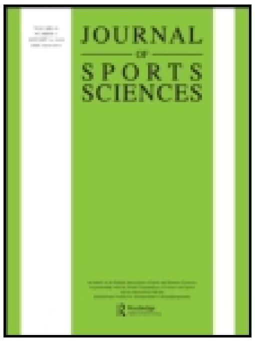

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Laterality of a second player position affects lateral deviation of basketball shooting

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Abstract
Asymmetrically placed visual distractors are known to cause a lateral bias in the execution of a movement directed toward a target. The aim of the present experiment was to verify if the trajectory of the ball and the trajectory of the jump for a basket-shot can be affected by the sole position of a second player, who stays in front of the shooting player in one of three possible positions (centre, left or right) but too far to physically interfere with the shot. Young basketball players were asked to perform 60 shots at 6.25 m from a regular basket, with or without a second player staying in front of them in, alternately, a centre, left or right position. A computerised system measured the angular deviation of the jump direction from the vertical direction and the lateral deviation of the ball trajectory from the midline. The results showed that both the jump direction and the entry position of the ball deviated toward the opposite side from the second player's side; however, these effects were too small to significantly affect the mean goal percentage. This result confirms that some placements of the players can have an effect as visual distractors. Further studies are necessary to find what game conditions can make such distractors harmful for the athletic performance.

Keywords: *attention, sports performance, perceptual motor performance, visual motor coordination*

Introduction

Generally, things or situations that influence movement strategy directed toward a target are called 'distractors'. Several studies have reported the effects of some distractors in sports; for example, it has been shown that the presence of an audience or its incentives can negatively affect the performance (Geisler & Leith, 1997; Baumeister & Showers, 1986); moreover, Rojas, Cepero, Ona, and Gutierrez (2000) have shown that in basketball, compared with a situation without any opponents, when shooting against an opponent who is trying to intercept the ball, the shooting player attempts to release the ball more quickly and from a greater height. This is an evident strategy to reduce the chance of the opponent intercepting the ball. These kinds of distractors appear to act through a psychological/emotional mechanism. The main question that the present work wants to address is whether the position of the second player can influence the lateral error in the direction of a basket-shot. This topic is relevant to eventually improve, by a specific training programme, the rate of successful basket-shots by basketball players.

Some other studies, in non-sporting conditions, have indicated that other distractors can influence the lateral error in the direction of a movement through a perceptual mechanism. In fact it has been shown that the estimation of the centre of a segment drawn on a white paper is biased toward one side if there are other figures flanking the segment asymmetrically; in this case, the bias is usually toward the opposite side with respect to the position of the distractor (Chieffi, 1996, 1999; Chieffi & Ricci, 2002; Fischer, 1994). Moreover, this kind of 'perceptual distractor' also produces a deviation in the trajectory of the hand when drawing a line toward a target-point flanked by other distracting figures (Chieffi, Ricci, & Carlomagno, 2001), or when reaching an object to grasp (Chieffi, Gentilucci, Allport, Sasso, & Rizzolatti, 1993; Gangitano, Daprati, & Gentilucci, 1998; Keulen, Adam, Fischer, Kuipers, & Jolles, 2007).

This evidence raises the question of whether the figure of a player can represent a 'perceptual distractor' when flanking the basket in the visual field of a shooting player; thus, the aim of the present

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experiment was to verify if the trajectory of the ball and the trajectory of the jump for a basket-shot can be affected by the position of a second player, who stays in front of the shooting player in one of three possible positions (centre, left or right) but too far to physically interfere with the shot. According to the results of the above-cited literature, it was expected that when the second player was placed in a lateral position from the midline, the trajectories of the jump and of the ball would deviate toward the opposite side, compared with the trajectories obtained when the second player stayed on the midline in front of the shooter.

Methods

Participants

The participants were selected from the students of the second year of the course of Movement Sciences of the University of Naples 'Parthenope' who were willing to participate. Five male basketball players were selected who had the most similar anthropometric features: age 22.2 ± 0.86 years, height 1.80 ± 0.02 m, body mass 79.6 ± 5.1 kg, body mass index 24 ± 1 kg · m^{-2}, have practised basket for the last 7.2 ± 1.3 years in non-professional teams, with an average 3-point field goal percentage of 24 ± 3% (mean ± standard deviation); all participants were right-handed. The study was conducted in accordance with the ethical standards of the Declaration of Helsinki and with all Italian national rules and local rules on human experimentation; all procedures were approved by the ethical committee of the University of Naples 'Parthenope', Napoli, Italy; all participants were informed of the procedure and gave their consent prior to participation.

Recording system

A low-cost computerised system has been used for the present experiment. A commercial webcam (model SPC1030NC, Philips, Amsterdam, the Netherlands) was fixed on a stable vertical column (the heavy support of a moveable basket); the cam was placed on the longitudinal midline of the court at 832 cm from the basket (towards the centre of the court), and at an height of 190 cm above the ground. The longer side of the frame of the cam was aligned with the vertical axis; the frame was centred on the mid-vertical axis passing across the centre of the basket; the frame included simultaneous non-overlapped views of both the basket board and the whole of the shooting player (from his back) who stayed on the midline at 625 cm from the basket (Figure 1). The webcam was connected to a portable PC ('netbook' type) placed on a desk behind the cam support, so the experimenter sat behind the shooting player and was not visible during the shot. Custom software was written with LabView (National Instruments, Austin, TX, USA) to automatically assign the random sequence of the tests (see below), to manually start and stop the recording of each test, and to analyse offline the recorded videos (tracking of the jump and the ball). Frames had a resolution of 480 × 640 pixels; the acquisition rate was 30 frames · s^{-1}.

A white plastic semi-sphere (cut from a regular ping-pong ball, 38 mm in diameter) was fixed on the centre of the nape of the shooter with a thin elastic band; this white spot was used as a marker to automatically track the trajectory of the shooter during the jump. The direction of the jump was defined by two points of the track, the lowest and the highest positions of the track (i.e., respectively, the smallest and the greatest Y coordinates of the marker among the sequence of the frames; the lowest height was reached exactly at the start of the jump, due to knees bending). Thus, the angular deviation of the jump was calculated, and was defined as the angle between the jump direction and the vertical direction, assigning positive values for rightward-jumps and negative values for leftward jumps (Figure 1).

The tracking of the ball started when the ball arrived near the basket board and was obtained with the 'particle analysis' function of LabView-Vision (National Instruments); a dark regular basketball ball, with all marks removed, was used to obtain the best contrast with the bright background and so aided the most effective automatic identification of its position. The lateral deviation of the ball trajectory was defined as the distance of its vertical trajectory (before touching the basket or the board) from the central vertical direction, assigning positive values for rightward-deviations and negative values for leftward deviations (Figure 2).

Procedure

The experiments took place on a regular indoor basketball court. Each participant was asked to position himself 6.25 m from the basket in the middle of the court and to shoot the ball at the basket each time the experimenter gave the signal; the participants were trained to play on a court that was not upgraded with the 3-point line at 6.75 m from the basket, thus the shooter position was at 6.25 m. A second player was present at alternately on one of three previously marked positions in front of the shooter (face-to-face) with both arms stretched up, or far from the shooter and out of his view; thus, there were four different experimental conditions (centre, right, left or no second player); 20 trials were repeated for each experimental condition, so a

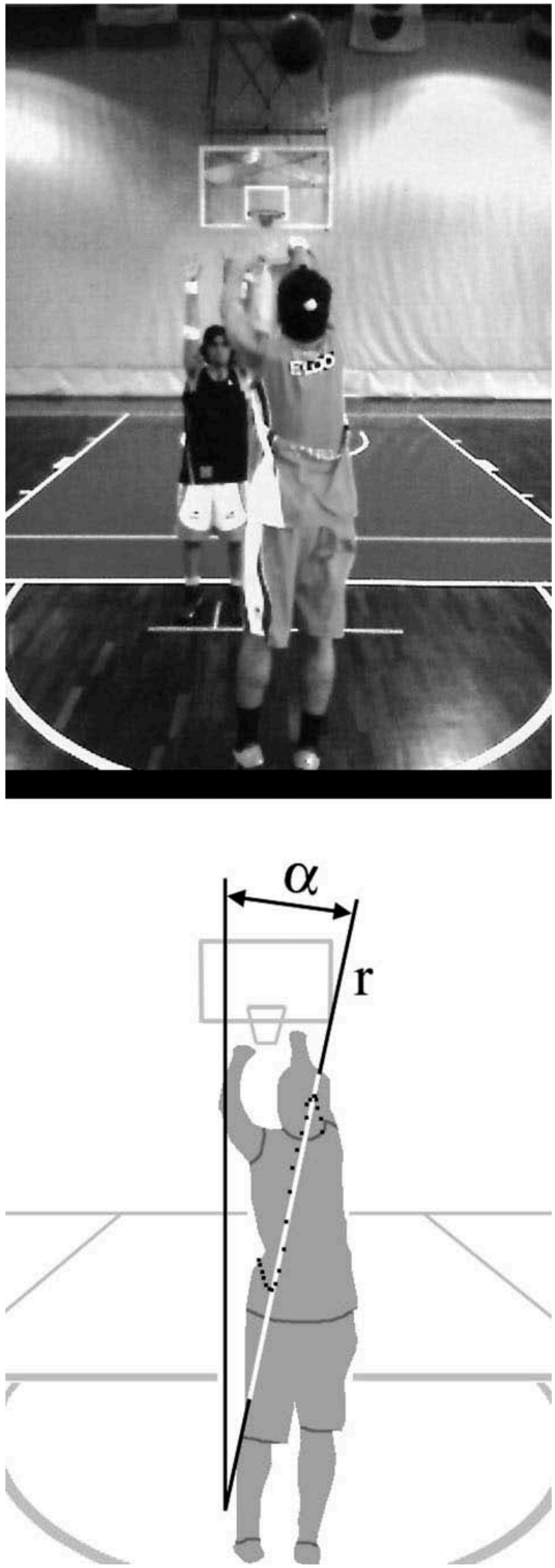

Figure 1. Upper panel: frame from the webcam captured when the jump reached its apex. Both the thrower's marker (half of a white ball fixed on his nape) and the basket board can be seen without overlapping. Lower panel: scheme of the jump showing the sequence of the positions of the nape-marker (black dots), the direction of the jump identified by the two points with respectively the higher and the lower height (r), and the angular deviation of the jump from the vertical direction (α).

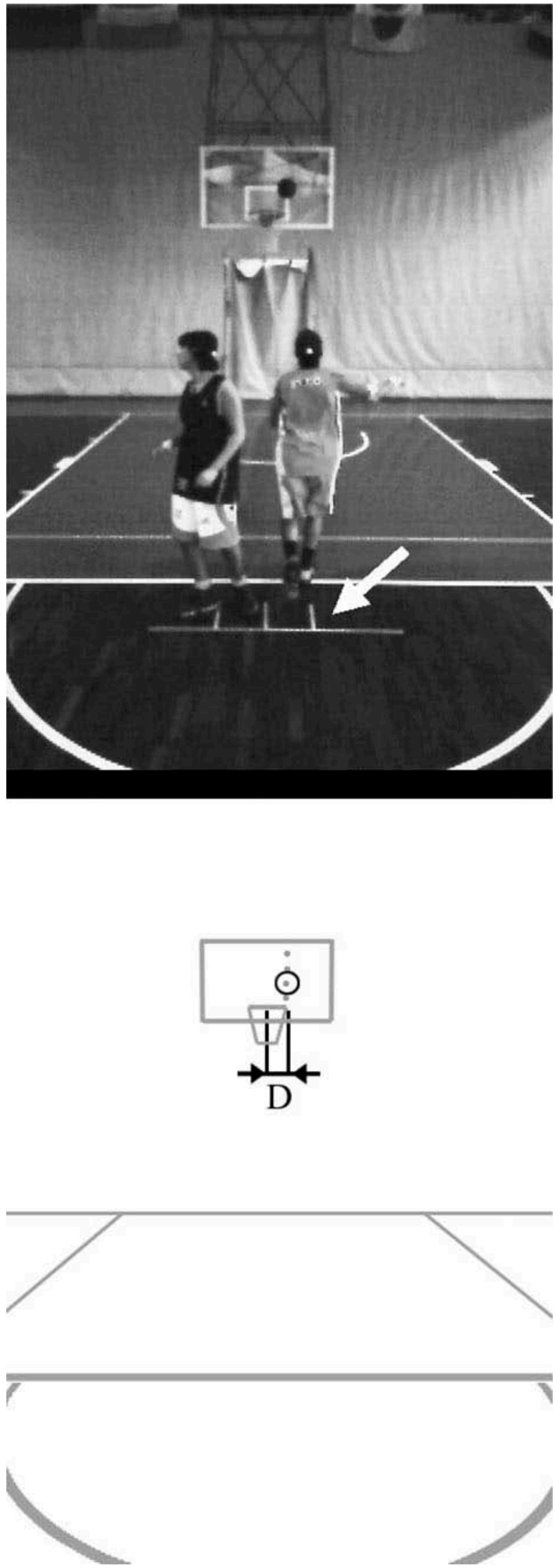

Figure 2. Upper panel: frame from the webcam captured when the ball reached the basket. The markers for the three alternative second player positions can be seen on the floor (arrow). Lower panel: scheme of the frame showing the deviation of the ball trajectory from the center of the basket (D).

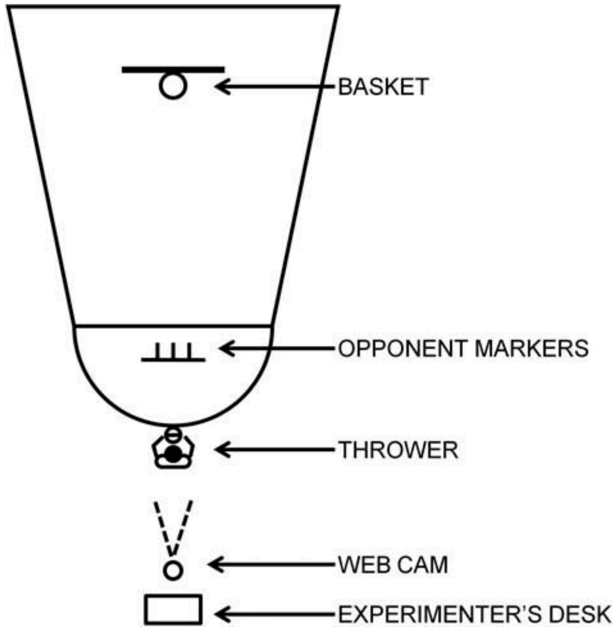

Figure 3. Scheme of the experimental set-up showing the positions of the experimenter, the webcam (832 cm from the basket, 190 cm above the ground), the thrower player (625 cm from the basket), and the second player (140 cm in front of the thrower; alternatively on center, 30 cm toward left or 30 cm toward right).

total of 80 trials were made by each participant in the same experimental session with a random sequence of the conditions assigned by the software (see above). The order in which the players shot in the four different conditions was randomly assigned by the software to prevent, in the analysis, bias due to a fatigue-effect. All players reported that the fatigue experienced during this experiment was smaller than that experienced during a regular training session. The fatigue effect on jump deviation, ball deviation and goal percentage was evaluated by comparing the results of the first five shots and the last five shots made by each player during the series of 20 for each of the experimental conditions (centre, left, right), and the results of the first 20 shots and the last 20 shots of each player. No significant difference was seen for any of the comparisons.

Markers on the ground were placed so that the second player placed the tip of his shoes behind a transverse line that was 140 cm from the shooter (towards the basket), with both feet next to a longitudinal line (one on the left, one on the right) that was in the middle of the playing area (centre condition) or 30 cm to the right (right condition) or 30 cm on the left (left condition) of the middle of the court (Figure 3). In the rest of this paper 'right' and 'left' will refer to the shooter's point of view. The second player was instructed to stay still, thus, due to the distance he neither obstructed the view of the basket nor hampered the execution of a normal free shot.

After the players took their places according to the conditions indicated before each test, the experimenter started the recording and allowed the shooter to make the shot. To exclude as much as possible other biasing variables in the scene watched by the shooter before the shot (e.g. the movements of the second player before taking his position), the shooter was instructed to abstain from watching the basket and to keep his view on the ground until the experimenter gave the 'go' command. The recording was then stopped after the ball reached the basket.

In order to avoid the audience effect (Geisler & Leith, 1997; Baumeister & Showers, 1986), the researcher was seated all the time at a desk behind the shooter (Figure 3) and there were no other people in the surroundings.

Statistical analysis

Data are presented as means ± standard error. A repeated measures study design was used, with multiple (four) levels and multiple trials in a randomised order. Data are presented as means ± standard error of the mean. The variables considered for the analysis were (1) the angular deviation of the jump and (2) the lateral deviation of the ball trajectory. The statistical analysis was performed with the analysis of the covariance for repeated measures, using the 'no second player' position as a covariate. Multiple comparisons were done with the Fisher's least significant difference test.

Results

The results showed that when the second player was placed to one side, both the jump trajectory and the entry position of the ball on the basket board were biased towards the opposite side with respect to the no-second player or the centre-second player conditions. The analysis of the covariance, considering the no-second player condition as a covariate, showed significant effects for the position on both the jump direction, $F(2, 6) = 9.19$, $P < 0.05$, and the ball position, $F(2, 6) = 8.09$, $P < 0.05$; pair-wise comparisons showed that the means obtained in all the second player positions (centre, left, right) differed from each other. The no-second player condition was used as a covariate because each player had his own 'baseline' lateral bias in both jumping and ball shooting. The mean absolute direction of the jump trajectory in the no-second player condition was 4.22 ± 1.28°; in other conditions the deviations from the direction recorded in the no-second player condition were 0.00 ± 0.15° in the centre-second player condition, 0.48 ± 0.20° (rightward) in the left-second player condition, and –1.31 ± 0.45° (leftward) in the right-second player condition. The mean absolute deviation of the ball trajectory from the centre of the basket in the no-second player condition was 6.88 ± 1.55 cm; in other conditions, the deviations from the direction recorded in the no-second player condition were –0.42 ± 1.61 cm in the centre-second player condition, 4.30 ± 0.96 cm (rightward) in the left-second player condition, and –5.80 ± 1.12 cm (leftward) in the right-second player condition. The presence and position of the second player did not significantly affect the goal percentage compared with the no-second player condition.

Discussion

In the present study it was demonstrated that the position, rather than the simple presence, of a second player can represent a distractor for the action of a basketball player targeting the basket. Because the shooting player was aware that the second player could not physically interfere with the shot, the distracting effect of the second player should be mainly attributed to a perception bias of the shooter in the evaluation of the position of the goal (the basket), rather than to a 'fear' reaction. It can also be noted that the differences between the centre-position condition and the no-second player condition were null for both the jump deviation, the ball deviation and the goal percentage (Figures 2 and 3); this means that the presence of the second player in the centre-position was not a significant distractor for the lateral deviation in the present model, likely because the shooting player did not consider the second player as an obstacle for the shot. Nevertheless, the small laterality in the position of the second player, when positioned at 30 cm lateral and at a distance of 140 cm, meaning 12° from the shooter's point of view, resulted in a deviation of the jump and the shot towards the opposite side. This effect agrees with the results of previous experiments (Chieffi 1999; Chieffi & Ricci, 2002), in which the centres of the distractors were exactly in the range of 11–13° (in fact, there were geometrical figures centred at 11–14 cm lateral from the target and 46 cm far from the volunteer's eye), and the effect was again a bias towards the opposite side.

It can be noted that the effect of the distractor on the athletic gesture shown in the present model did not affect the relevant aim of the game, namely the chance to make a goal; in fact the goal percentages in the different conditions did not differ (Figure 3). This was likely due to the fact that the distractor caused an absolute lateral bias of only 5.05 ± 1.60 cm (4.30 ± 0.96 cm or –5.80 ± 1.12 cm) from the player's habitual targeting point in shooting in the no-second player condition (Figure 2); such bias, in fact, was smaller than the variability of the entry position of the ball at the basket, which was in the range of 16.59 ± 2.40 cm (95% confidence interval) in the no-second player condition. The individual asymmetries in the jumping technique (4.22 ± 1.28°) and in ball-shot direction (6.88 ± 1.55 cm) were significantly higher than those due to the presence of the opponent; possibly the absence of the second-player influence on the mean goal percentage is due to this factor. Because training can reduce the variability in the execution of an athletic gesture, future studies should be conducted to evaluate whether in higher level players the biasing effect of the second player would be (paradoxically) significant, even though very small.

It can also be noted that the bias found in the final position of the ball was about 0.5 ± 0.1° from the shooter's point of view (5.05 ± 1.60 cm at a distance of 625 cm), which was smaller than the bias reported in the model used by Chieffi & Ricci (2002), in which the bias was greater than 1 mm at a distance of 46 cm (more than 1° in the view-field). This difference can obviously be attributed to the different experimental conditions, but could also be due to the fact that in the present model the participants were highly trained for both the gesture (shooting to the basket) and the presence of the distractor (the second player); in fact, in different experimental models, it has been demonstrated that training can modify the influence of distractors (de Lussanet, Smeets, & Brenner, 2002; Mruczek & Sheinberg, 2005; Song & Nakayama, 2007).

The mechanism by which the position of the second player affects the shot can either involve the perceptual analysis of the scene, according to the hypothesis of the 'centre of mass effect' (Shuren, Jacobs, & Heilman, 1997), or the ideation of the movement strategy, according to the 'lateral inhibition theory' (Howard & Tipper, 1997; Tipper, Howard, & Houghton, 1998). In fact, when the second player was laterally placed, his shape created an asymmetry in the global visual field that the shooter had to analyse to evaluate the exact centre of the basket, which was his primary target; according to the 'centre of mass effect' (Shuren et al., 1997) this asymmetry can cause an alteration in the esteemed position of the centre of the target and, thus, an error in the direction of the shot. On the other hand, the second player can be unconsciously interpreted by the shooter as a putative obstacle, even if the shooter was aware that the second player could not physically interfere with the shot; according to the 'lateral inhibition theory' (Tipper et al., 1998), this unconscious interpretation can evoke a different movement strategy, namely an avoidance of the putative obstacle, which competes with the primary movement directed toward the target and, thus, causes a deviation of the shot.

In conclusion, in our study, a second player can represent a lateral distractor producing a lateral bias in the view-field of a shooter in basketball shooting. This result encourages the initiation of more extensive studies on the visuo-motor distracting effects of other real game situations.

Limitations

The major limitation of the present study was that the model simulated a very particular game condition that is actually rare in a real match; moreover, the effect of fatigue due to playing a match has not been evaluated because, in the present model, the participants performed a very light exercise. Nevertheless, to avoid minor effects of fatigue on the means calculated for each experimental condition, the sequence of the order in which the players shot in the four different conditions was random. In such context, the 'disturbing player' could even be replaced by another fixed element next to the hoop; future works could use both kinds of distractors (a person or a 'cartoon') to eventually reveal a different psychological effect between them. Here, a person was used as a distractor because this was intended as a preliminary study for future works on other more realistic matching situations, possibly with the use of more sophisticated motion tracking systems. Another limitation was that a single marker was used to evaluate the jump trajectory; considering the limitations of the system used for the analysis, this compromise was acceptable and was sufficient to reveal the biasing effect of the distractor; anyway, the use of more markers in future works will give the possibility to properly evaluate the trajectory of all body segments during the jump.

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