view of the research previously mentioned, we could hypothesize that the addition of the feedback to the physical practice would permit to increase the performance in a motor task.

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Motor Imagery and Sport Performance

According to Robin et al. (2007), Motor Imagery (MI) is a conscious process that requires that individuals mentally simulate an action without performing it. MI is a mental technique that is frequently used in learning, exercise, performance enhancement and rehabilitation (Di Rienzo et al., 2015; Guillot & Collet, 2008; Robin, Coudevylle, Hue, &Sinnapah, 2017). MI can be used to complete physical practice to improve accuracy (Ingram, Kraeutner, Solomon, Westwood, & Boe, 2016; Robin et al., 2007) and motor execution (Kanthak, Bigliassi, Vieira, & Altimari, 2014). In the football domain, previous studies have investigated the influence of MI in novice and professional players (Blair, Hall, & Leyshon, 1993; Hegazy, 2012; Jordet, 2005; Seif-Barghi, Kordi, Memari, Ali-Mansournia, & Jalali-Ghomi, 2012; Thelwell, Greenlees, & Weston, 2006), however, few researches showed a performance improvement following MI intervention (Blair et al., 1993; Thelwell, Greenlees, & Weston, 2010). In a penalty-kicking task, Hegazy (2012) found a small effect with MI intervention. Other studies revealed an absence of MI effect (Sosovec, 2004) or inconsistency in their results (e.g., Seif-Barghi et al., 2012; Thelwell et al., 2006). As suggested by Veraksa and Gorovaya (2012), the inconsistency regarding the effect of MI intervention may be due to differences in imagery ability in the participants, which makes it necessary to control this factor (Hall, 2001; Robin et al., 2007).

Observation of a Model and Physical Practice

According to Grèzes and Decety (2001), MI and Observation of a Model (OM) are two forms of motor simulation that activate the motor system in the absence of overt motor execution. As argued by Eaves et al. (2016), "OM evokes a cognitive representation of the observed motor action," also called "motor resonance" by Rizzolatti and Sinigaglia (2010). Romano-Smith, Wood, Wrigt, and Wakefield (2018) added that the beneficial effect of OM seems to reflect involuntary activation of motor codes corresponding to observed actions. Wild, Poliakoff, Jerrison, and Gowen (2010) showed that observers copy the motor action kinematics (e.g., speed) of the model, which is coded through biological motion. OM is an effective technique for improving motor learning in a variety of motor skills (for a review, see Ste-Marie et al., 2012). Indeed, OM permits to reduce the number of physical practice trials required to achieve a given performance, and OM combined with physical practice permits greater performance than a control group that had no observation (for a review, see Blandin, 2002).

Potential Beneficial Effect of Combining Observation of a Model, Imagery, and Feedback

OM and MI have traditionally been considered as separate techniques for performance or motor learning improvement, but recent studies are now focusing more on their combined use, rather than their independent application (see Eaves et al., 2016 for a review). Researches recently showed that excitability and corticomotor activity were significantly increased when OM and MI were used in combination (Ohno et al., 2011; Wright, Williams, & Holmes, 2014) when compared with the same movement was only observed or imagined (Mouthon, Ruffieux, Wälchli, Keller, & Taube, 2015). In the sports domain, Smith and Holmes (2004) observed that OM plus MI improved performance in a golf putting task more than MI alone and similar results were observed in a bicep curl test over a 6-week video-guided imagery intervention (Wright & Smith, 2009). As we were interested in non-expert football players that have not developed an "optimal" mental representation of the actions to realize (Frank, Land, Popp, & Schack, 2014; Jeannerod, 2001), it is possible that the OM and MI of a specific movement would be more efficient if it is preceded by extrinsic feedback. The feedback would, in particular, permit to realize the MI based on a "corrected" mental representation of the action to realize. In addition, Weir and Leavitt (1990) suggested that the addition of feedback could contribute to the models' effectiveness.

Given the importance of using feedback to modify and/or improve the mental representation of actions, and given the fact that the same representation is used during OM, MI, and physical execution, we presume that receiving feedback concerning prior physical performances, before OM and MI, would be particularly beneficial. The aim of this original study was to evaluate the potential beneficial effect of combining the three latter techniques with physical practice in a football-passing task. We first hypothesized that the participants receiving a combination of physical practice and MI or OM would have better performance than physical practice only. Secondly, we expected that the addition of the feedback to the physical practice would improve performance. Finally, we hypothesized that receiving feedback after physical trials but before watching a model and realizing motor imagery would improve football pass accuracy to a greater degree than in other conditions due to more structured and elaborate representations as evoked by Frank and collaborators (2014).

METHOD

Participants

Sixty-one (M_{age} = 18.93, *SD* = 1.81) self-declared right-handed and right-footed university students were volunteers to take part in the experiment and provided their written informed consent. They were competing not higher than at a regional level and played football for more than 3 years. The participants were divided into five experimental groups (Control, Model, Imagery, Feedback, or Feedback plus Model plus Imagery), as illustrated in Figure 1. Two of them were excluded because they had missed one experimental session or the post-test. This study was approved by the local ethics committee of the University and was conducted in accordance with the Declaration of Helsinki (1964).

Material and Task

This study was realized in an outdoor football field. A vertical plastic target (1.7-meter high and 4-cm diameter) was located at 20-meters from a plastic cone corresponding to the start position of the ball (a regulation, size five soccer ball). In order to give the instruction to the participants, a tablet (Samsung Galaxy Tab4 model SM-T533, Android 5.1.1, 10.1 inches) was used with a V7 over-the-head stereo headphone (HA510).

Imagery Ability

Individual imagery ability was assessed to ensure that the sample did not include participants with extremely low MI ability (see Robin et al., 2007, for a similar procedure). All of them completed the Movement Imagery Questionnaire-Revised (MIQ-R; Hall & Martin, 1997), which is composed of 8 items that assess individual kinesthetic and visual imagery abilities. Each item of the MIQ-R corresponds to a separate simple movement (e.g., leg, arm, or whole-body) that was specifically described so that every participant performing the MIQ-R mentally simulates the same movements. The participants rate the difficulty or ease of forming a mental representation using two 7-point Likert-type scales (from 1 = *very hard to feel/see* to 7 = *very easy to feel/see)* referring to kinesthetic and visual imagery, respectively. The psychometric properties of the MIQ-R have been consistently adequate, with a Cronbach α of .82 for both kinesthetic and visual scales (Lorant& Nicolas, 2004).

Football Task

Participants had to realize, with a soccer-ball, 3 blocks of 4 passes toward a vertical target. Each pass error (i.e., the distance in meters and centimeters between the inner side of the ball and the vertical target) was measured using a tape measure placed on the grass perpendicular to an imaginary line from the target to the starting cone.

Observation of a Model Task

Standing on the football field with the tablet on their hand, the participants of the Model and Feedback plus Model plus Imagery (FMI) group had to watch a skilled peer model realizing a pass that touches the target, whereas the participants of the Control, Feedback, and Imagery group watched a video clip, after the execution.

Mental Task

The Control, Model, and Feedback group performed a mental task: Countdown from 10 to 0, which approximately corresponded to the length of time that Imagery and FMI groups spent on motor imagery.

Motor Imagery Task

During this phase, which was realized on the football field, participants of the Imagery and FMI groups were required to perform internal visual imagery (imagining being inside his/her body as if there were looking with their own eyes), by focusing their attention on the ball trajectory that hit the target (see Robin et al., 2007, for a similar procedure). Brief interviews concerning MI were conducted during the experiment and served as manipulation checks.

Procedures

As illustrated in Figure 1, before the start of the experiment, the participants completed the MIQ-R. They were then randomly assigned to Control, Model, Imagery, Feedback, or FMI groups.

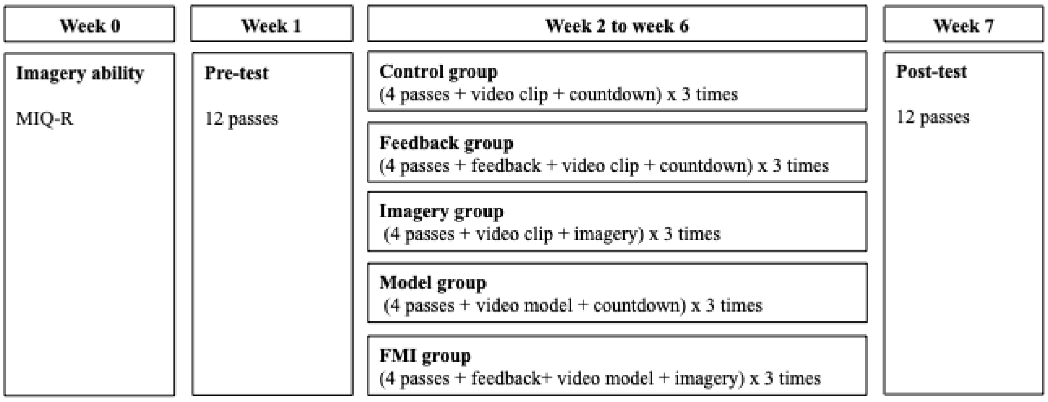

*Figure 1.*Time course of the experimental design.

During the pre-test (week 1), participants realized a standardized 20-minutes warm-up and then performed 12 physical trials. During a trial, they had to pass toward the target as accurately as possible. The intervention phase took place during the four following weeks (2 to 6). Each intervention session started with a 20-minutes warm-up and lasted approximately 30-minutes. Following the warm-up session, the participant had to perform 3 identical blocks of 4 physical trials per week. After each block, the Feedback and the FMI groups received verbal feedback given by a coach (physical education teacher, soccer-expert, and coach at the University) on the prior 4 physical trials. The feedback was positive (e.g., "good, continue like this") when the ball touched the target or cues about movement corrections (e.g., "you must touch the ball with that part of your foot"). Then, the Control and the Feedback groups were required to perform a countdown task, whereas the Imagery and FMI groups had to realize MI. The instruction was given by the tablet for all the groups. Finally, the post-test (week 7) was similar to the pre-test.

Data Analysis

The MIQ-R scores were first examined to confirm that there were no between-group imagery ability differences. Second, the mean Variable Error (VE), Absolute Error (AE), and Total Error ($TE = \sqrt{VE^2+AE^2}$), for the pre- and post-tests, were computed and retained as dependent variables. The latter was submitted to a 5 Group (Control vs. Feedback vs. Imagery vs. Model vs. FMI) x 2 Test (pre-test vs. post-test) ANOVAs with repeated measures on the second factor. The significant main effects and interaction were broken down using the Newman-Keuls or Bonferroni tests. Normality was checked (Kolmogorov-Smirnov test), effect sizes (η_p^2) were indicated, and $\alpha$was set at .05 for all the analyses. Non-parametric Kruskall-Wallis ANOVA by ranks was performed in the case of the absence of normality.

RESULTS

Imagery Ability

The mean and standard deviation MIQ-R (i.e., visual and kinesthetic) scores are presented in Table 1. The ANOVAs revealed no main group effect on the visual MIQ-R scores [$F_{(4,\ 54)} = 0.43$, $p = .78$, $\eta_p^2 = 0.01$]. The Kruskal-Wallis ANOVA revealed no main group effect on kinesthetic scores [$H_{(4,\ N=59)} = 1.17$, $p = .88$, $\eta_p^2 = 0.01$].

Total Error

Very similar results were obtained in AE and VE analyses as illustrated in Table 2, we therefore decided to present the results obtained in TE.

Table 1

Kinesthetic and visual MIQ-R scores

Groups	Kinesthetic MIQ-R scores		Visual MIQ-R scores	
	M	*SD*	*M*	*SD*
Control (n = 11)	21.8	2. 6	24.3	2.3
Feedback (n = 11)	20.8	1.6	23.5	1.1
Imagery (n = 12)	21.2	1.1	23.7	1.4
Model (n = 12)	21.4	2.1	23.6	2.6
FMI (n = 13)	21.53	2.0	23.69	2.1

FMI corresponds to Feedback plus Model plus Imagery group. Each kinesthetic and visual MIQ-R score is obtained by adding the score of 4 items that can range from 1 to 7. The minimum total score for each MIQ-R modality is 7, and the maximum is 28.

Table 2

Variable error (VE), absolute error (AE), and total error (TE), in meter, across the experimental groups

Groups	Dependent variables	Pre-test		Post-test	
		M	*SD*	*M*	*SD*
Control (n = 11)	VE	1.10	0.32	1.03	0.35
	AE	0.95	0.31	0.83	0.35
	TE	1.45	0.44	1.31	0.50
Feedback (n = 11)	VE	0.97	0.29	1.10	0.30
	AE	0.84	0.17	0.95	0.28
	TE	1.28	0.31	1.44	0.39
Imagery (n = 12)	VE	1.09	0.36	1.08	0.37
	AE	0.91	0.34	0.90	0.32
	TE	1.42	0.48	1.40	0.47
Model (n = 12)	VE	1.02	0.17	1.15	0.23
	AE	0.87	0.19	1.03	0.22
	TE	1.34	0.25	1.55	0.25
FMI (n = 13)	VE	1.15	0.30	0.53	0.11
	AE	0.99	0.27	0.44	0.10
	TE	1.52	0.39	0.69	0.14

FMI corresponds to Feedback plus Model plus Imagery group.

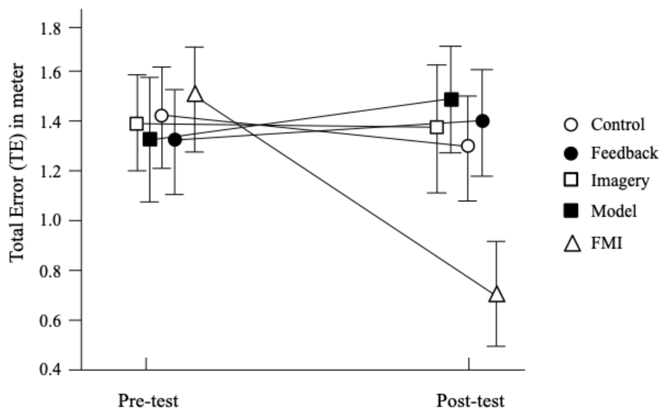

Figure 2. Significant interaction between the tests (pre-test vs. post-test) and the group (Control vs. Feedback vs. Imagery vs. Model vs. FMI) for the total error (TE). $p< .05$. I-beams indicate 95% confidence intervals for the mean values. FMI corresponds to Feedback plus Model plus Imagery group.

The analysis revealed a significant main group effect [$F_{(4, 54)} = 2.59$, $p = .047$, $\eta_p^2 = 0.16$] and a trend for the test $F(1, 54) = 3.83$, $p = .056$, $\eta_p^2 = 0.06$]. Moreover, the ANOVA revealed a significant interaction between group and test factors [$F_{(4, 54)} = 10.22$, $p < .01$, $\eta_p^2 = 0.43$]. As illustrated in Figure 2, the post-hoc Bonferroni test revealed that the participants of the FMI group decreased their error from the pre- to the post-test. Moreover, the participants of the FMI group made lower post-test errors than the participants of the four other groups. The Control, Model, Feedback, and Imagery groups had similar between group performances, whatever the tests.

DISCUSSION

The aim of this original study was to investigate whether there was an advantage of receiving, during training sessions, expert feedback (on previous motor performance) combined with OM and MI on passes accuracy in intermediate level football players.

Feedback and Pass Performance

Contrary to what was hypothesized, the results of the current study revealed that the Feedback group, like the Control group, remained stable and had a similar performance from the pre- to the post-test. This result indicates that the use of verbal feedback (i.e., qualitative positive and cue about movement correction), given by the coach during five learning sessions, did not influence passes performance. This result seems to be consistent with Kernodle and Carlton (1992), who evoked that providing verbal cues about corrections is only useful for simple tasks performed by beginners. Indeed, Tzetzis and collaborators (2008) showed that young participants who received correction cues and positive feedback had better scores in easy badminton skills than a control group that had no feedback. However, in this study, the players were not beginners, playing for more than 3 years and competing at not higher than the regional level, and the passing task was not easy to perform as indicated by the accuracy error measured during the pre-test.

We may first consider that the addition of the external feedback given by the coach, concerning previous physical performance, with the internal feedback (knowledge of result estimated by the participant's vision) could be difficult to process, at the same time, in non-expert participants. The cognitive processing system would need more learning sessions or more time during a learning session, to efficiently use the feedback given by the coach, serving as a guide (Schmidt, 1991). We may also consider that the use of feedback might have both beneficial but also detrimental effects (Schmidt & Lee, 1999), involving a kind of dependence (Winstein & Schmidt, 1990) and limiting the processing of intrinsic information (Salmoni, Schmidt, & Walter, 1984). Although, the feedback was given after 4 physical trials and after a delay of 10 seconds to allow the processing of the intrinsic feedback (Swinnen et al., 1990), it is possible that the football players needed more than 10 seconds to process knowledge result given by the vision of their passes or that the summary feedback should have been based on more than 4 trials, to avoid dependence effect (Schmidt & Lee, 1999). Finally, it is possible that the external and internal feedbacks were similar and did not present a different stimulus limiting the involvement of the participant in the correction of his movement and the attention to the task (Landin, 1996). More research is needed, including the comparison between intrinsic and extrinsic feedback to better comprehension.

Observation of a Model Combined with Physical Practice

Contrary to what was hypothesized, the combination of physical trials and the observation of a model (OM) during the five learning sessions had no influence on football pass performance between the pre- and post-test. As reviewed by Blandin (2002), many factors could explain this lake of results. First, we may consider that the participants needed more amount of practice (physical trials plus

OM) to increase their performance. Second, it is possible that the model type (i.e., skilled peer model) used in this study, was not optimal. However, Ste-Marie and collaborators (2012) revealed inconsistent results in the literature concerning the model type used in OM. For example, Gould and Weiss (1981) found that observation of an unskilled peer model improved a leg exercise task better than observing a non-peer skilled model. In contrast, George, Feltz, and Chase (1992) showed that the model ability was more important than the similarity of the model. They observed that skilledpeer and skillednon-peer held their leg up longer than unskillednon-peer and unskilledpeer. In addition, Weir and Leavitt (1990), using a dart-throwing task, showed no significant difference between the skilledpeer and unskilled peer models. More research on this topic is needed.

Finally, we may consider that the use of the self-as-a model could be a more powerful technique than the OM of another due to heightened functional similarity with that of physical motor action (Holmes &Calmels, 2008). However, inconsistent results are also reported in the literature. While a study has shown self-observation video to be less effective (Zetou, Kourtesis, Getsiou, Michalopoulou, & Kioumourtzoglou, 2008), an experiment showed no difference whatever the model types (Emmen, Wesseling, Bootsma, Hoogesteger, & Whiting, 1985, and some studies have shown positives effects (e.g., Clark & Ste-Marie, 2007; Onate et al., 2005).

Motor Imagery Combined with Physical Practice

Contrary to what was hypothesized, the results of our study showed that the participants of the Imagery group had similar performances to those of the Control group during the tests, and remained stable from the pre- to the post-test. This result is consistent with Frank et al. (2014), who showed that the "mental-physical combined practice group" performed equally to "physical practice group" in a golf-putting task. This result is also consistent with studies that showed an absence of MI (internal visual perspective) intervention effect on penalty kick (Sosovec, 2004) or others that revealed inconsistency in their results depending of the age of the soccer player (Seif-Barghi et al., 2012). For example, Thelwell et al. (2006) observed an absence of clear improvements on tasks (first touch, pass, and tackle) performance in certain elite midfield players after a psychological skills intervention package including relaxation, self-talk and MI. As suggested by Frank et al. (2014), we could first consider that the non-expert players needed more MI intervention to improve their pass accuracy. According to Shambrook and Bull (1996), when using MI intervention, it should not be expected that the results are going to be evident immediately, as the imagery skill itself has to be perfected. For example, Veraksa and Gorovaya (2012) argued in favour of participants' imagery ability influence: People with a "higher level of imagination" being more inclined to use MI. In order to ensure that none of the participants encountered difficulties in realizing MI, individual imagery ability was assessed in the current study. There was no difference between groups according to imagery ability (MIQ-R scores), and the sample did not include anyone with extremely low mental imagery ability indicating that this factor was probably not responsible of the lake of MI effect.

Moreover, less is documented on exactly how many sessions are needed for athletes to use MI as an instrument of performance enhancement (Seif-Barghi et al., 2012). It is important to note that in the current study, the duration, number of the intervention sessions as well as the number of trials was conditioned by the constraints related to the weather, the availability of the football field of the University and the students. In addition to a sufficient amount of intervention, the potential beneficial effect of MI may depend on player mental representation "quality". We may consider that MI could be more efficient for experts (Jordet, 2005; Robin et al., 2007) who have already constructed an "optimal" motor representation of action (Hegazy, 2012; Mulder, Zijlstra, Zijlstra, & Hochstenbach, 2004). We may consider that the non-expert football players would need to have external expert feedback in order to, in one hand, modify the representation of the movement using the advice and recommendation of the coach before MI, or in the other hand imagine the same well-realized movement (reinforcing the mental action representation).

Feedback Combined with Observation of a Model and Motor Imagery Increases Football Pass Performance

It was finally hypothesized that receiving summary feedback after previous physical trial and just before OM and MI would improve the football pass accuracy to a greater degree than when MI, OM, and feedback were used as separate techniques. The result of this original study confirmed this hypothesis and showed that the participants of the FMI group had greater performances than the participants of all the other groups. This result is consistent with Gray and Fernandez (1989), who showed, in a basketball-shooting task, better performance when combining OM and MI. In line with Onestak (1997), we could suggest that visual information (i.e., observation of a model) supported by MI (and vice versa) could enhance learning and performance (Eaves et al., 2016).

The result of the current study is also consistent with McCullagh and Meyer (1997), who showed the beneficial effect of adding feedback and OM in a free weight squat form task. It seems that the addition of expert feedback could contribute to the model's effectiveness (Ste-Marie et al., 2002), but when it is combined with MI and OM. The fact that the number of feedback received was similar for the Feedback and FMI groups seems to indicate that this is not the number of feedback received that could explain the difference in performance between these two groups. In addition, one could argued that the participants of the FMI groups had more time to real think about their errors but the brief interviews revealed that that the participants declared having performed MI. The fact that the performance of the Feedback group remained stable, whereas that of the FMI group increased, seems to indicate that using feedback (e.g., cues about movement corrections) in order to improve passes performance on the basis on "corrected" mental representation of action during MI and after OM can be particularly efficient as previously evoked.

It is also possible that the results of the current study depend on the age and years of practice. Indeed, the participants of the current study were young adults with a motor pattern already quite assimilated due to more than 3 years of football practice. Whereas expert athletes are known to frequently use MI (Guillot & Collet, 2008), OM (Ste-Marie et al., 2012), or a combination of the two latter (Eaves et al., 2016), we need to ask ourselves about the potential beneficial effect of a combination of technics (i.e., FMI) in younger and non-expert athletes. Indeed, although recent studies showed the beneficial effect of a combination of MI and OM on free-throw performance in 14 year-olds novice pupils (Robin, Charles-Charlery, & Coudevylle, 2019); or a combination of feedback and video gymnastic movement learning in 12 year-olds pupils (Potdevin et al., 2018), further studies are needed to investigate the effect of a combination of feedback, OM and IM in teenagers and younger participants for whom the mental representation of the action to perform is in the construction phase, and the motor pattern is not already assimilated.

As combining physical practice plus feedback, OM and MI was the most effective intervention, we could suggest coaches adapting their training session by incorporating OM, MI in addition to cues about motor action corrections, specifically when having short duration intervention possibilities (e.g., 6-10 weeks). Future research is needed to confirm the beneficial effect of combining feedback OM and MI; and if the same model could be beneficial for both right- and left-footed or if a congruence of the foot is needed (Maher, Feki, Missoum, & Sessi, 2007). Finally, it is important to note that the current study has limitations. As previously evoked, the lake of performance passes improvement of the Feedback, OM, and MI groups could be explained by the short number of intervention sessions and trials. Due to the football field, environmental conditions, short interval between school holidays and/or participants' availabilities, it was not possible to realize the experiment for more than seven weeks.

CONCLUSION

To conclude, the results obtained in the current study highlight the beneficial effect of combining verbal feedback (i.e., positive or cues about movement correction), OM, and MI in football pass improvement in non-expert players. This study sheds more light on the scheduling of observation of a model and motor imagery in football training during a short learning session.

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Nothing to declare.

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