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Creative actions in team sports are rooted in motor skills rather than in a divergent thinking ability

Players who are capable of performing creative actions are highly valued in team sports, especially in invasion games like football (e.g., Cross, 2013). In these sports, developing creative players is widely discussed as a crucial—as well as a challenging—goal (e.g., Wein, 2007). Driven by its practical relevance, the construct of creativity has attracted interest in sport science (e.g., Caso & van der Kamp, 2020; de Sa Fardilha & Allen, 2020; Memmert, 2015b). Furthermore, there have been multiple calls from the field of creativity research in general psychology to study creative behaviours in specific domains such as sports (e.g., Baer, 2016; Kaufman, Glăveanu, & Baer, 2017).

In sport science, creativity has been considered 'key to expert performance' (Roca, Ford, & Memmert, 2018, p. 1). In high-level football, the importance of creative actions is further underlined by the recent findings of Kempe and Memmert (2018) who show that the creativity of performed actions, as rated by experts, were positively associated with the teams' success in major international tournaments. Accordingly, based on empirical studies, a variety of training and teaching approaches for developing creativity have been proposed over the recent years (e.g., Memmert, 2015b; Santos, Memmert, Sampaio, & Leite, 2016).

In studies on creativity in team sports, various conceptualizations and operationalizations of creativity have been adopted (for a review, see Zahno & Hossner, 2020) but in most empirical work, creativity has been defined and assessed as a player's sport-specific divergent thinking (DT) ability (Memmert, 2015a). DT is a traditional concept in general creativity research (Guilford, 1967) which has been transferred to the domain of sports (cf. Memmert, 2013). Generally, DT is defined as the cognitive ability to generate multiple ideas in response to a given problem and is widely used as a measure in domain-general creativity tests (Reiter-Palmon, Forthmann, & Barbot, 2019). In such tests, participants are asked to generate ideas in response to open-ended problems. As an indicator of a person's creativity, three DT-components are assessed: fluency (the number of generated ideas), flexibility (the variety of generated ideas) and originality (the unusualness of generated ideas). In sport-specific studies, general creativity tests quantifying individual differences in DT have been translated to sport-specific game situations (Memmert, Hüttermann, & Orliczek, 2013) to quantify players' sport-specific creativity (e.g., Klatt et al., 2019).

In the conceptualization of creativity as a player's DT ability, three core theoretical elements can be identified: First, creativity is attributed to a purely cognitive ability. In other words, a player's capacity to come up with ideas is assessed while explicitly not considering his/her motor skills. Second—and more specifically—, players' creativity is attributed to a specific stage within a sequential process of behavioural control, namely an idea generation stage which is described as follows: 'First of all, a situation is anticipated and perceived based on past experiences (memory), then attention is paid to specific targets of the situation, and finally a range of ideas is collected (creativity) and one of them is chosen (intelligence)' (Memmert, 2015a, pp. 364–365). This implies that the choice is based on a process of 'intellectual generation of a certain number of solution options (divergent thinking) from long-term or working memory' (Memmert, 2015a, p. 365) before the action. Third, DT is thought to represent a relatively general cognitive component and is thus expected to manifest itself in actions 'across different situational contexts' (Memmert & Roca, 2019, p. 210). From this conceptual standpoint, it is inferred for sports practice that 'unlike motor competencies, it is possible to train tactical creativity independently of the movement techniques' (Memmert & Roth, 2007, p. 1429).

Empirically, a range of factors affecting players' sport-specific DT have been revealed (for an overview, see Memmert et al., 2015a). For example, it has repeatedly been shown that sport-specific DT is positively associated with a wide breadth of attention, defined as 'the number and range of stimuli that a person is able to attend to at any one moment in time' (Memmert, 2011, pp. 94–95; Hüttermann, Memmert, & Nerb, 2019; Memmert, 2006, 2007; Memmert & Furley, 2007). In line with the findings of general creativity research (for a meta-analysis, see Scott, Leritz, & Mumford, 2004), a substantial body of sport-related research indicates that DT can be improved through practice interventions (Memmert, 2015b). Based on these find-

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ings, the Tactical Creativity Approach (TCA; Memmert, 2015a, b, 2021) has been suggested as a framework for sports practice, including methodological principles to foster creativity in team sports by enhancing DT. However, so far, no empirical support has been provided for the underlying assumption that enhanced DT transfers to creative on-field actions.

This core assumption was recently challenged by Zahno and Hossner (2020) on a conceptual level, proposing an alternative interpretation drawing from a relational understanding of creativity and a functional approach to behavioural control. Generally, according to its standard definition (cf. Runco & Jaeger, 2012), creativity refers to products or behaviours, such as players' actions, that are both functional (i.e., satisfy task-relevant constraints) and novel or original (i.e., beyond current standards) within a particular context. In a *relational* view, as proposed by Westmeyer (1998), it is thus emphasized that the construct of creativity inherently implies a judgement of products or behaviours relative to a social or cultural context, rather than representing something that can be 'possessed' by individuals. On the individual level, however, it is argued that specific resources and skills may well enhance or limit the probability of displaying actions that go beyond current standards or expectations and will thus be perceived as creative. This perfectly aligns with an expert-performance view on creativity, predicting that with the refinement of task-relevant skills, 'adaptation to situational demands will increase and reflect higher levels of creativity' (Ericsson & Lehmann, 2011, p. 488; see also Ericsson, 1999). For DT, the proposed relational view implies a change of status: Instead of being equated to creativity it becomes one potential resource among others that may or may not be relevant for creative performance in a particular context.

In the context of team sports, instead of attributing creativity to an individual's distinct cognitive ability (i.e., DT), it is argued that creative actions result foremost as a consequence of a player's enhanced repertoire of sensorimotor skills: As a highly skilled player is less constrained by his/her motor skills, the probability of performing functional solutions that go beyond expectations—and are thus perceived as creative actions—will increase naturally. Furthermore, based on a *functional* approach to behavioural control, the idea of an isolated DT stage—apparently rooted in a sequential-stages view of classical information-processing models (e.g., Sternberg, 1969)—can be fundamentally challenged. More recent approaches (e.g., Hommel, Müsseler, Aschersleben, & Prinz, 2001: Theory of Event Coding; Todorov & Jordan, 2002: Optimal Feedback Control) stress the irrefragable anticipatory character of action control; meaning that, on a behavioural level, actions are necessarily planned in terms of anticipated effects (i.e., predicted sensory consequences) of one's own actions and thus not independently of one's motor skills. Both arguments nicely converge with the standpoint put forward from an ecological perspective (Caso & van der Kamp, 2020; Orth, van der Kamp, Memmert, & Savelsbergh, 2017) that creative solutions emerge *in* action and are based on a large and adaptive action repertoire rather than in a mental idea generation process before the action. Taken together, the outlined functional–relational framework provides a conceptual alternative to the idea of creativity as one distinct ability (i.e., DT) that could be trained with specific interventions. For practice, this conceptual shift would suggest that players' capability to perform creative actions is better fostered by enhancing their motor skills—and thus expanding their action repertoire—than by improving DT.

Since (1) no empirical support has been provided thus far for the assumption that improvements in DT transfer to creative on-field actions and (2) rather motor skill-focussed interventions seem to be advisable from a functional–relational perspective on creativity, the present study was designed to empirically test these two suppositions. To this end, we conducted a field-based experiment in elite youth football. With interventions integrated into their regular club training, players participated in play and practice tasks specifically designed to enhance either their football-specific DT (DT group) or their motor-skill repertoire (functional skills; FS group). Before and after the training intervention, we assessed, on the one hand, players' football-specific DT using a football-specific DT task, and, on the other hand, the functionality and creativity of actions performed in a representative game situation using expert ratings. We expected that players in the DT group would outperform their FS counterparts in the football-specific DT task after their DT training intervention. Furthermore, we expected that, due to the specific motor skill-related intervention, the FS group would show greater improvements in the functionality rating of on-field actions. More decisively, if the assumption holds that enhancing players' DT transfers to creative actions on the field, it would be expected that improvements in the DT scores should reflect in the creativity ratings of on-field actions. Challenging this assumption, we hypothesized that creative actions are foremost rooted in an enhanced repertoire of motor skills. Therefore, we predicted larger improvements in the FS group than in the DT group regarding not only the functionality ratings but also the creativity ratings of on-field actions.

Methods

Participants

A total of 24 male elite youth football players participated. They were recruited from the under-13 team of the BSC Young Boys, a professional football club in Switzerland. All participants were part of a talent-development program and engaged, on average, in four football-specific training sessions and one match per week. From the initial sample, five participants were not available for the posttest and three participants were excluded due to attendance of less than five of the six training sessions. A complete data set of 16 players ($M_{age} = 12.90 \pm 0.27$ years) was available for the final analyses. The study was approved by the University's ethics committee and carried out in accordance with the Declaration of Helsinki.

Accordingly, permission to participate was obtained from the players' parents in advance.

After excluding dropouts, eight participants remained per experimental group (DT and FS, respectively). The groups did not differ in terms of age ($M_{DT} = 12.93 \pm 0.29$ years; $M_{FS} = 12.87 \pm 0.27$ years; $t(14) = 0.41$, $p = 0.69$), club-football experience ($M_{DT} = 8.43 \pm 0.80$ years; $M_{FS} = 7.62 \pm 1.25$ years; $t(14) = 1.54$, $p = 0.15$), general technical skill as assessed by a standardized passing and dribbling test conducted before the interventions (Forsman, Blomqvist, Davids, Liukkonen, & Konttinen, 2016) ($M_{DT} = 40.69 \pm 3.51$ s; $M_{FS} = 40.92 \pm 2.43$ s; $t(14) = -0.15$, $p = 0.88$) or the amount of football played outside of regular training during the time of the study ($M_{DT} = 2.44 \pm 0.68$ h per week; $M_{FS} = 2.88 \pm 0.99$ h per week; $t(14) = -1.03$, $p = 0.32$).

Tasks and materials

Football-specific divergent thinking task

Similar to previous studies of creativity in sports, a video-based task was used to assess each player's football-specific DT (Furley & Memmert, 2015, 2018; Hüttermann, Nerb, & Memmert, 2018, 2019; Klatt et al., 2019; Memmert et al., 2013). In this task, participants were individually shown 20 video clips of attacking game situations that were temporally occluded at key moments by freezing the final video frame. The participants' task was to imagine themselves as the player in ball possession and to name as many possible solutions as they could think of within a 45 s time interval.

Due to data protection issues, the authors were not provided with the video scenes used by Memmert and colleagues (e.g., Memmert et al., 2013) and needed to construct their own test battery. In order to select video clips of game situations in which (a) the player in ball possession has multiple appropriate solutions and (b) that these solutions can be attributed to varying solution categories, seven football experts with longstanding coaching ($M = 17.36 \pm 7.48$ years; UEFA A or B qualifications) and playing ($M = 25.43 \pm 5.60$ years) experience were recruited. In a first step, the experts independently evaluated 40 attacking scenes (approximately 10 s long) from Swiss first (i.e., Super League, $n = 25$) and second division (i.e., Challenge League, $n = 15$) matches of the season 2018/19. These scenes were preselected by the first author based on the aforementioned criteria. For every scene, experts indicated all possible options for the player in ball possession and rated these options in terms of quality (1–5; 5 = excellent, 1 = not good at all). In addition, they were asked to rate the feasibility of each of six predefined solution categories for the respective scene (shot on goal, dribbling, short pass, feint followed by a pass, lob, cross; 0–5; 5 = excellent, 0 = not feasible; cf. Memmert et al., 2013). The experts were generally encouraged to comment if the respective scene could lead to any ambiguities. Based on this evaluation, scenes were omitted if they (a) led to ambiguous interpretations (qualitative criterion, e.g., the player in ball possession seems to be off-balance in the freeze frame), (b) had less than three solution categories with a rating score of ≥ 2 or (c) did not show sufficient agreement between experts' ratings of quality of solution categories (i.e., intraclass correlation [ICC] < 0.90). The remaining 33 scenes were subsequently ranked according to the number of potential solutions, weighted by the respective quality rating; meaning that, for each scene, the quality ratings for all possible options were first summed up for each expert individually and then averaged across experts. For validation purposes, we asked the same expert panel to individually view the top 24 scenes a second time and to express agreement with the average ratings of solution categories for each scene (1–6; 6 = absolute agreement, 1 = absolute disagreement). As the experts did not show a considerable disagreement ($M = 5.7$, $SD = 0.7$), the top 20 clips were finally selected for the DT task. In these scenes, the agreement between experts on the quality of solution categories was very strong (ICC = 0.95).

Abstract

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Creative actions in team sports are rooted in motor skills rather than in a divergent thinking ability

Abstract
Creative actions are considered decisive in team sports. In most empirical studies on the topic so far, creativity has been understood as a player's divergent thinking (DT) ability. Sport-specific DT has been assessed by the number, variety and originality of ideas a player is able to generate in response to game situations. Numerous studies indicate that DT can be improved with training. However, the fundamental assumption that enhanced DT transfers to creative on-field actions has yet to be examined. Alternatively, we argue that players' potential to perform creative actions is foremost rooted in their motor-skill repertoire rather than in DT. In a field-based experiment, predictions deduced from both explanations were put to test. Elite youth football players participated in training interventions to enhance either football-specific DT (DT group) or their motor-skill repertoire (functional skills; FS group). Before and after the interventions, we assessed players' football-specific DT as well as the functionality and creativity of actions performed on-field using expert ratings. As expected, in DT, the DT group improved more than the FS group. On the field, however, improvements in DT did *not* manifest in more creative actions. Rather, the FS group showed more pronounced improvements not only in the functionality but also in the creativity of on-field actions. This pattern of results challenges the so far predominant theoretical framework for creativity in sports. For sports practice, our findings suggest that on-field creativity is better fostered by enhancing players' motor skills—and thus expanding their own action repertoire—than by improving DT.

Keywords
Creativity · Motor learning · Motor performance · Transfer · Football

Functionality and creativity ratings of on-field actions

To assess the functionality and creativity of participants' actions, the players took part in a semi-structured, 2-vs-1 game situation on the field (for a similar task, see Laakso, Davids, Liukkonen, &

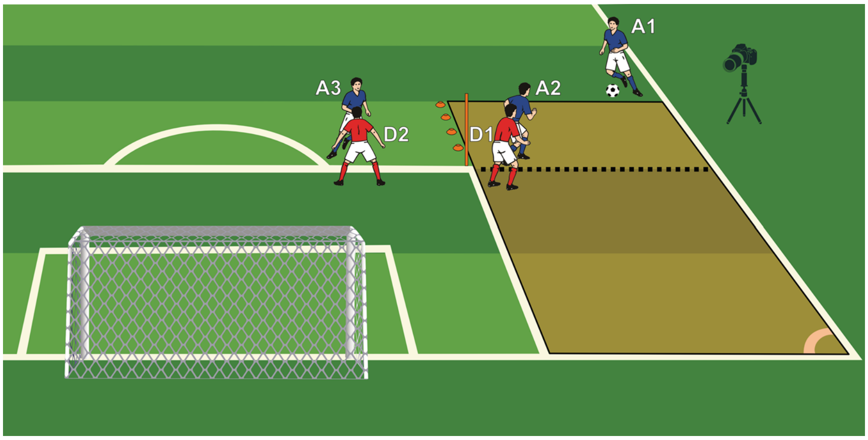

Fig. 1 ▲ On-field 2-vs-1 game situation to assess the actions of attacking players A1 and A2. Defending players (D1 and D2) are in *red*, while attacking players are in *blue*. The task goal for the attacking players A1 and A2 is to outplay the defender D1 within the predefined playing area on the wing in order to create a goal-scoring opportunity. After passing the *dotted line*, players may dribble into the penalty area or pass the ball to attacking player A3

Travassos, 2019). The task goal for the two attacking players of interest was to outplay a defender within a predefined area on the wing to create a goal scoring opportunity. No specific instructions on how to reach this goal were provided and players were encouraged to compete as in a match. Starting positions were standardized across trials, as illustrated in **Fig. 1**. The ball carrying attacker (A1) started the trial by dribbling into the defined 2-vs-1 area (24 m × 10 m) on the right or left wing. As soon as A1 began, the defender (D1) and the second attacker (A2) came into play. To increase task representativeness, a third attacker (A3) and a second defender (D2) were placed in the centre of the pitch outside the 2-vs-1 area. Players were only permitted to dribble into the penalty area or pass the ball to A3 after the ball carrier passed the dotted line. Furthermore, players A1 and A2 were not allowed to enter the penalty area before the ball did and players A3 and D2 were not allowed to enter the 2-vs-1 area. The functionality and creativity of the actions performed by players A1 and A2 were later assessed; meaning that only the players in these two positions were evaluated in the on-field task, whereas the other four players served to create a realistic game situation.

The actions performed in the on-field task were video recorded. Experts were then asked to rate the two players' individual actions in each situation in terms of functionality and creativity. The expert rating was conducted in accordance with the Consensual Assessment Technique (CAT; Amabile, 1996; Hennessey, Amabile, & Mueller, 2011), which has been deemed as the gold standard in creativity research (Baer, 2016; Kaufman, Plucker, & Baer, 2008). In contrast to DT tests, the CAT is not tied to any particular theory (Kaufman et al., 2008) but grounded in a consensual definition of creativity, with the understanding that 'a product or response is creative to the extent that appropriate observers independently agree it is creative' (Amabile, 1996, p. 33). Based on this notion, the CAT provides a number of procedural requirements (cf. Hennessey et al., 2011): In essence, a panel of experts is asked to rate the creativity of products—in the present study, of players' actions—(a) independently, (b) relative to one another (as opposed to rating against some absolute standard), and (c) solely based on one's subjective conception of creativity, i.e., on what one perceives as creative in the present context and on the basis of one's experience in the respective domain. Therefore, it is essential for the validity of the CAT, that experts are *not* trained in advance to agree with one another in the assessment nor instructed to use specific criteria against which creativity of actions should be assessed (cf. Amabile, 1996).

Interventions

In coordination with the club's coaches, play and practice tasks were designed that aimed at enhancing either players' football-specific DT or their motor skills (for in-depth descriptions of exemplary tasks, see the appendix).

Training sessions for the DT group comprised of playful and pronouncedly variable game forms, stimulating players to come up with a variety of new solution ideas across a wide range of situations. The game forms were developed based on the methodological principles of the TCA (e.g., Memmert, 2015b). Principles were combined and incorporated into sessions based on deliberate play (including variable numbers of players; see Greco, Memmert, & Morales, 2010) or one-dimension games (e.g., identification of gaps; see Memmert, 2015b). In these games, a wide range of stimuli were introduced by, for example, adding unexpected environmental changes, introducing various possibilities to collect points or alternating between using feet and hands, as recommended by the diversification principle of the TCA. Additionally, inspired by creativity trainings in school settings (e.g., Fasswald-Magnet, Hefler, Papousek, Weiss, & Fink, 2014; Fink, Reim, Benedek, & Grabner, 2020) and social priming (Furley & Memmert, 2018), game-like tasks stimulating DT in football situations were designed and integrated into certain game forms. All DT sessions also aimed to increase players' breadth of attention (cf. Memmert, 2007; see also the deliberate coaching principle of the TCA) by creating practice environments that demanded a wide focus of attention and by refraining from providing feedback and instructions during play. Furthermore, in accordance with the deliberate motivation principle of the TCA (see also Hüttermann et al., 2018), all games were instructed with a promotion rather than a prevention focus (e.g., 'you can collect points for your team by' or 'your goal is to', as opposed to 'you have to go to the middle zone if you lose the ball' or 'I expect from you to').

In contrast, the training sessions for the FS group were comprised of motor skill-related practice tasks. The focal points of these sessions were derived from situational task demands and to-be-achieved action goals (cf. Hossner, Schiebl, & Göhner, 2015), including, for example, de-stabilizing the direct opponent when dribbling towards him. Hence, the 'functional' aspect of the FS training laid focus on guiding players to expand and stabilize their own functional task-solutions rather than practicing 'ideal techniques'. Based on the generally accepted recommendations for motor-skill practice from both movement science literature (e.g., Davids, Button, & Bennett, 2008; Hossner, Kredel, & Franklin, 2020; Williams & Hodges, 2005) and football coaching literature (e.g., Daniel, Peter, & Vieth, 2014), players were confronted with representative tasks and given instructions in terms of the intended movement effects, i.e., towards desired states (e.g., to bring the opponent off-balance). Given multiple attempts in each situation, players were encouraged to explore different—though still functional—ways to solve the task at hand. Meanwhile, variability was introduced by systematically changing task-relevant constraints (e.g., distances and angles between the attacker and the defender). Accordingly, players were 'forced' to continuously adapt and explore alternative solutions to reach the task goal in a functional manner.

Procedure

The study was carried out over 4 weeks, with testing and training sessions fully integrated into the regular club training. The 3-week intervention phase comprised of six 20 min training sessions. Players were randomly assigned to one of the two experimental groups (DT vs. FS) after the pretest. Both the DT and the FS sessions were delivered in small groups (5–6 players; for games requiring more players, additional players who did not participate in the study joined). DT and FS sessions were conducted in parallel and, thus, under exactly the same weather and pitch conditions (artificial turf). Two instructors delivered the intervention sessions. Both instructors were football-experienced sports students. While not being blinded about the experimental hypotheses, the instructors were provided with a clear protocol that was collaboratively designed by the researchers and club's coaches and they affirmed to have delivered the training sessions accordingly. To further ensure that treatment effects were independent of the instructors, they switched from leading either the DT or FS sessions to instructing the other group halfway through the intervention.

The pretest was conducted one week before the start of the intervention over two consecutive days. Both field-based assessments were carried out on the first day, which included the standardized technical skill test followed by the on-field game situation. The standardized technical skill test was conducted only to ensure that both experimental groups did not differ in general technical skill. Participants were randomly allocated to groups of five players for the pretest (independent of the later formed experimental groups). After a collective warm-up of 20 min, the first two groups partook in the standardized technical skill test whilst the remaining players engaged in their regular training. Following the technical skill test, the 2-vs-1 situations were presented. Instructions on the task goal and rules were given, and players were assigned to their starting positions in the task (as illustrated in **Fig. 1**). After every trial, players rotated positions. After a full rotation, the procedure was repeated on the wing on the other side of the field where the initial order was reversed and players D1–A2 and D2–A3 switched positions to ensure new attacker-defender pairings. Consequently, each participant performed four trials in attacking positions of interest, i.e., each player completed two trials as A1, and two trials as A2. After approximately 40 min, the next two groups followed the same procedure. All trials were recorded on video (GoPro Hero 4, 1920 × 1080, 25 fps) from the nearest sideline (**Fig. 1**).

On the second day, the DT test was conducted. To this end, participants attended individual sessions that lasted about 30 min. After being provided with instructions and a demo scene, participants were presented with 20 test scenes on a standard tablet (9.7-inch). Each scene lasted approximately 10 s before the video stopped at a key moment of action. Participants were asked to imagine themselves as the player with the ball. For the subsequent frozen-frame period of 45 s, a countdown was visible on the screen. Participants were instructed to name all options they could think of within the given time period. Furthermore, they were asked to indicate the option they would finally choose; however, in accordance with established procedures (e.g., Hüttermann et al., 2019), the latter was not included in the data analysis. The verbal responses were recorded on audio tape and in the experimenter's notes on a response sheet.

The exact same procedures were followed for the posttest, which started two days after the last training session. Although the procedure ensured that both experimental groups were tested and treated under the same weather and pitch conditions, the comparability of environmental factors at pre- and posttest could not be guaranteed. Specifically, in comparison to the pretest, the weather conditions during the on-field assessment at posttest were extremely poor (i.e., heavy rain followed by a substantial temperature drop). Consequently, pre–posttest main effects may not only reflect learning but also the more or less pronounced adverseness of weather conditions, such that the interpretation of group differences should be based on the interaction between group (DT vs. FS) and time of measurement (pre vs. post).

Measures

Football-specific divergent thinking task

To quantify players' DT ability from their responses in the video-based task, the three DT components—fluency, flexibility and originality—were assessed following the standard procedure in sports-related creativity research (cf. Memmert et al., 2013). Accordingly, participants' audiotaped verbal responses—supplemented by the experimenters' notes on a response sheet—were first coded corresponding to the classification of options defined in the test construction. Fluency was evaluated as the number of solution ideas a player generated for each scene. For the flexibility score, each response was grouped into a solution category (i.e., shot on goal, dribbling, short pass, feint followed by a pass, lob, cross; cf. Memmert et al., 2013) and one point was given for every distinct category in which a player had generated a solution. For the originality score, each proposed solution was rated by two independent experts (coaching experience: $M = 27.00 \pm 3.00$ years, UEFA A and B+ level) on a Likert scale (1–5; 5 = very original, 1 = not original) and then the two ratings were averaged to obtain an originality value for every solution (ICC = 0.74). In conclusion, that means that, for all 20 scenes, we assessed the number of ideas (fluency), the number of different categories of ideas (flexibility) and the unusualness of the ideas (originality) that the participants came up with. The three component scores (fluency, flexibility and originality) were first independently calculated, then z-standardized and averaged to obtain an overall DT-score for each participant (cf. Memmert et al., 2013).

Functionality and creativity ratings of on-field actions

In order to rate players' actions in the on-field task, five football experts (coaching experience: $M = 22.20 \pm 11.05$ years, UEFA A and B level; playing experience: $M = 27.20 \pm 7.63$ years) who did not personally know the players were recruited. After the posttest, the video footage from both pre-and posttest was cut into separate video clips for each single trial and reassembled in random orders. To ensure that the experts were completely neutral, we did not inform them about the research question and the experimental groups. In fact, we only informed the experts after completion of their ratings that the videos originated from two different times of measurement and that a training intervention was conducted.

The experts were asked to rate the actions of players A1 and A2 in the game situations in terms of functionality, creativity and technical quality, with the final category included to disguise the experimenters' research focus. According to the CAT guidelines (Amabile, 1996), no prior training or instruction was provided for the experts to suggest any criteria or definitions of the three qualities. Rather, experts were asked to rely on their expert understanding of how functional, creative and technically well-executed the actions were in relation to the other actions presented and to the specific situational context. At the beginning of the expert rating, 16 randomly selected video clips were presented in order to familiarize the experts with the game situation and the level of the players. Subsequently, the test video comprising of 64 relevant clips (2 test times × 4 trials × 16 participants/2 participants per scene) was shown, which played each clip twice. To reduce sequence effects, the assortment of video clips and the three quality categories (functionality, creativity and technical quality) were presented in a different random order for each expert. Experts were asked to make their judgements intuitively by providing written marks on continuous scales (1–5; 5 = very functional/very creative/very well executed technically; 1 = not functional/not creative/not well executed technically). Furthermore, experts were asked to rate actions of the same player independently of the player's previously shown actions. From the experts' responses on the continuous scales, rating scores (1–5) were measured to two decimal places. Each trial was thus rated by all five experts in terms of functionality (ICC = 0.69) and creativity (ICC = 0.63), whilst the additional ratings for technical quality were not further considered. The ratings of the five experts were then combined by computing a mean value for every action. For each participant, the highest functionality and creativity ratings from the four trials in pre- and posttest were used as measure for further analyses, respectively.

Statistical analysis

For each of the three dependent variables (football-specific DT score, functionality rating and creativity rating of on-field actions), a 2 (groups: DT vs. FS) × 2 (time of measurement: pre vs. post) ANOVA (analysis of variance) with repeated measures on the second factor was conducted. The significance level was a priori fixed at $\alpha = 0.05$ and the initial sample size had been determined in advance to ensure sufficient power to detect medium-to-large interaction effects ($\alpha = 0.05$, $1-\beta = 0.80$, $f = 0.30$). Significant interaction effects were further analysed with planned *t*-tests. Furthermore, when the groups differed at pretest (i.e., in their baseline level), we additionally conducted an ANCOVA to compare pre–posttest differences, while controlling for pretest scores. One-tailed tests of significance were conducted for a priori predicted differences and two-tailed tests for further revealed effects. Effect sizes are reported as η_p^2 and Cohen's *d*.

Results

The pre- and posttest results for the two experimental groups are depicted in **Fig. 2**, i.e., the football-specific DT task (left) as well as the functionality (middle) and creativity (right) ratings of actions in the on-field task.

Football-specific divergent thinking

From pre- to posttest, players in the DT group showed greater improvements in DT than did players in the FS group, as indicated by a significant interaction effect, $F(1,14) = 13.47$, $p < 0.01$, $\eta_p^2 = 0.49$. As anticipated, after the training intervention, DT test scores were superior in the DT group ($M = 0.81$, $SD = 0.46$) compared with those of the FS group ($M = -0.13$, $SD = 0.52$), $t(14) = 3.84$, $p < 0.01$ (one-tailed), $d = 1.92$. Considering the component scores that underly the DT test score, the overall improvement of the DT group was reflected by significantly greater improvements than the FS group in both fluency, $F(1, 14) = 26.11$, $p < 0.01$, $\eta_p^2 = 0.65$, and flexibility, $F(1, 14) = 13.66$, $p < 0.01$, $\eta_p^2 = 0.49$. In originality, the significant improvement of the DT group, $t(7) = -4.39$, $p < 0.01$ (one-tailed), $d = 1.55$, was by trend more pronounced than the nonsignificant improvement of the FS group, $t(7) = -1.26$, $p = 0.25$ (two-tailed), $d = 0.45$.

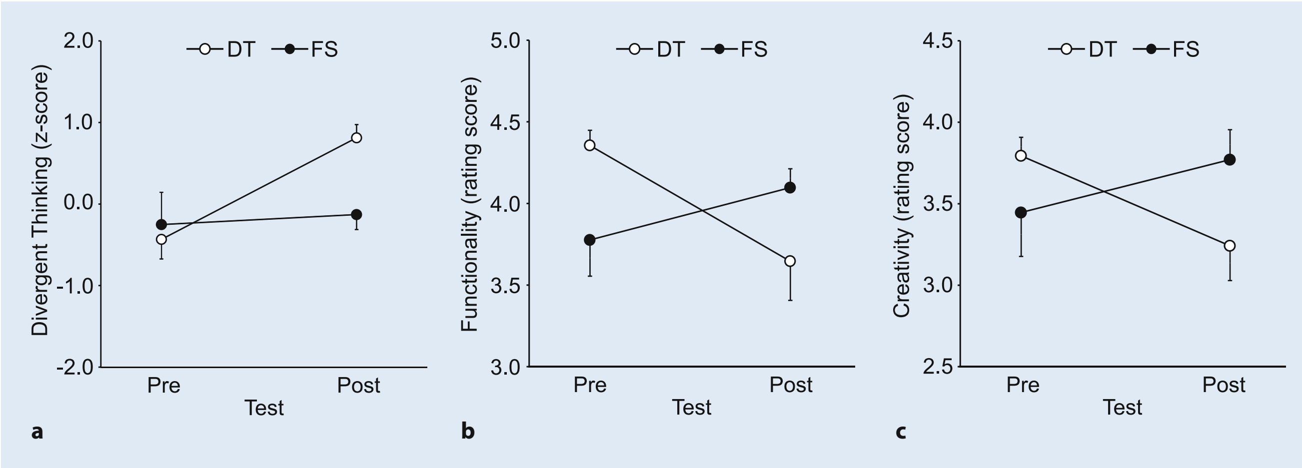

Fig. 2 ▲ Pre- and posttest results of the divergent thinking (DT) and functional skill (FS) groups in the football-specific divergent thinking task (**a**) as well as in the functionality (**b**) and the creativity (**c**) ratings of actions in the on-field game situation. Error bars represent SE and are displayed only one-sided

Functionality of on-field actions

At pretest, actions performed by players of the DT group ($M = 4.36$, $SD = 0.26$) were rated as more functional than those of the FS group ($M = 3.78$, $SD = 0.63$), $t(14) = 2.42$, $p = 0.03$ (two-tailed), $d = 1.20$. However, given that the predictions refer to performance improvements, these differences at the pretest are not critical. From pre- to posttest, the functionality ratings of the DT group significantly declined ($M_{post} = 3.65$, $SD_{post} = 0.68$), $t(7) = 2.72$, $p = 0.03$ (two-tailed), $d = 0.96$, whereas those of the FS group ($M_{post} = 4.10$, $SD_{post} = 0.32$) descriptively improved, $t(7) = -1.35$, $p = 0.11$ (one-tailed), $d = 0.48$. The resulting significant interaction effect, $F(1, 14) = 8.61$, $p = 0.01$, $\eta_p^2 = 0.38$, indicates the predicted positive effect of FS training, rather than DT training, on the functionality of actions performed in the on-field task. When controlling for different pretest scores, differences between the groups in pre–posttest gains (+0.31 in the FS group vs. −0.71 in the DT group) do not reach statistical significance, $F(1,13) = 2.03$, $p = 0.09$, $\eta_p^2 = 0.14$, but still yield a large effect size.

Creativity of on-field actions

The creativity ratings of on-field actions follow a similar pattern as the functionality ratings. At pretest, descriptively, actions of players in the DT group ($M = 3.79$, $SD = 0.32$) were rated as slightly more creative than those of the players in the FS group ($M = 3.45$, $SD = 0.76$), without a significant difference, $t(14) = 1.19$, $p = 0.25$ (two-tailed), $d = 0.59$. As opposed to the significant decline in the DT group's creativity ratings from pre- to posttest ($M_{post} = 3.24$, $SD_{post} = 0.60$), $t(7) = 3.04$, $p = 0.02$ (two-tailed), $d = 1.08$, the FS group descriptively improved ($M_{post} = 3.77$, $SD_{post} = 0.52$), $t(7) = -1.04$, $p = 0.17$ (one-tailed), $d = 0.37$, resulting in a significant interaction effect, $F(1, 14) = 5.87$, $p = 0.03$, $\eta_p^2 = 0.30$. Differences between the groups in pre–posttest gains (+0.32 in the FS group vs. −0.55 in the DT group) remain significant after controlling for different pretest scores, $F(1,13) = 4.07$, $p = 0.03$., $\eta_p^2 = 0.24$. Overall, the comparison of the result patterns for creativity of on-field actions with the DT task on the one hand and the functionality ratings on the other hand suggests that players' creative on-field actions are rooted in motor skills rather than in a DT ability.

Discussion

Driven by the practical goal of developing creative players in team sports, creativity research in sport science so far, has mainly focused on examining factors that enhance players' DT (cf. Memmert, 2015b). Therefore, in the present study, we investigated whether improvements in players' DT test scores actually manifest themselves in more creative actions displayed on the field. As a conceptual alternative, we argued that performing creative actions is foremost rooted in an enhanced repertoire of motor skills rather than in a DT ability. Consequently, both explanations were put to empirical test in a field-based experiment.

As anticipated, elite youth football players who received DT training improved significantly more in DT from pre- to posttest than did their counterparts who received motor skill-related practice, whereas players in the FS group showed greater improvements in the functionality of on-field actions than did the DT group. Importantly, due to poor weather conditions that all players endured during the on-field assessment at posttest, the observed decline in the functionality ratings of the DT group should not be interpreted as a detrimental effect of the DT intervention, but as a reflection of the more difficult environmental conditions. Consequently, the interpretation of the results should be solely based on the group × time of measurement interaction. This interaction indicates the expected positive effect of FS training, rather than DT training, on the functionality of actions performed in the on-field task.

Hence, the stage is set to examine the main research question of whether creative on-field actions coincide with improvements in players' DT—as to be expected from the so far dominating conceptualization of creativity in sports (e.g., Memmert, 2015b)—or rather with their motor skills—as predicted from the alternative functional–relational perspective outlined above (see also Zahno & Hossner, 2020). The obtained pattern of results clearly speaks in favour of the latter hypothesis. While the pronounced improvements of the DT group in the DT task did *not* transfer to creative actions in the on-field task, the FS group showed significantly greater improvements than the DT group not only in functionality but also in creativity ratings of on-field actions.

Generally, the results are consistent with previous findings underlining the trainability of DT in both non-sports-specific contexts (e.g., Sun et al., 2016; for an overview, Scott et al., 2004), such as school-based interventions (e.g., Fink et al., 2020; for an overview, Clapham, 2003), and sports-specific contexts (e.g., Memmert, 2007; for an overview, Memmert, 2015b). However, the missing transfer of DT improvements to creative actions, as shown in the present study, severely challenges the conceptualization of creativity as a player's football-specific DT ability that manifests itself across different situations within football and even beyond. Hence, the appropriateness of using DT as an outcome measure to empirically substantiate recommendations for sports trainings (e.g., Memmert, 2015b) or the suggestion to apply DT tests as a talent assessment tool (e.g., Roca, Ford, & Memmert, 2021) should be critically considered.

In contrast, our on-field results perfectly align with the predictions derived from the alternative functional–relational explanation. In a relational view, the idea of creativity as an individual's ability is fundamentally questioned, as creativity inherently represents a judgement of products or behaviours relative to a social and cultural context (Westmeyer, 1998). Consequently, in this view, aiming to train 'creativity' itself misses the point. Instead, the focus should shift towards increasing task-relevant skills which allow players to perform creative solutions in specific situations, i.e., functional solutions beyond the opponent's expectations or, consequently, even beyond the respective social and cultural frame of reference. In this regard, the present findings suggest that performing creative solutions in on-field game situations is more constrained by a player's motor-skill repertoire than by his/her capacity to generate divergent ideas. Notably, this latter point perfectly aligns with recent critiques brought forward by proponents of ecological psychology (Orth et al., 2017; see also Withagen & van der Kamp, 2018), which severely challenge the notion that creative ideas are first generated by the individual 'in the head' and subsequently executed to solve a problem. Contrasting this sequential concept, it is emphasized that creative actions emerge from the interaction between individual, task and environmental constraints, while the player aims to satisfy constraints of the unfolding situation.

Nevertheless, it should be noted that the alternative framework we propose does not completely rule out DT (alongside other factors) as a *potential* resource for creative behaviour. However, rather than equating DT to creativity on a conceptual level and using a DT score as an undisputable outcome measure, the question of if—or to what degree—DT functions as an additional resource for creative behaviour needs to be addressed as an empirical question. In this regard, if DT tasks were further developed (as discussed by Roca et al., 2021) to assess options in terms of motor responses—i.e., not as a set of options *per se*, but as *one's own* actual options in a specific situation—, such a measure might be a valid and practically useful predictor for creative performance. Such evidence, however, still needs to be provided.

In the present study, we aimed to take a first step towards critically examining fundamental assumptions made in the current creativity research in sports. Obviously, the results obtained in such a first experiment need to be replicated in further studies to claim generalizability. In this regard, the predictions derived from both the DT and the proposed functional–relational frameworks need to be tested with larger samples, players with different ages and levels of expertise and, more importantly, with distinct as well as more complex on-field game situations. Methodologically, we suggest that both field-based experiments as well as correlational studies are promising approaches to do so. Specifically, further field-based experiments should allow the hypotheses to be tested not only in a double-blind-design but also under more comparable environmental pre- and posttest conditions and without baseline differences between experimental groups (e.g., by assigning participants to groups based on pretest results). In addition, correlational designs allowing for a direct comparison of relationships between players' DT scores and creative actions on the one hand, and players' motor skill level and creative actions on the other hand, might be a straightforward approach to test the proposed hypotheses. Such studies are planned to be conducted in our research group in the near future.

Taken together, the results of the present study invite a re-evaluation of the predominant theoretical framework used to address creativity in team sports. In terms of sports practice, rather than defining and assessing creativity as a player's DT ability—and thus seeking ways to improve DT in training—, it appears more productive to address the practical goal of developing creative players from a functional viewpoint. Accordingly, the main objective would be to target task-relevant sensorimotor skills that allow a player to solve specific situations in many ways, i.e., to expand *his/her* action repertoire rather than aiming to improve a competence to come up with options per se. As a result of such a conceptual turn, we would expect to develop players who might not stand out by fluently and originally *thinking* about actions, but by *doing* things others simply cannot and consequently being more creative *in action*.

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Declarations

Conflict of interest. S. Zahno and E-J. Hossner declare that they have no competing interests.

The study was approved by the University's ethics committee and carried out in accordance with the 1975 Helsinki declaration. Permission to participate was obtained from all participants' parents in advance.

Appendix

Training intervention: examples of implemented play and practice tasks

Divergent thinking intervention

Example 1: Identification of gaps (see also Memmert, 2015b, pp. 88–90). The playing field was divided into three zones marked by cones. Players could only move within their zone. The task goal of the players in the two outer zones (*blue*) was to find gaps in the defensive line (*red*). They collected points for every pass to a teammate in the zone on the opposite side (promotion focus) as opposed to going to the middle zone when the ball is intercepted (prevention focus). Players were encouraged to explore all solutions that came to mind in a playful way. No further instructions were provided and no tactical feedback was given during play.

Variations in the game: (1) changing the length and width of the zones, (2) using feet or hands (bounce passes through the defensive line), (3) rotating players, (4) additional task for the defending players: counter-attack; i.e., if they intercept the ball, their aim is to reach the opposing baseline with the ball (Fig. 3).

Example 2: Free play and coming up with new ideas. Two teams played a 2-vs-2 + 1 game. No tactical instructions nor feedback was provided. Teams gained points by either (a) scoring in mini-goals or (b) dribbling through the orange cones. During play, additional possibilities to collect points were incrementally introduced: (1) chip into the hoop (2 points), (2) when the coach announced "side" (acoustic signal): 1 point for dribbling through the yellow cones at the side of the playing field, (3) when the coach raised a red or blue cone (visual signal): one player from the corresponding team had the opportunity to collect extra points for his team by partaking in a playful creativity exercise on the side line while the 2-vs-2 game went on. The player was shown a picture of a game situation from a famous team (e.g., FC Barcelona) and asked, for example, "How could Messi solve the situation?", "Can you come up with two ideas that no other player has proposed yet?" Players were encouraged to continue generating solution ideas until they found a novel one (which was understandably easier at the beginning and increasingly difficult as the game progressed). If the player provided one or two new solutions, he collected 1 or 2 points for his team, respectively. The flow of the football game was never interrupted. After a period of free play, the game was closed with a short group brainstorming: "Can we find even more solutions for the game situation together?" (Fig. 4).

Functional skill intervention

Example 1: Face to face—de-stabilizing an opponent 1-vs-1 and reaching zones from various angles. The task goal for the attacking player (A) is to outplay the defending player (D) in order to reach determined zones with the ball at his feet. Emphasis was placed on producing the effect of de-stabilizing the opponent. Across a series of attempts, players gathered specific experiences in order to detect task-relevant relationships and own functional solutions. Within the given task, variability was introduced in the starting positions and targeted ending zones by using different commands: (1) "go": direct start for A and D, A's goal was to reach the opposing baseline with the ball at his feet. (2) "yellow": direct start for A while D had to go back to the yellow line before being allowed to defend (increasing distance A–D; D in backward movement), the targeted zone (red, blue or baseline) was communicated beforehand either to only A (uncertainty for the D) or to both players A and D. (3) "blue" or "red": Both A and D (A with and D without the ball) had to go around their respective blue or red cones (changing angle), A's goal was then to reach the blue or red line, respectively.

Variations in the task: (1) Changing distances between cones in terms of (a) length and/or (b) width. (2) Switching the side of blue and red cones (for A or D) in order to change angles (Fig. 5).

Example 2: With his back to the goal—receiving to turn and de-stabilizing the opponent. In this task, A2 received the ball from A1. The task goal for A2 was to turn in order to score in one of the two mini-goals. A trial started with the coach calling one of three colours (e.g., "red"). In this case, while player A1 passed to A2, D had to go around the red cone before defending. Thus, across multiple attempts, A2 could gather experiences of receiving the ball with pressure from varied angles and distances in the specific task.

Variations in the task: (1) Frequently changing the positions of the cones (enhancing the variety of constellations). (2) Changing distances: A2 to goal (i.e.,

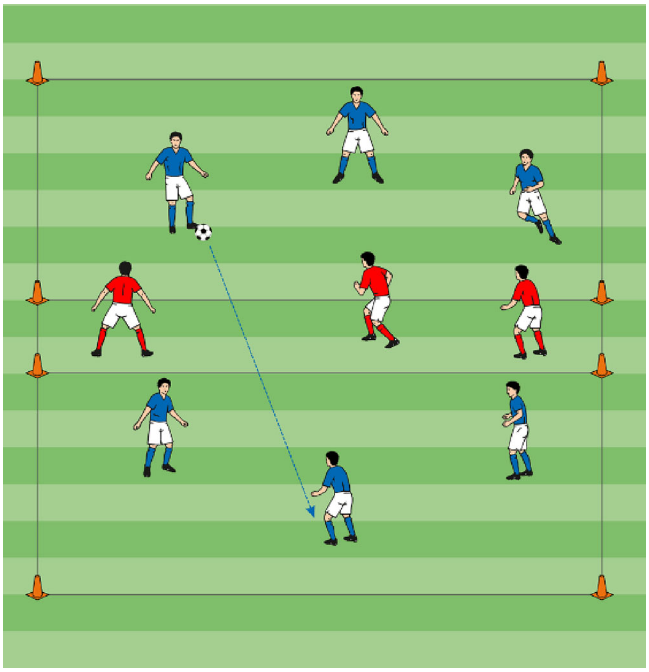

Fig. 3 ▲ Identification of gaps

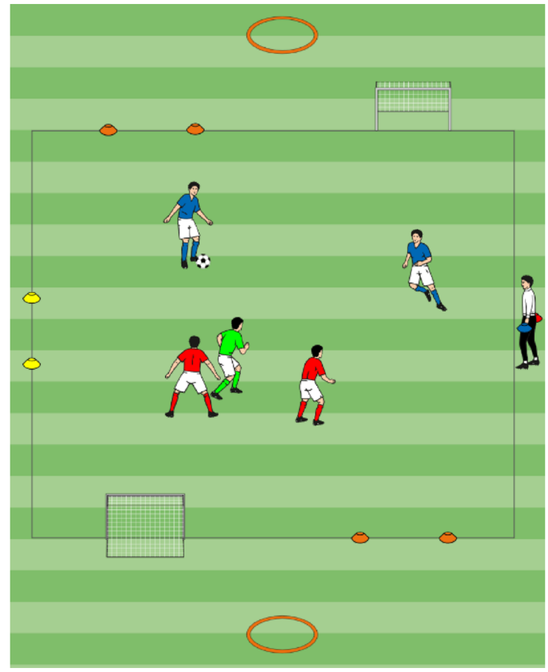

Fig. 4 ▲ Free play and coming up with new ideas

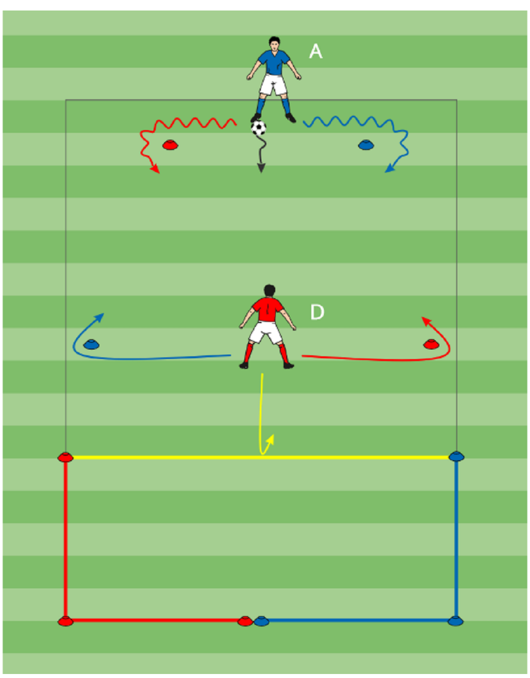

Fig. 5 ▲ Face to face—De-stabilizing an opponent 1-vs-1 and reaching zones from various angles

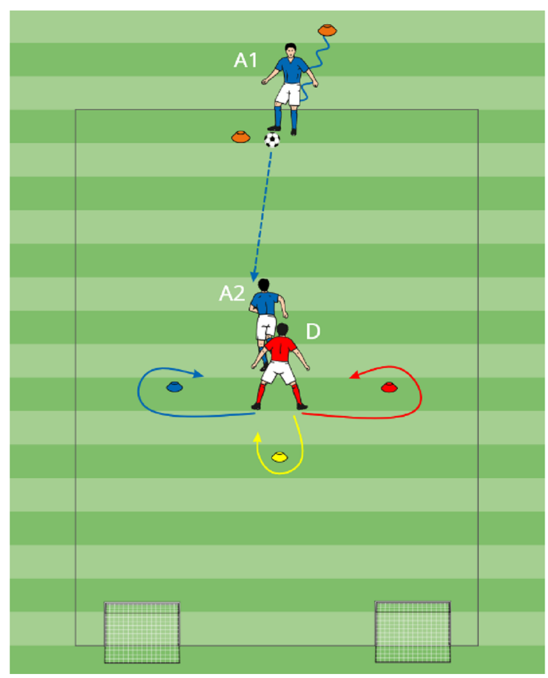

Fig. 6 ▲ With his back to the goal—receiving to turn and de-stabilizing the opponent

the space in his back) and A1 to A2 (i.e., the passing distance). (3) Changing width of the playing area. (4) Changing the position of the goal (providing different angles). (5) Different starting movements (e.g., more dynamic: A1 had to dribble to a cone before playing the first pass; A2 starts with the ball and plays a one-two with A1; ◘ **Fig. 6**).

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