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Assessment of Integrating Mental and Physical Training for Skill Acquisition in Football

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ORIGINAL ARTICLE

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Abstract

Mental imagery is an essential element in the human movement system. Research in the sports psychology literature shows that training with motor imagery (mental practice) is an effective strategy for improving motor performance in planning and executing goal-directed movements. The primary objective of this study is to explore the impacts of integrating mental and physical training on the acquisition of a demanding football motor skill, specifically the "head kick." A total of 40 participants, consisting of 18 women and 22 men, who were students from the Physical Education & Sports department at Nevşehir Hacı Bektaş Veli University, were randomly divided into two groups: one group receiving combined physical education and mental practice, and the other group solely undergoing physical education training. The Vividness of Movement Imagery Questionnaire–2 (VMIQ-2; Roberts et al., 2008) and video analysis procedure were used in this study. Based on the research problem, the Repeated Measure ANOVA test was used. Motor skill performance was assessed both before and after an eight-week training period. To gauge improvements in motor skill acquisition, three independent expert evaluators analyzed video recordings of the motor task before and after training in both situations. The findings highlighted that engaging in mental imagery exercises improved timing and coordination, emphasizing the potential effectiveness of this intervention for enhancing proficiency in intricate motor skills. These study findings also illustrate the practicality and precision of employing video-based motion analysis to gauge enhancements in motor performance.

Keywords: Motor Imagery, Motor Performance, Motor Skill

Futbolda Motor Becerinin Öğrenilmesinde Kombine Zihinsel ve Fiziksel Antrenmanın Değerlendirilmesi

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Öz

Zihinsel imgeleme, insan hareket sisteminde önemli bir unsurdur. Spor psikolojisi literatüründeki araştırmalar, motor imgeleme (zihinsel pratik) ile antrenmanın, hedefe yönelik hareketlerin planlanması ve yürütülmesinde motor performansın iyileştirilmesi için etkili bir strateji olduğunu göstermektedir. Bu çalışmanın amacı, zihinsel ve fiziksel antrenmanı birleştirmenin futbolda karmaşık bir motor becerinin (kafa vuruşu) öğrenilmesi üzerindeki etkilerini araştırmaktır. Çalışmaya Nevşehir Hacı Bektaş Veli Üniversitesi, Spor Bilimleri Fakültesi, Beden Eğitimi ve Spor bölümünden beden eğitimi ve zihinsel antrenman ya da sadece beden eğitimi derslerine rastgele atanan 40 öğrenci (18 kadın, 22 erkek) katılmıştır. Bu çalışmada Hareket İmgeleminin Canlılığı Anketi-2 (VMIQ-2; Roberts ve ark., 2008) ve video analiz prosedürü kullanılmıştır. Araştırma problemine bağlı olarak Tekrarlı Ölçüm ANOVA testi kullanılmıştır. Motor performans, sekiz haftalık bir eğitim dönemi öncesinde ve sonrasında değerlendirilmiştir. Motor öğrenme performansını değerlendirmek için, üç bağımsız uzman değerlendirici tarafından her iki koşulda da eğitimden önce ve sonra motor görev üzerinde bir video analizi yapılmıştır. Bulgular, zihinsel imgeleme uygulamasının zamanlama ve koordinasyonu geliştirdiğini ve bu müdahalenin karmaşık motor becerilerin eğitiminde potansiyel etkinliğini gösterdiğini ortaya koymuştur. Çalışmanın sonuçları, motor performans gelişimlerini değerlendirmek için video tabanlı hareket analizi kullanmanın uygulanabilirliğini ve doğruluğunu göstermektedir.

Keywords: Motor İmgeleme, Motor Performans, Motor Beceri

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Introduction

Athletes usually exercise to develop new skills, and in certain situations, the misexecution of a skill can cause an athlete to make mistakes. In team sports, such mistakes have the potential to affect not only the individual but also the whole team (e.g., the opponent team player can steal the ball and score a goal after a passing mistake of a player in the defensive line in football, which puts the defensive player's team at a disadvantage; Di Rienzo et al., 2015). It is argued that mental exercises through motor imagery can improve motor learning processes since it allows for the explicit representation of a movement and its sub-stages (Ingram et al., 2016; Sherwood & Lee, 2003). More specifically, the mental imagery is a cognitive process that allows us to mentally recreate sensory information without external input. In this process, motor imagery involves mentally rehearsing a specific motor movement in our working memory without physically executing it. Motor imagery can be defined as an intention to perform a movement that never takes place consciously. The effectiveness of motor imagery lies in its ability to activate the brain in a manner similar to physical practice. Neuroimaging studies have demonstrated that motor imagery elicits brain activation patterns that largely overlap with those observed during physical practice. Extensive research indicates that motor imagery is effective in not only improving skilled performance in individuals but also at cortical and subcortical levels support the idea that mental practice can lead to motor learning.

For instance, Ranganathan and colleagues (2004) demonstrated that engaging in mental practice can result in enhanced muscle strength, influencing the way movements are programmed. Their research demonstrated that mentally simulating a movement has an impact on the motor-evoked potentials of the relevant muscles, although this effect is only observed when the actual movement is performed. Similarly, Ehrsson and co-workers (2003) identified a distinct connection between the activation of motor regions organized based on body segments and motor simulation. Additionally, neuroimaging research showing that both overt and covert execution of movements activate comparable neural networks has further bolstered the idea that mental practice contributes to motor learning. To explain motor imagery effects we need to mention the motor simulation theory (ST) that presents a neurocomputational model that explains how humans maintain knowledge related to their abilities. According to ST, our understanding of what we can do is rooted in simulation mechanisms that are activated offline in brain regions responsible for motor control. These simulations play a crucial role in aligning our perceptual experiences with our behavioral capabilities. In essence, we perceive objects based on their affordances because the simulation mechanisms allow us to mentally simulate the potential actions associated with those objects during perceptual processing.

Mental training involves mentally practicing a task without physically moving the muscles, as defined by Olsson et al. in 2008. Within the mental training literature, you often encounter terms like "motor imagery" and "mental preparation." "Mental preparation" is a broad term encompassing all mental techniques athletes can employ during training sessions. In contrast, "motor imagery" is more precisely described as mentally rehearsing a movement without actually engaging the muscles, as articulated by Jeannerod in 1994. It's crucial to recognize that there is a differentiation between intrinsic (kinesthetic) and extrinsic (visual) imagery, as explained by Lang in 1979. Adopting an intrinsic viewpoint entails individuals mentally performing a task from their own vantage point, emphasizing simulated sensations and sensory experiences. In essence, the athlete imagines performing the skill as if they were physically executing it.

On the other hand, extrinsic imagery represents the process in which the athlete imagines s/he is watching someone who is executing the skill (task). In other words, the execution of the skill by someone else is imagined. However, according to Jeannerod (1994), only intrinsic imagery should be accepted as motor imagery, and extrinsic imagery is more about visual imagery. Intrinsic motor imagery, to be more precise, incorporates an element that enables the individual to genuinely 'sense' the imagined movement, encompassing not only visual aspects but also spatial and kinaesthetic elements of the motion. Even though no physical movement occurs during this mental exercise, motor imagery shares functional characteristics with physical training. For instance, the time spent envisioning the movement is correlated with the time needed to execute the same movement physically (Johnson-Frey, 2003). This relationship between the duration of motor imagery and the actual execution time of a motor skill persists even after specialized training aimed at enhancing the execution time of that skill, as demonstrated (Louis et al. 2008). Moreover, picturing the execution of a skill as if it were physically exerting effort triggers similar physiological responses, such as an increase in heart rate and respiration rates, as observed by Decety et al. in 1991. Additionally, there is research indicating that the physical constraints experienced during the actual execution of a skill can impact both one's ability to engage in mental imagery and their real-life performance (Ramsey et al., 2010).

At the neurologic level, there is a strong evidence base that the imagery ability and physical execution of a skill share the same neuron base (Karni, 1995; Jackson, 2003; Miller, 2010). Researchers, armed with compelling evidence demonstrating the functional and neuro-physical connections between real and imagined movements, have suggested the use of mental training, bolstered by motor imagery, as a method to improve motor learning. This proposition has been put forth by scientists such as Feltz and Landers in 1983, Driskell et al. in 1994, Guillot and Collet in 2008, and Kim et al. in 2017.

The combination of motor imagery with mental training has been implemented across various sports disciplines, with studies revealing the beneficial outcomes, including improvements in speed, precision in performance, muscle strength, movement mechanics, and motor skill proficiency (Taktek, 2004; Cumming & Williams, 2012). In addition, related literature identified specific procedures to increase the efficiency of motor imagery training (Driskell et al., 1994). Hardy and Callow (1999) investigated the relative effectiveness of extrinsic and intrinsic (kinaesthetic) imagery in sports environments for the Karate branch. They found that extrinsic imagery is more effective in learning a skill. However, they also underlined that intrinsic imagery was more effective for experienced athletes in learning complex skills that required the use of various body parts.

In sports that include closed skills, it is easier to understand the natural movement that needs to be executed. In open sports, on the other hand, athletes have to deal with various factors that can have an impact on the proper execution of the task. Furthermore, researchers found that mental training supported with motor imagery can produce more efficient and effective results when implemented in teaching closed sports skills rather than open ones (Coelho, 2007). In other words, the effect of motor imagery is higher since the skill is practiced in an environment where the opponent does not have an effect and the activity is carried out in a similar and observable environment (Robin et al., 2007; Hammond et al., 2012).

The head kick technique (since it has a structure that can be transparently coded and the proper execution of the movement prioritizes accuracy) was selected to be studied in the present study. A mistake in the stage of positioning one's legs on the ground during the execution of a header can prevent an athlete from adequately acting: each athlete should learn the exact order of the sub-stages of the skill, coordinate the movements of the ankles, knees, hands, and the upper extremity to execute the skill; and rhythmically reach the ball with his/her head at the highest point possible.

In light of the above, the present study aims to investigate the effectiveness of mental exercise for developing the learning process of complex motor skills in football. The hypothesis to be tested is as follows; physical exercises supported by mental exercises can contribute to developing certain aspects of a complex motor skill.

Method

Participants

The study participants were 40 volunteers who studied in the Sports Sciences Faculty at Nevşehir Hacı Bektaş Veli University (M = 20.54, SD = 1.8 years old). Eighteen participants were female, and the remaining 22 were male students. They were randomly assigned into one of the following groups: mental training supported with traditional physical training (the experimental group) and only physical training (the control group). Both groups consisted of 20 students (the group who received motor imagery and physical training: M = 19.8; SD = 1.17; the group who received physical training only: M = 21.3; SD = 1.53). None of the participants had any prior football or heading training.

Data Collection Tools

Imagery Ability

Imagery ability is assessed using the Vividness of Movement Imagery Questionnaire–2 (VMIQ-2; Roberts et al., 2008), which gauges one's capacity to mentally visualize various movements, such as walking or jumping. This questionnaire comprises 12 items that prompt individuals to employ internal visual imagery (IVI), external visual imagery (EVI), and kinesthetic imagery (KI). Participants are instructed to rate the clarity and vividness of their mental imagery on a five-point Likert scale, ranging from 1 (very hard to see) to 5 (very easy to see). Vividness is considered a crucial aspect of imagery ability because it sustains the integrity of the mental image and relies on working memory and active rehearsal. Factors influencing image vividness include its shape, color, level of detail, context, prominence, and ease of retrieval from long-term memory. Significantly, vividness has been shown to influence actual motor execution, highlighting its effectiveness as a performance-enhancing attribute during the mental imagery process. The VMIQ-2's validity, both in terms of construct and concurrent validity, has been rigorously established, with the IVI, EVI, and KI sub-scales demonstrating high reliability values. Additionally, reliability analysis for the IVI, EVI, and KI sub-scales has yielded Cronbach alpha values of 0.95, 0.95, and 0.93, respectively.

Head Kick Technique

Header performance was assessed via a 5-point Likert scale (1= very weak, 5 = very good) that evaluated four aspects of the movement. Those aspects included; taking a position, timing, coordination, and balanced landing.

Taking position represents the process in which the athlete positions their body according to the direction that the ball comes from, and timing represents the moment they touch the ball. The player should touch the ball at the highest point possible. Coordination represents the athlete’s ability to control and accurately move their parts of the body as required to execute the move successfully. In particular, the coordination among legs, arms, and upper extremities is evaluated for a header. Balanced landing focuses on the need that the athlete balances themselves after a header jump to prevent an injury and be able to start their next move.

Materials

The command file, which included the directives for motor imagery, was recorded as an Mp3 sound file and then saved into a CD. The Mp3 file was one minute and 10 seconds long. The directives were created from the perspective of internal-visual imagery. Each athlete was reminded that they were supposed to remember the real feelings of the move. In line with this, it has been observed that the quality of the mental representation of the movement impacts motor imagery. For example, the mental simulation of a skill that the participant could not execute physically may not increase by reaching optimal performance. Since the participants did not have previous experience in utilizing mental simulation (motor imagery) to enhance their performance (Frank et al., 2016), it was assumed that the quality of the command file would be an important factor in increasing participants' performance. The command file utilized in the study included the following:

'Imagine that you are in the penalty area on a football pitch, and the goalpost is right in front of you. Imagine that you are moving towards a ball that will be directly sent to you. First, your dominant leg, and then the other, you feel the momentum starting on your feet and spreading throughout your body. Contemplate that you are focused on the ball. While the skill develops, you use your dominant leg to change the horizontal power that allows you to move vertically at the exact moment that you believe you can reach the ball at the highest point possible. You jump as high as you can and feel your body flies. Imagine that you swing your body (from back to front), look for the goal, and hit the ball. Then, align your legs and complete the move utilizing your knee as a spring and having your arms open as wide as your shoulders.'

Many factors in this scenario helped the participants during their practice. For example, each participant was asked to imagine the movement via an intrinsic perspective using the second-person singular. The aim here was to increase the student's participation in the process of learning the skill and a novel approach was considered to have the potential to facilitate this process. Furthermore, words were selected carefully in order to allow each participant to feel as if they were executing the action. This scenario is more than just the raw description of the right movement.

Procedures

The research encompassed three sequential phases: pre-training, training, and post-training. During the initial pre-training phase, participants were instructed to perform five headers (t1), and the researcher documented these header actions to establish a baseline measurement. During the training stage, students in the Motor Imagery (MI) group were provided with an Mp3 file that contained verbal instructions aiming to facilitate the mental practice of the header technique.

As recommended in prior research (Olsson, 2008), participants were instructed to engage in mental exercises on three occasions weekly. Each mental exercise session involved practicing the header technique for five iterations, each lasting 10 minutes (equivalent to two minutes per iteration), resulting in a total of 30 minutes per week (3 times a week x 10-minute session). In order to observe the harmony, participants were asked to fill in a report that asked participants to define the emotions (feelings) they had during mental trainings.

Students in the control group completed a 30-minute physical exercise twice a week for a total of six weeks, and the MI group (experimental group) also completed the same amount of physical training. In the post-training stage (t2), each participant executed a second series of five headers which were recorded by the researcher to evaluate students' performance. There were six weeks intervention between pre-training and post-training stages.

Statistical Analysis

The SPSS 25.0 package program was used in the analysis of the data in this study, and the results were primarily used in descriptive statistical techniques and statistical interpretative techniques. Repeated Measure ANOVA to analyze the relationship between the results and Pearson Correlation to analyze the relationship between obtained scores and performance development. The level of significance in the study was accepted as $p < 0.05$.

Ethics of Study

All participants were briefed on the study and completed a consent form. The training protocol and research design received ethical approval from the Ethics Committee at Nevşehir Hacı Bektaş Veli University with the decision number 2018.10.110.

Findings

Students' performance was video recorded pre- and post-training during the process where they were asked to execute the motor task. Afterward, recordings were collated and sent to post-production in order to create individual movie clips documenting each participant's pre- and post-training performance. Those movie clips were then randomly recorded into a DVD. The DVD was copied and sent to three football coaches (all male, mean age = 43.5 years old). The coaches were asked to evaluate each hitting technique (just once and without stopping). Two of the coaches were also academics and had ample experience in training, evaluating, and assessing young athletes, and they did not have any financial expectations in return for their contributions.

Cronbach's alpha was calculated in order to test the interrater agreement between the assessors. The alpha values for the evaluations ranged between 0.81 and 0.90, which indicated consistency and high levels of reliability.

Table 1 shows average improvements for each measurement ($t_2 - t_1$). The participants in the mental training group improved their performance more than those in the control group. Five-times repeated measures ANOVA 2 (MI x C) x 2 (t_1 x t_2) were calculated in order to test the statistical significance of the observed differences.

Table 1
Mean Improvement (t2 – t1) on Selected Performance Categories

Variable	Motor imagery training group (N =20)	Control group (N =20)
Positioning (s)	0.18	0.10
Timing (s)	0.80	0.11
Coordination (s)	1.10	0.03
Balanced landing (s)	0.24	0.16

ANOVA results showed that physical training supported with mental training resulted in a statistically significant difference for the aspects of Timing [$F_{(1, 38)} = 4.823$, $p < 0.05$, $\eta^2 = 0.082$] and Coordination [$F_{(1, 38)} = 4.260$, $p < 0.05$, $\eta^2 = 0.076$]. No significant difference was observed between the other two aspects of the move (Positioning and Balanced landing).

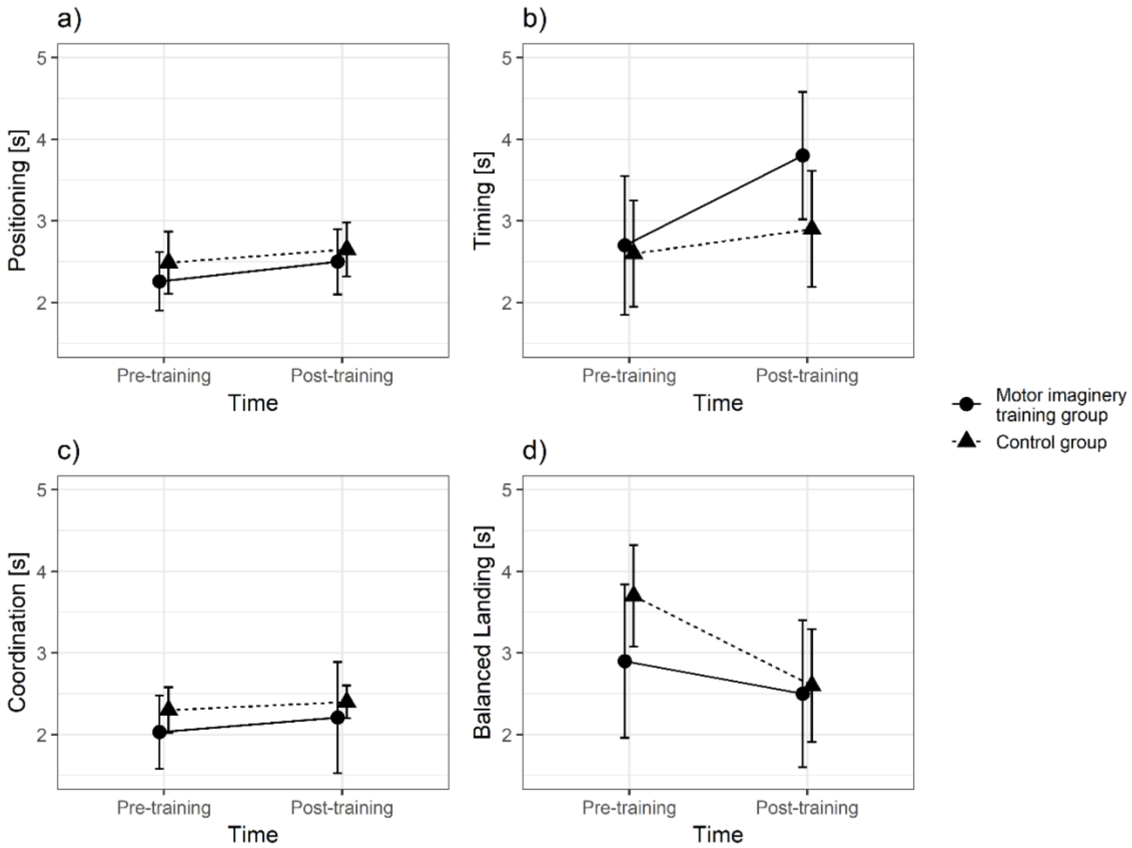

Figure 1. Differences after the 8-week exercise program

Various calculations were performed in order to analyze the relationship between VMIQ-2 scores and performance development. Participants' scores ranged between 32 and 56, and the average score of the whole cohort was 44.10. For example, three groups were created based on the imagery ability of participants (VMIQ-2 scores) as assessed prior to training. Then, performance scores were calculated using Pearson correlation (the average difference between t_1 and t_2 for every aspect). However, no significant difference was found.

Discussion and Conclusion

In accordance with the primary hypothesis of this study, the results indicate that combining mental and physical training can enhance the performance of a closed sports skill. These outcomes align partially with the findings from previous research that has explored the use of motor imagery in football and other sports disciplines (Guillotet al., 2013; Jordet, 2005; Post et al., 2010; Thelwell et al., 2010; Veraksa et al., 2012;). However, some studies have found that motor imagery has positive effects on football skills such as penalty kicks (Hegazy, 2012; Sosovec, 2004), passing (Robin et al., 2020; Seif-Barghi et al., 2012), and sliding tackle (Thelwell et al., 2006). Sodiya and Syed Ali (2018) aimed to enhance young footballers (n =61) drippling movements. Their results showed that the group who exercised both motor imagery training and physical training for nine weeks had significantly higher skill performances in comparison to other groups. In their study, the enhancement in performance was only observed among the members of the group who followed mental imagery training but not in the control group. In the present study, the header technique was investigated considering the following aspects: 'Positioning,' 'Timing,' 'Coordination,' and 'Balanced landing .'The results showed significant improvements in the aspect of 'Coordination,' and the assessors particularly focused on evaluating the coordination among legs, hands, upper extremities, and head region. The execution of this skill can be a difficult challenge for individuals who have yet to receive prior training. This is because they should not only learn movement patterns involving various parts of their body but also synchronize them. The command file, including the visual instructions provided by our training protocol, supported the participants (who have not practiced or received training on this skill before) by informing them on each stage of the movement and, in particular, on how they can associate each stage to execute a homogeneous movement. To the best of our knowledge, the present study is but one study that documents the positive effects of motor imagery on coordination while learning a complex motor skill in sports (Gaglioli et al., 2013; Seif-Barghi et al., 2012; Veraksa & Goroyava, 2012). Furthermore, clinical studies have revealed comparable results concerning the application of motor imagery in individuals with developmental coordination disorder (Doussoulin and Rehbein, 2011; Wilson, 2002). It's worth noting that this current study is the initial one to demonstrate the beneficial impacts of motor imagery on the acquisition of a complex motor skill in the realm of sports. Conversely, within the domain of clinical research, analogous findings have been reported in studies centered on the utilization of motor imagery with patients diagnosed with developmental coordination disorder.

The developments observed at the timing stage are directly related to the cognitive dimension of motor learning (Brouziyne and Molinaro, 2005). The real difficulty for an individual who is learning the header skill is to be able to hit the ball approaching him/her at the highest point and in the right contact area. In this sense, the command file guided the participants through the steps that needed to be taken. The perceptions aimed to be conveyed through the visual scenario allowed the athletes to be able to feel and evaluate the most efficient way of hitting the ball toward the goal. Firstly, participants followed the instructions in the command file with an intrinsic perspective; thus, she/he learned both the right way to execute the skill and the bodily feelings and sensations experienced during the execution. In other words, s/he learned how to carry his/her body during the execution of the skill. Athletes, who were provided with a detailed scenario on which they could focus, better grasped the stages of exercising the skill for actual practice via a meaningful model.

Secondly, we presented a methodology that can be used to evaluate motor skill performance for a target movement based on previously recorded video files. Recent studies have sought to examine the impact of motor imagery using self-assessment tools like the Standardized Basic and Combined Movements Scale (Dossoulin and Rehbein, 2011) and the Sport Imagery Questionnaire (Hall et al., 1998). These investigations aimed to discern the contribution of imagery training to the cultivation of psychological skills, including individual and collective efficacy (Shearer et al., 2009), as well as imagery skill (Cumming et al., 2001).

The examination of kinematic characteristics in various sports disciplines has been approached from a mathematical standpoint, employing rigorous parametric analyses to assess both the distance and angle of movements (Smith et al., 2008; Olsson et al., 2008). These studies specifically investigated the golf branch (Smith et al., 2008) and the high jump branch (Olsson et al., 2008), respectively, shedding light on the scientific understanding of these phenomena. Only a handful of studies evaluated the end score of the movement or the number of successful attempts (Peynircioğlu et al., 2000; Ploszay et al., 2006).

Nevertheless, video clip evaluation carried out by independent assessors can be one alternative strategy to evaluate motor performance and it is believed it can help decrease problems encountered when utilizing self-report measures (i.e. social desirability effect) in research. Rather than an overall evaluation of development, this methodology allowed for emphasizing specific aspects of a skill and enabling its grading simply and directly.

On the other hand, the present research has several limitations. To begin with, the study sample included participants who registered for the football class during the term that the study was conducted, and this limits the generalizability of the findings. In addition, it is not very clear to what extent these findings apply to athletes since the study sample consisted of students. Future research can focus on how this newly developed visual protocol can be integrated into the training program of a professional football team. In particular, a training program that will be developed in line with pre-determined skills can be utilized to support athletes who experience problems with the execution of a skill that requires synchronizing. For example, a coach can determine the strengths and weaknesses of each athlete and can offer each one of them personalized training developed with the help of a psychologist. Moreover, in future studies, the athletes should evaluate both themselves and their other friends and what kind of progress the result of this can be examined. In this idea, there will be 3 groups, one group will be only physical exercise, and the other group will be motor imagery training, but the author/authors will evaluate it. The 3rd group will evaluate themselves and other friends on motor imagery according to the criteria.

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