Rodriguez, F. A. (1991). Valoracion funcional del jugador de hockey sobre patines. *Apunts: Educacio Fisica I Esports,* 23, 51-62.

THE PERFORMANCE OF THE ICE HOCKEY SLAP SHOT: THE EFFECTS TO STICK CONSTRUCTION AND PLAYER SKILL

D.Pearsall[1,2], A.Hodges[1], T-C. Wu[1], R.Turcotte[1], R.Lefebvre[3], D.Montgomery[1], H.Bateni[2]
[1]Department of Physical Education, [2]School of Physical & Occupational Therapy, McGill University, Montréal, Québec, Canada
[3]Bauer-Nike Hockey Inc., St.Jerome, QC, Canada

The purpose of this study was to examine the interaction of players' skill level, body strength, and sticks of various construction and stiffness on the performance of the slap shot in ice hockey. Twenty male players were tested: ten skilled, and ten unskilled. Each subject performed three slap shots with three sticks of different construction and shaft stiffness. Ground contact forces were measured while simultaneously video recording at 480 frames/second the stick movement and bending. The results indicated that 1) puck velocity was influenced by skill level and body strength but not stick type and that 2) variability in performance measures across subjects was greater than the variability across the stick stiffness. Further studies are needed to address the specific influence body strength and skill on the slap shot.

KEY WORDS: ice hockey, slap shot, stick, bending, stiffness, body strength

INTRODUCTION: In the last few decades, ice hockey equipment has evolved substantially, including the hockey stick (Pearsall & Turcotte, 2000). A hockey stick is a fundamental implement for playing the game. Players use it for passing, stick handling, and shooting. A slap shot is a shooting technique that is commonly executed by both forwards and defensive players to generate maximum puck velocity (Fig 1). The slap shot is executed by grasping the stick with both hands 0.40 to 0.60 m apart. The stick is initially raised backwards then swung forwards with maximum effort to impact the puck upwards of 30 m/s. The puck is propelled by the blade of the stick. This movement consists of six phases: backswing, downswing, pre-loading, loading, release, and follow through (Pearsall et al, 1999).

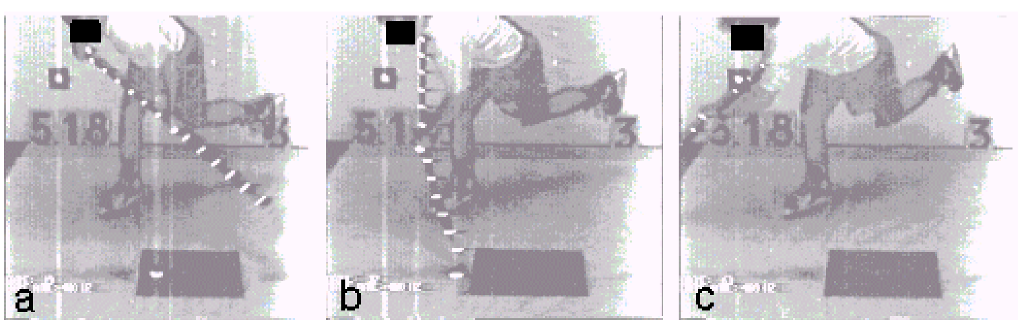

Figure 1 - Different phases of a slap shot a) downswing b) contact, and c) follow through.

Several factors are thought to influence the outcome of the shot such as skill level, body strength, stick material type, and ice surface condition. More precisely, some of the mechanical factors identified as important in shooting include: (1) velocity of the lower (distal) end of the shaft prior to contact with the ice, (2) pre-loading of the stick, (3) elastic stiffness characteristics of the stick, and (4) contact time with the puck (Doré & Roy, 1976; Hoerner, 1989, Marino, 1998)). However, the direct relationship between mechanical properties of the stick and shot performance have not been identified. This is an important issue to coaches and athletes alike. Recently, Pearsall et al (1999) found stick stiffness properties had minimal effect on shot velocity for six highly skilled players, indicating that the stick properties may not be as important for the slap shot. However, given the small, homogeneous sample, it is not possible to generalize to all player levels. Hence, the purpose of this study was to investigate the performance of the slap shot as affected by different stick types across different skill level and body strengths of the players.

METHODS: Twenty male subjects volunteered to participate in both shooting and general strength tests of this study. Ten varsity level ice hockey players were classified as the skilled group; the remaining ten subjects with recreational experience in ice hockey were grouped as unskilled. Each subject used his own gloves and skates (if appropriate) and performed the shooting task on a force platform (AMTI). In total, each subject performed three slap shots with three different constructions of stick shaft: medium, stiff, and a carbon composite with corresponding 3-point bending stiffness of 13.7, 16.6, and 17.9 kN/m, respectively. Subjects were allowed three warm up slap shots prior to each test. As well, the subjects had a thirty second rest interval and a two minute pause between stick types. The order of subjects and the types of sticks were randomized.

Each stick had nine reflective markers placed every 0.10 m. A hockey net was placed 8m away and a sports radar gun (SR 3000) was placed behind the net to record the puck velocity. In addition, a high speed camera (Redlake, 480 frames/second) recorded the movement and deflection of the stick as seen in the sagittal plane. Following the shooting test, the players also performed a general strength test consisting of 1RM bench press and a grip strength test. Subjects warmed up with a low resistance. After successful completion of one repetition, the weight was increased with a minimum of five pounds increment and the subject attempted the new weight after a brief rest. Each subject was given three chances to lift a maximal weight. Subsequently, all subjects performed a maximal grip test with a grip dynamometer. Each subject performed two grip tests with each hand, and the highest score for each hand was recorded. All the data were analyzed using APAS, Biobench, Statistica, and Excel software programs.

RESULTS AND DISUSSION: No significant difference in shot velocities between stick models was observed for both the skilled and unskilled groups (Table 1).

Table 1 Average Peak Shot Velocity for Skilled and Unskilled Groups for Stick Types

	Velocity (m/s)	SD	CV
Skilled (all)	30.0	2.5	3.8
Medium	30.6	2.6	3.8
Stiff	29.2	2.6	3.9
Composite	30.3	2.5	3.7
Unskilled (all)	23.3	3.8	7.3
Medium	23.0	3.8	7.4
Stiff	23.3	3.6	7.0
Composite	23.6	4.4	8.3

$p < 0.05$, ANOVA 2W analysis conducted

However, significant differences in peak velocity were observed between skilled and unskilled groups ($p < 0.05$), Figure 2.

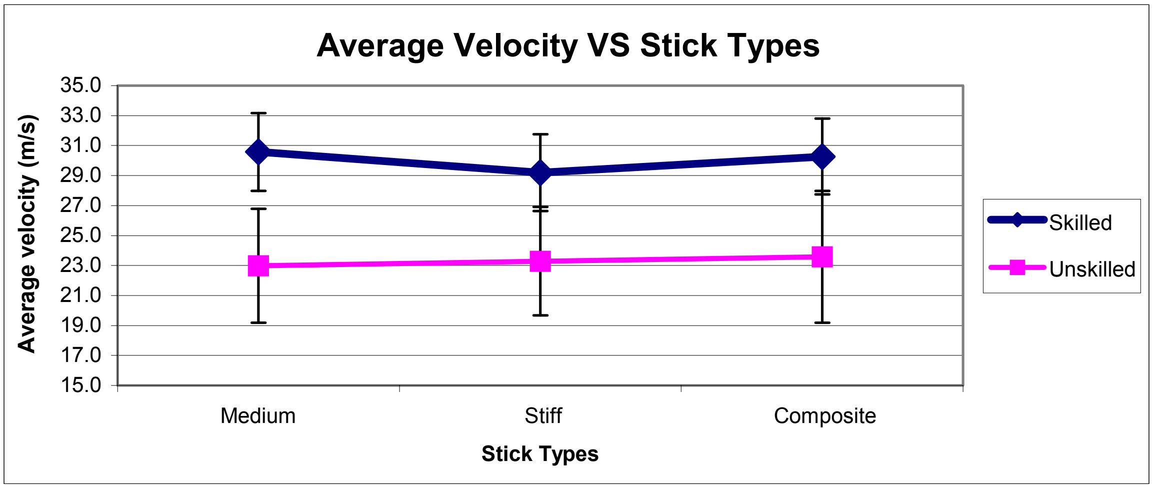

Figure 2 - Average velocity versus stick types for skilled and unskilled groups.

On average, skilled and unskilled players performed the slap shot at 30.0 m/s and 23.3 m/s, respectively. Similarly, differences in several other dependent variables including vertical force (FMAX_Z), stick bending angle (P_Theta), and deflection angle (Deflec) were found between skilled and unskilled groups ($p < 0.05$) (Table 2).

Table 2 Comparison of Strength & Stick Shot Measures for Skilled and Unskilled Groups

Variables	Mean Skilled	SD	Mean UnSkilled	SD	p
VELOCITY (kph)	30.0	2.5	23.3	3.8	0.00*
BENCH (kg)	93.0	22.3	83.0	23.7	0.11
GRIPR (kg)	59.0	11.7	59.1	8.8	0.95
GRIPL (kg)	56.3	16.5	54.6	9.2	0.64
FMAX_Z (N)	164.7	49.9	104.7	48.2	0.00*
P_THETA (degrees)	19.1	5.0	12.5	3.5	0.00*
DEFLEC (degrees)	5.7	1.5	3.7	1.0	0.00*

Statistically significant different at $P < 0.05$, MANOVA 2W

The skilled players were able to shoot the puck faster and generated more vertical force on impact ($p < 0.05$). As a result, the hockey stick bent to a greater extent and produced a greater deflection of the stick shaft. There was no difference in strength (bench and grip) between skilled and unskilled players ($p < 0.05$). However, of all the variables measured velocity most correlated to subject characteristics in height ($r = 0.67$). Weight and grip strength were somewhat correlated to the velocity ($r = 0.40$), (Table 3).
It is not possible to establish a cause effect relation between these variables and puck velocity; however, they do suggest the importance of size and strength. Individual differences were the greatest factors related to shot velocity.

Table 3 Correlation of Subject Characteristics

	VELOCITY	HEIGHT	WEIGHT	BENCH	GRIPR	GRIPL
VELOCITY	**1.00**	–	–	–	–	–
HEIGHT	0.67	**1.00**	–	–	–	–
WEIGHT	0.38	0.12	**1.00**	–	–	–
BENCH	-0.01	-0.38	0.54	**1.00**	–	–
GRIPR	0.42	0.42	0.43	0.24	**1.00**	–
GRIPL	0.41	0.48	0.38	0.14	0.88	**1.00**

CONCLUSION: The results of this study suggest that different stick properties did not affect puck velocity. It appears that the skill level was the most important factor in determining puck velocity. In addition, measures of vertical force, stick bending and deflection angles were significantly different between skilled and unskilled players. Furthermore, the player's height, weight, and grip strength variables were correlated to the velocity, particularly the height with the highest correlation. These results support the previous findings of Pearsall et al (1999). Therefore, it may well be that in order to have a faster slap shot, both shooting technique (i.e. skill) and body strength are more critical factors than the stick stiffness. More in depth studies are needed to address the importance of the physical characteristics and identify the specific motor technique of skilled shooting.

REFERENCES:

Doré, R. & Roy, B. (1976) Dynamometric analysis of different hockey shots. In: *Proceedings of the Fourth International Congress on Biomechanics*, Biomechanics, V-B, (ed. Komi P.V.), pp. 277-285.

Hoerner, E.F. (1989) The dynamic role played by the ice hockey stick. *Safety in Ice Hockey*, ASTM STP 1050, (eds Castaldi C.R. & Hoerner E.F) American Society for Testing and Materials, Philadelphia, PA, 154-163.

Marino, G.W. (1998). Biomechanical investigations of performance characteristics of various types of ice hockey sticks. *ISBS'98 Proceedings I.* 184-187.

Pearsall, D. J., & Turcotte R. (2000). *Exercise & Sport Science ed.* Garrett & Kirkendall 675-692

Pearsall, D. J., Montgomery, D. L., Rothsching, N., & Turcotte, R. A. (1999). The influence of stick stiffness on the performance of ice hockey slap shots. *Sports engineering*. 2, 3-11.

ACKNOWLEDGMENTS:

The authors would like to thank Bauer-Nike Hockey Inc. (St. Jerome, Quebec, Canada) for providing the various stick shafts and blades for testing and McGill University Redmen Ice Hockey teams. Further, the authors acknowledges Research Grant support from the National Science and Engineering Research Council (NSERC) of Canada