A METHOD FOR THE PERFORMANCE EVALUATION OF JUMPING HEADERS IN SOCCER

Giuseppe Marcolin[1], Nicola Petrone[2]

[1]Exercise Science, University of Padova, Italy
[2]Department of Mechanical Engineering, University of Padova, Italy

The aim of the present work was to develop a method for the evaluation of soccer heading performance in jumping headers by means of a stereophotogrammetric system. Three non-professional players were involved in this pilot study. The attention was focused on the following variables: the player's jump height at the impact instant, the ball velocity variation and the initial ball angle after the impact with the forehead of the player. The analysis of these parameters permitted to characterize the biomechanical technique and the performance ability of each player in such a way that a trainer can define individual procedures to improve the efficacy of this fundamental skill in soccer. Finally an Elevation Index (E.I.) was developed to compare the players performances and to draft a ranking between them.

KEY WORDS: soccer, heading, performance.

INTRODUCTION: It is well known that in modern soccer an efficient technique in heading the ball is very important. There are several ways to impact the ball and the choice of the proper one is determined by the situation during the match.

Investigations from a biomechanical point of view concentrated in two kinds of headers: the standing header and the jumping header. The first was investigated by Burslem and Lees (1998) in terms of head acceleration during the impact. Later, Kristensen (2002) investigated the segmental characteristics in jumping headers with particular attention to the head's velocity relatively to the torso at the impact instant and to the arm and leg influence on heading the ball.
The purpose of this study was to develop a repeatable standard test procedure to evaluate the performance of each jumping header in terms of the following parameters: the ball velocity variation, the height of the jump at the instant of impact and the initial angle described by the ball trajectory. The introduction of an Elevation Index allowed to compare the testers involved in the study in order to evaluate the player's attitude and ability in this complex but very important skill in soccer.

METHOD:

Data Collection: Three non-professional soccer players were involved in the study. Before the tests, each player subscribed a written informed consent. A stereophotogrammetric system (BTS, Padova, Italy) composed by 6 infra-red cameras working at 60 Hz was used to acquire the soccer heading. Cameras were placed at a height of 4mt in order to create a large calibrated volume. All subjects had 26 reflective markers placed on special pre-selected body anatomical landmarks: head (3), wrists (2), elbows (2), acromions (2), trunk (1 at C7), pelvis (2 at PSIS and 2 at ASIS), great trochanters (2), knees (4), ankles (2) and feet (4). Four soft markers were also sticked to the ball surface. The correct application of this customized marker protocol was essential for further kinematical analysis. Each test was also recorded with a commercial digital video camera from the right side of the tester. Tests were performed indoor. The ball was fixed with a stiff cable of 6 mt length to the ceiling structure, centrally with respect to the calibrated volume, in a way that its height from the floor could be easily varied of maximum 50 cm.
The test procedure consisted in two stages: 1) the player was standing in front of the suspended ball and he was asked to jump from the place and impact downwards the ball with the forehead at the maximal power (Figure 1a); 2) the player, after a 5mt short run, impacted downwards the ball at the maximal power, jumping with his preferred leg (Figure

1b). A third type of tests was performed with the ball oscillating as a pendulum and players impacting the incoming ball, but results are not reported in the present work.
The nominal height (h_o) of the ball suspended on the calibrated volume was calculated from the top of the players head to the bottom of the ball as sketched in Figure 2. For each tester, h_o increased regularly at every trial until he was not able to impact the ball with the medial part of the forehead.

(a)

(b)

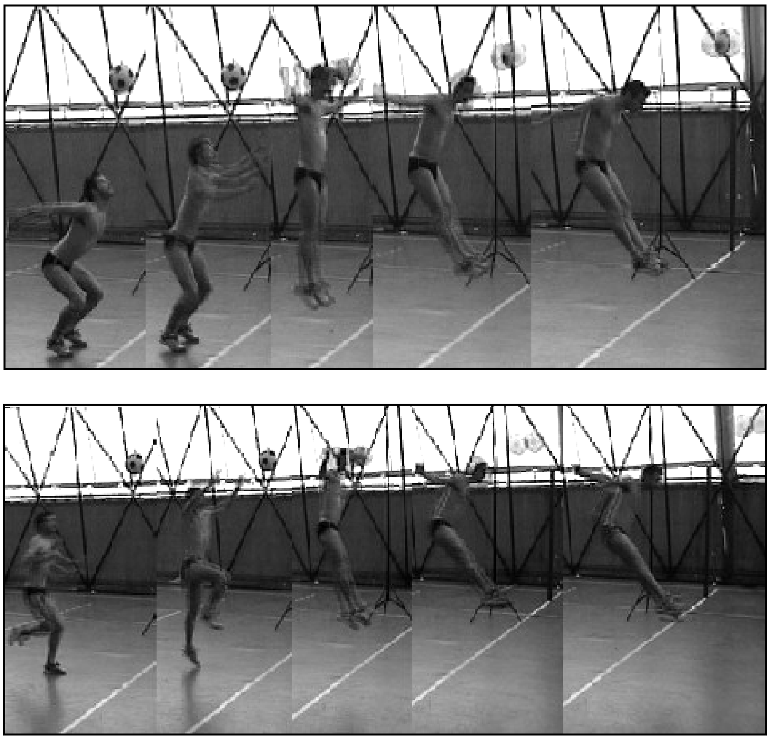

Figure 1: **(a)** Standing jump heading. **(b)** Short run jumping heading with preferred leg (Tester 1).

Data Analysis: for each trial 3D markers coordinates were interpolated and filtered using BTS analysis software. For the kinematical analysis four parameters were evaluated:

- the nominal height h_o from the top of the player's head to the bottom of the ball;
- the elevation Δh of each trial of each player;
- the ball velocity variation Δv;
- the initial angle α described by the ball after the impact with the forehead.

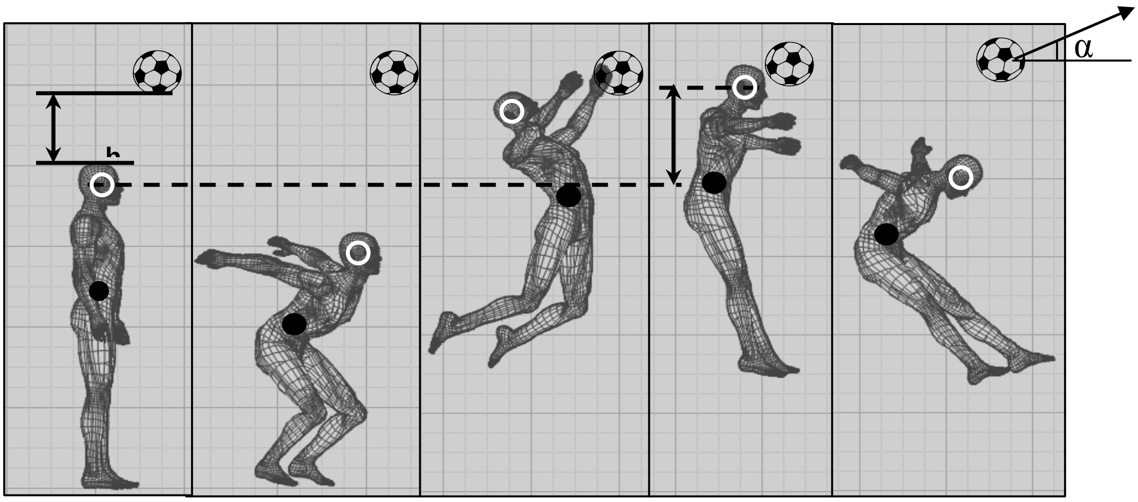

Figure 2: Kinematical parameters evaluated in the study for a standing jumper

The elevation *Δh* was defined as the vertical distance reached by the head markers (placed in front of the ear's centre) from the initial marker's position in standing. The speed variation *Δv* was defined as the difference of speed magnitude after and before the impact. High values of the angle α were considered correlated to an incorrect heading with respect to the requested task of downward heading.
The Elevation Index (*E.I.)* was calculated as the ratio in percentage between *Δh* and the height of each subject.

RESULTS: In Figure 3 the trends of *Δh* and *Δv* at increasing nominal height h_o is plotted for the two different tests of Tester 1: the effect of the short run is appreciable as an increase both of ball velocity values and of heading heights.

Figure 4 gives the trend of elevation *Δh* and of ball angle α for best headings (trials with lowest angle values) of each nominal height:
Finally Figure 5 compares the three testers in terms of Elevation Index E.I. (obtained normalizing *Δh* values to tester's height) and of ball speed variation.

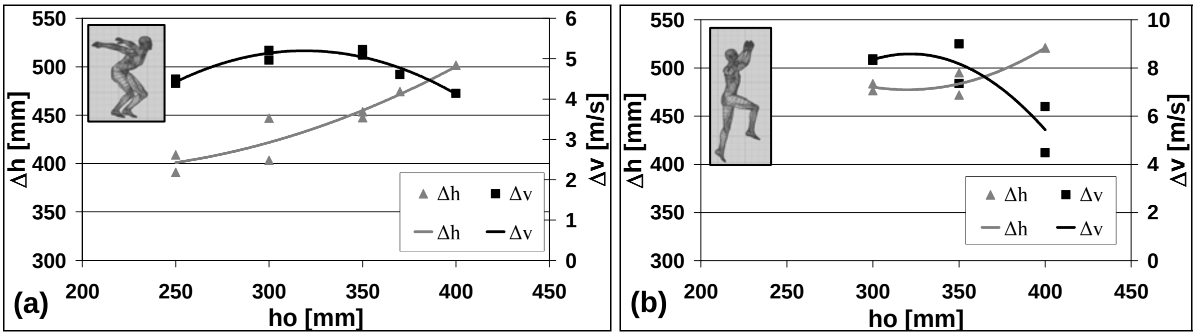

Figure 3: Tester 1 *Δh* and *Δv* trends in standing jump **(a)** and in short run jump **(b)**.

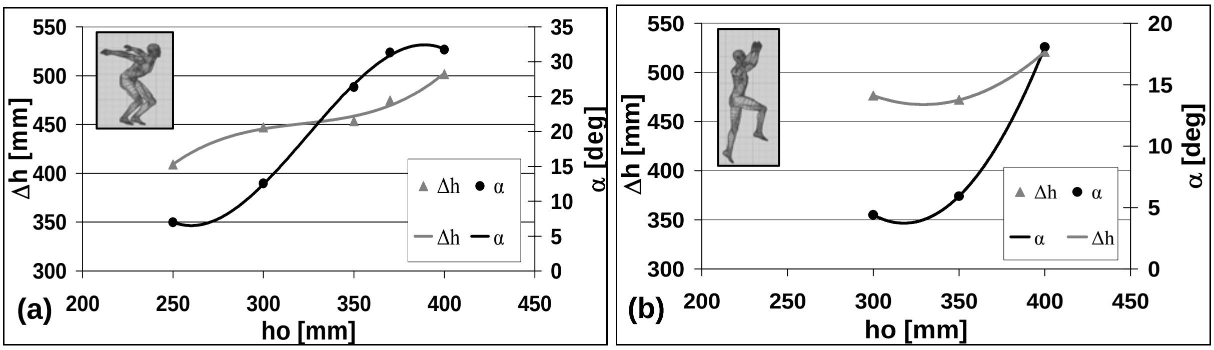

Figure 4: Tester 1 *Δh* and α trends in standing jump **(a)** and in short run jump **(b)**.

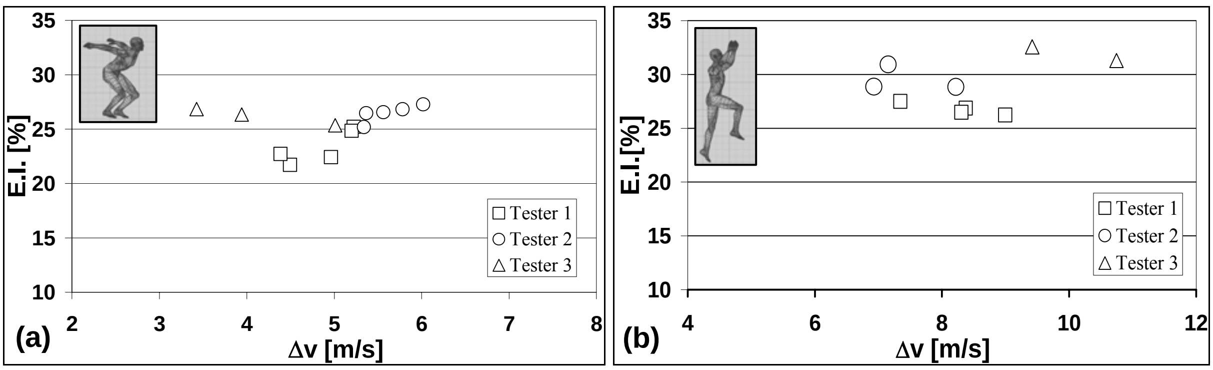

Figure 5: Elevation Index and ball speed increment: comparison between testers in standing jump **(a)** and in short run jump **(b)**.

DISCUSSION: In this pilot study, two types of tests were developed to evaluate jumping headers performance. Tests were performed at increasing nominal height h_o, that can be considered as the exercise task to be executed with a maximum power downward heading.

From the analysis of Figure 3 it is evident that Δh increases with the increase of h_o as expected. The plot of Δv shows that there is a relative maximum of ball speed variation Δv, that is, there is an optimal zone of heading that can be characterized for each tester. For Tester 1 this zone corresponds to h_o ranging between 300 and 350 mm, with elevation reaching 450mm in standing jumping.

Furthermore, from the analysis of Figure 4, a steep increase of ball initial angle α for nominal heights higher than 350 mm marks the incorrect forehead heading and confirms a functional elevation limit of the player. Ball angles higher than 15° were assumed to indicate a wrong heading execution and therefore the reaching of a limit performance of the player.

The analysis of Figure 5 can suggest several useful considerations for the development of a method of functional evaluation of heading in soccer. In fact, it can be assumed that best heading players will be placed in the highest-right part of the diagrams, corresponding to best elevation indexes and best ball speed increments, whereas worst players will be in the lowest-left part.

From the examination of Figure 5.a, the ranking of players in standing jumping results the following: Tester 2, Tester 3, Tester 1. From the examination of Figure 5.b, the ranking of players in running jumping is different, giving Tester 3, Tester 2, Tester 1.

It is evident that Tester 1 is the worst performing header: an interesting evidence is the opposite ranking of Testers 2 and 3 in standing and running jumping. This could be explained with a poor coordination ability of Tester 3 in standing jumping where he showed also the worst ball speed increment values. Further investigation involving the study of trunk-leg relative motion from available kinematic data will help in confirming this hypothesis.

The results of Figure 5 seems to confirm the presented method and to open the possibility of using this approach for the evaluation of the training effects on the players, as well as for the comparison of the different players in terms of definition of preferred roles in the match.

Further experiences with professional players and correlation with established roles are being carried out.

CONCLUSION: A method for the performance evaluation of jumping headers in soccer was presented on the basis of pilot tests on non-professional players. Several parameters were quantified like the ball velocity variation, the height of the jump at the impact instant and the initial angle described by the ball trajectory. The analysis showed that it is possible to identify a maximum efficient heading elevation for each player related to highest ball speed increments and correct ball angles. Furthermore, the introduction of an Elevation Index can be useful in comparing the players in order to classify their ability in heading high balls with high impact energy: this will be helpful for the evaluation of training effects during a season or for defining a proper role mostly for young players.

REFERENCES:

Burslem I., & Lees, A. (1998). Quantification of impact accelerations of the head during the heading of a football. In T. Reily (Ed.) *Science and Football,* 243-248. London: E. & F.N.SPON.

Kristensen, L.B. (2002). Investigation of segmental characteristics in powerful soccer heading. *ISBS symposia 2002,* 409-412. Spain