

Full Length Research Paper

Elbow but not knee joint kinematics can be assessed using photogrammetric methods during a non-stationary slap shot in ice hockey

Ayhan Goktepe^{1*}, Isil Ozfidan², Hakan Karabork³ and Feza Korkusuz²

¹Selcuk University, Technical Science College, Department of Geodesy and Photogrammetry, Konya 42075, Turkey.

²Middle East Technical University, Faculty of Education, Department of Physical Education and Sport, Ankara 06531, Turkey.

³Selcuk University, Faculty of Engineering and Architecture, Department of Geodesy and Photogrammetry, Konya 42075, Turkey.

Accepted 4 January, 2010

In this study, elbow and knee joint kinematics of the non stationary ice hockey slap shot was investigated using photogrammetric methods. Four right handed elite Turkish ice hockey players from various teams participated in the study in order to scientifically obtain a general description of elbow and knee joint kinematics during a non-stationary slap shot. The loading, contact and follow through phases were analyzed using a dual camera and Pictran software system. The results showed an elbow angle pattern consistent with previous studies, however a general knee angle strategy could not be obtained.

Key words: Digital photogrammetry, motion analysis, biomechanics, ice hockey, slap shot.

INTRODUCTION

The main aim of slap-shot is to shoot the puck with maximal velocity (up to 140 km/h) directly towards the goal and score (Woo, 2004). Slap-shot is the fastest shot in ice hockey that is frequently used by all players (Montgomery et al., 2004). There are several factors affecting the success of slap-shot including stick stiffness, stick mass, and puck mass. Stick construction has been studied extensively (Worobets et al., 2006; Woo, 2004; Wu et al., 2003; Pearsall et al., 1999). Although previous studies proposed that stick stiffness is an important factor affecting the speed of the puck (Villasenor et al., 2006), recent studies (Worobets et al., 2006; Wu et al., 2003) suggest that joint kinematics, skill level and body strength are as important as the properties of the equipment.

The slap shot is executed in six distinct phases: (1) back swing, (2) down swing, (3) preloading, (4) loading,

(5) release and (6) follow through (Montgomery et al., 2004; Wu et al., 2003; Pearsall et al., 1999). In the preloading phase the stick makes the first contact with the ice making the "slap" sound. In the loading phase the puck is impacted by the (Pearsall et al., 1999). Slap-shot has been previously analyzed in the laboratory (Woo, 2004) but not in the field. In laboratory studies the shots had to be stationary.

Photogrammetry is the art and science of determining the position and shape of objects from photographs (Kraus, 1993). Until now, this technique is used in analysis of human and animal anatomy (Karabork, 2009; Ege et al., 2004), architecture (Yilmaz et al., 2007), production of topographic maps (Pesci et al., 2007), three-dimensional motion analysis for different aims (Goktepe et al., 2009; Yagisan et al., 2009; Goktepe et al., 2008), and many others.

The rationale of this study was to analyze elbow and knee kinematics of the slap-shot using photogrammetry in the ice hockey field.

*Corresponding author. E-mail: agoktepe@selcuk.edu.tr.

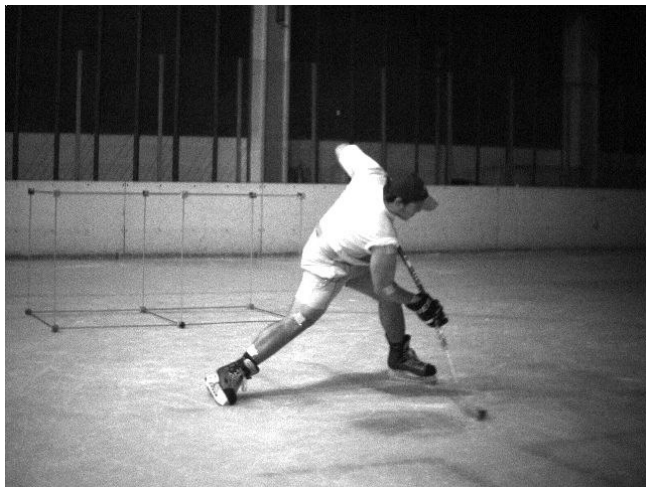
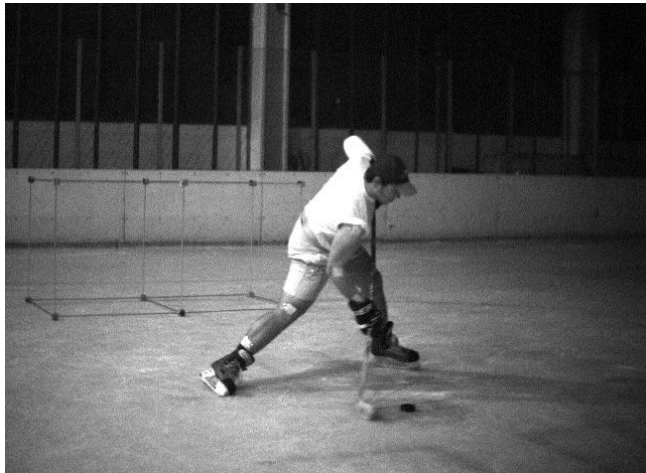


Figure 1. Images from the 1st camera during a non-stationary slap shot of a participant.

MATERIALS AND METHODS

In this cross-sectional study dependent variables were knee and elbow angle during dynamic slap-shots (Figure 1).

Four male right handed elite ice hockey players voluntarily

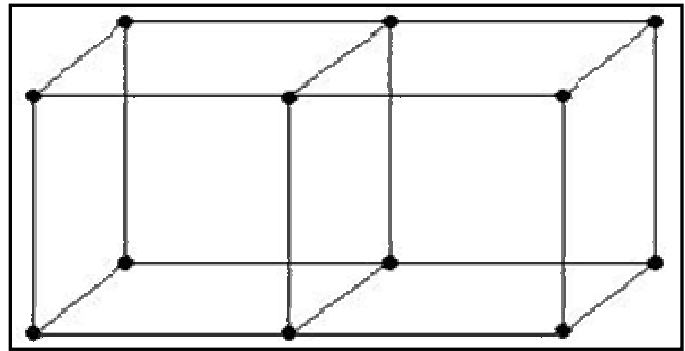


Figure 2. The 1.0 x 1.0 x 2.0 m calibration frame with 12 control points.



Figure 3. Marker positions and segments created.

participated the study. The players were between 18 and 29 years of age with a mean height of 179 cm (± 4), mean weight 79.25 kg (± 14.25) and an average of 12.25 years (± 6.75) of experience.

The slap-shots were recorded at a stereoscopic view with two digital cameras (Dragonfly Express, Point Grey Research, 2006) at a frame rate of 60 frames/s. The cameras were placed approximately at a perpendicular position to each other. A frame that covered the volume of 1.0 x 1.0 x 2.0 m with 12 control points was developed and used to calibrate the space where the slap-shots were performed (Figure 2). Finally, to measure the real coordinates of the calibration frame, a Topcon GTS 701 electronic digital measurement device was used.

Tests were performed in a rink. During each slap-shot, participants wore their own gloves and skates and used their own stick. Each participant performed 5 successful slap-shots towards the net which was 13.0 m away from the puck. Successful completion of an attempt was determined by verbal confirmation from the participant approving the slap-shot and puck reaching the target.

Elbow and knee angles were calculated using six reflective markers placed to the wrist (the pinkie side), elbow (radius head), shoulder (on the acromio-clavicular joint), pelvis (directly over the anterior superior iliac spine), knee (lateral epicondyle of the femur) and fibula (Figure 3). Arm and forearm segments were defined by connecting the first three markers to measure elbow kinematics. For knee kinematics, the markers of the leg and lower leg were used.

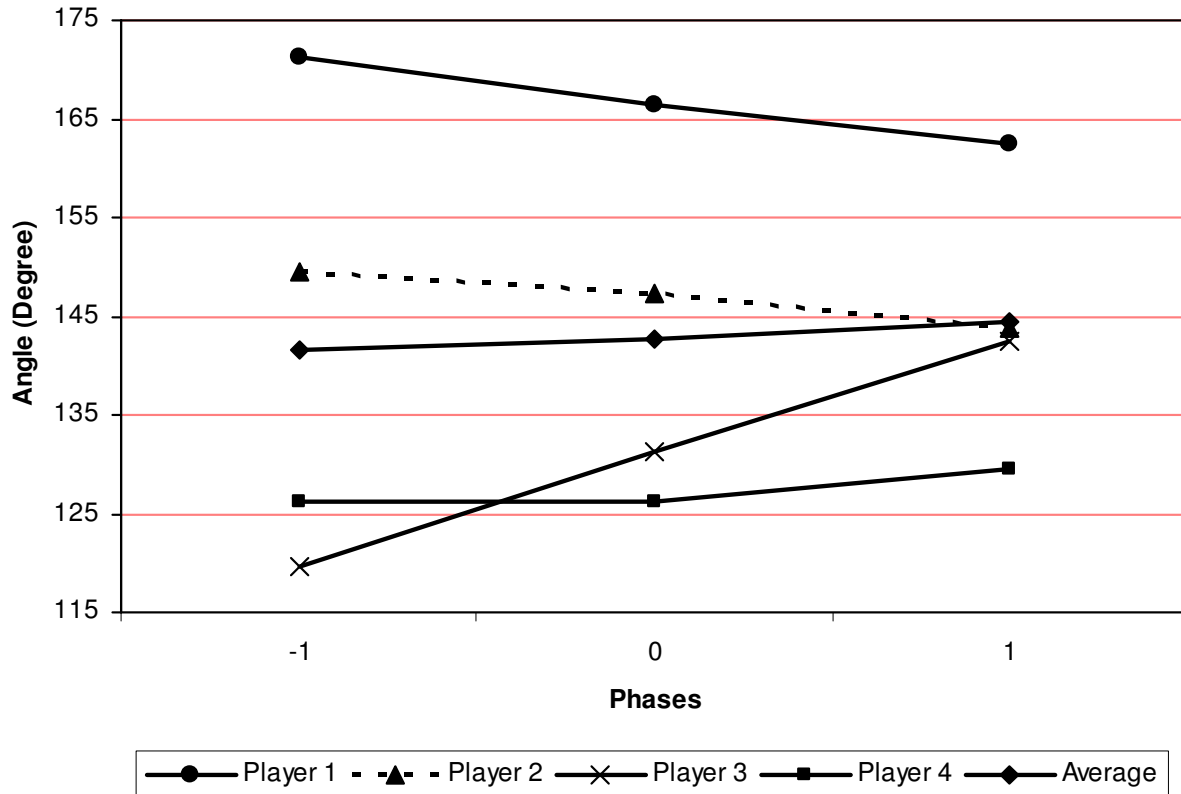


Figure 4. Knee extension strategies of players. (-1 and 1 phases in x-axis corresponds to third frames before and after the contact point respectively, 0 phase in x-axis is contact point).

RESULTS

Average of elbow and knee angles obtained from successful slap-shots are calculated for each player. Players had different knee flexion strategy during the slap-shot. Correlations between knee joint kinematics and successful completion of a slap-shot could not be established (Figure 4).

From the results obtained, the effects of the lower extremity, in conducting the slap shot, could not be understood. The results show no relation between the knee joint kinematics and successful completion of a slap shot. Figure 4 shows the change in knee extension strategies of the participants. From the graph obtained, it is not possible to make a general conclusion about the effects of this angle during a non-stationary slap shot.

On the other hand, Figure 5 shows that the players used similar elbow strategies while executing the slap-shot. Elbow angles differed significantly between the loading release and the follow through phases in each player. At phase -1, in the loading phase, (Third frame before the contact) the mean elbow angle was 144° (sd: 8°). At phase 0 (the contact point) the mean elbow angle decreased to 137° (sd: 9°) which was consistent with previous studies; in those studies the elbow angle at contact was 140° (Woo, 2004). At phase +1 the elbow angle increases to 158° (sd: 5°). (sd: Standart Deviation).

DISCUSSION AND CONCLUSION

The aim in this study was to scientifically obtain a general description of elbow and knee joint kinematics during a non-stationary slap-shot in the athletes' natural environments. As defined by previous studies, the right elbow and knee was named as the "trail elbow and knee" while the left elbow and knee was named as the "leading elbow and knee" (Woo, 2004).

This study was limited to Turkish players trained by Turkish coaches. All players were male and results should not be interpolated to females. Since ice hockey is a game played on ice using specific equipment, limiting the athletes' movement in laboratory setting would affect the tests. Thus, the advantage of this study was the field measurements.

Test conducted failed to define a general pattern for trailing the knee joint angle during the slap-shot. The study could be expanded to the "leading knee" to obtain a general result about the lower extremity during a slap shot with more cameras.

The elbow angle results for each player showed a similar pattern. Previous studies provided quantitative sets of data indicating the position and movement of the upper body during a stationary ice hockey slap-shot. It was found that, at contact the elbow was bent 140° during a stationary slap-shot (Woo, 2004). In this study,

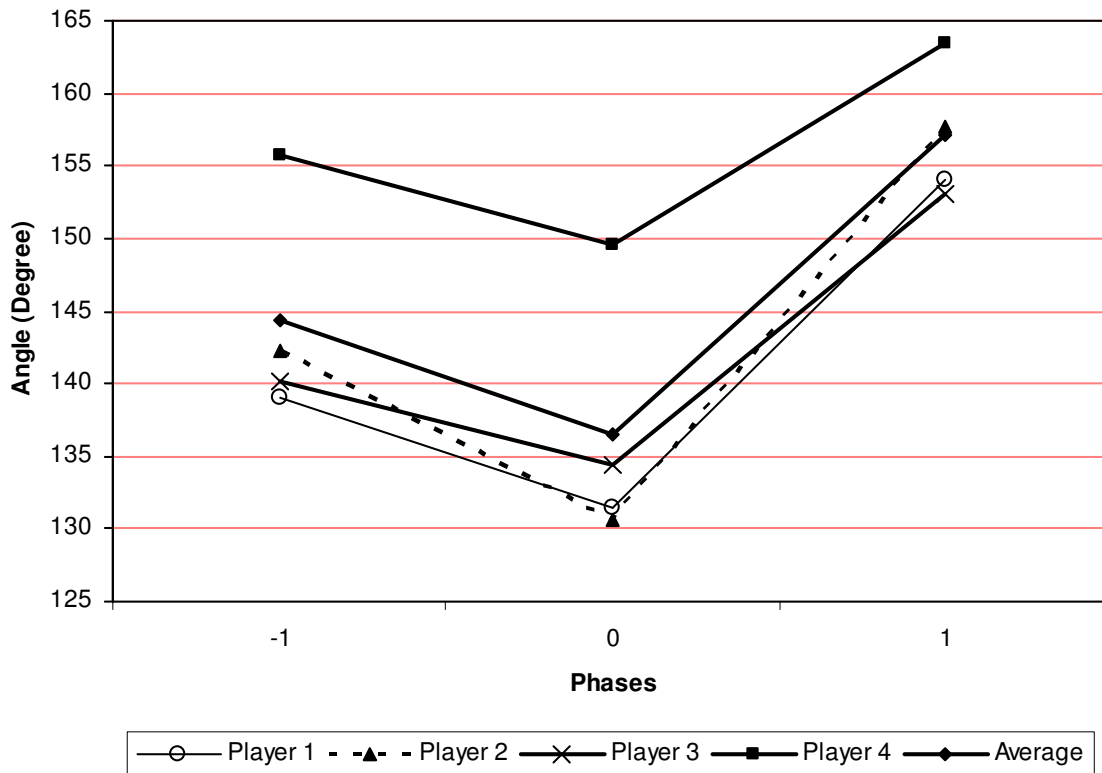


Figure 5. Elbow extension strategies of players. (-1 and 1 in phases x-axis corresponds to third frames before and after the contact point respectively, 0 phase in x-axis is contact point).

in the case of a non stationary slap-shot, it was found that the elbow angle at contact was 136.5° (sd: 8.7°) which was in line with previous studies.

In conclusion, it is managed to obtain a general description of the trail elbow but not the trail knee joint kinematics during a non-stationary slap-shot.

REFERENCES

- Ege A, Seker DZ, Tuncay I, Duran Z (2004). Photogrammetric analysis of the articular surface of the distal radius. *J. Int. Med. Res.*, 32: 406-410.
- Goktepe A, Ak E, Sogut M, Karabork H, Korkusuz F (2009). Joint angles during successful and unsuccessful tennis serves kinematics of tennis serve, *Joint Diseases and Related Surgery*, 20(3):156-160.
- Goktepe A, Karabork H, Ak E, Cicek S, Korkusuz F (2008) Kinematic Analysis Of Penalty Kick In Soccer, *Selcuk University J. Eng. Architecture* 23(3): 45-49.
- Karabork H (2009). Three-Dimensional Measurements of Glenohumeral Joint Surfaces in Sheep, Cat and Rabbit by Photogrammetry, *J. Anim. Vet. Adv.*, 8(7): 1248-1251.
- Kraus K (1993). Photogrammetry, WB Druck, Germany, 1: 397.
- Montgomery DL, Nobes K, Pearsall DJ, Turcotte RA (2004). Task analysis (hitting, shooting, passing, and skating) of professional ice hockey players, in D.J. Pearsall & A.B. Ashare (Eds) *Safety in Ice Hockey*, ASTM STP 1446. 4th ed. American Society for Testing & Materials. West Conshohocken, PA, USA.
- Pearsall DJ, Montgomery DL, Rothsching N, Turcotte RA (1999). The influence of stick stiffness on the performance of ice hockey slap shots. *Sports Eng.*, 2: 3-11.
- Pesci A, Fabris M, Conforti D, Loddo F, Baldi P, Anzidei M (2007). Integration of ground-based laser scanner and aerial digital photogrammetry for topographic modelling of Vesuvio volcano, *J. Volcanol. Geotherm. Res.*, 162: 123-138.
- Villasenor A, Turcotte RA, Pearsall DJ (2006). Recoil effect of the ice hockey stick during a slap shot. *J. Appl. Biomech.*, 22: 202-211.
- Woo TK (2004). Three Dimensional Kinematic Analyses of the Stationary Ice Hockey Slap Shot: Elite versus Recreational. M. Sc. Thesis, McGill University, Montreal, Canada.
- Worobets JT, Fairbairn JC, Stefanyshyn DJ (2006). The influence of shaft stiffness on potential energy and puck speed during wrist and slap shots in ice hockey. *Sports Eng.*, 9: 191-200.
- Wu TC, Pearsall D, Hodges A, Turcotte R, Lefebvre R, Montgomery D, Bateni H (2003). The performance of the ice hockey slap and wrist shots: the effects of stick construction and player skill. *Sports Eng.*, 6: 31-40.
- Yagisan N, Karabork H, Goktepe A, Karalezli N (2009). Evaluation of Three-Dimensional Motion Analysis of the Upper Right Limb Movements in the Bowing Arm of Violinists Through a Digital Photogrammetric Method, *Med. Problems Performing* 24(4): 181-184.
- Yilmaz HM, Yakar M, Gulec SA, Dulgerler ON (2007). Importance of Digital Close Range Photogrammetry in Documentation of Cultural Heritages. *J. Cult. Heritages* 8(4): 428-433.