STATIC AND DYNAMIC CHARACTERISTICS OF ALUMINUM VERSUS WOODEN HOCKEY STICKS

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INTRODUCTION

In view of the fact that aluminum shaft hockey sticks are becoming ever more popular among both professional and amateur ice hockey players, investigation of the specific safety and performance characteristics of these types of stick is warranted. The purpose of the study, therefore, was to investigate the differences between aluminum and wooden/woodfibreglass ice hockey sticks. Specifically, static testing was used to measure stick dimensions and inertial properties as well as the bending characteristics of sticks under external loads applied at various locations. In addition, both velocity and accuracy of shooting using aluminum and "wood" sticks was measured in onice testing of skilled hockey players.

METHODS

The independent variable in this study was the type of shaft used to construct hockey sticks. Seventytwo (72) professional quality wooden/woodfibreglass sticks and ten (10) aluminum shaft sticks were evaluated. Measures were taken of several static characteristics and each stick was used in on-ice tests of shooting velocity and accuracy. The dependent variables measured, listed below, comprised both static, structural characteristics and dynamic performance characteristics:

- WEIGHT
- LENGTH
- CENTRE OF MASS
- CENTRE OF MASS AS A PERCENTAGE OF STANDING HEIGHT
- SHAFT FLEXIBILITY
- COEFFICIENT OF RIGIDITY
- SHEAR FORCE TOLERANCE LIMITS
- SHEAR FORCE TOLERANCE LIMITS OF THE SHAFT SUPPORTED IN TWO LOCATIONS
- ON-ICE PERFORMANCE

RESULTS

The mean weights, lengths and centre of mass locations of the sticks tested are listed in Table 1. There were no statistically significant differences between the wood and aluminum sticks in either weight or length. However, the aluminum sticks, on average, were slightly lighter. This indicates that it is possible to design and manufacture a stick with less weight than the traditional wooden stick. This is particularly true in as much as one brand of aluminum stick was found to be very light (about 550 g) compared to most of the others. No significant differences existed between wood and aluminum sticks with respect to the location of the centre of mass of the stick. In all cases it fell approximately 47 % of the way from the toe of the stick to the end of the shaft. The balance and "feel" of the stick should be approximately the same, therefore, for both wood and aluminum models.

Table 1

Weights, Lengths and Centre of Mass of Wood/Wood-fibre and Aluminum Hockey Sticks

Stick	Weight (g)	Length (cm)	C.of M. % •
Wood (n = 72)	660.5 (27.1)	164.3 (.47)	47.3
Aluminum (n = 10)	602.9 (17.9)	167.2 (.28)	'46.8

• Taken from the toe of the stick

Table 2

Shaft Flexibility and Coefficient of Rigidity of Wood/Wood-fibre and Aluminum Hockey Sticks

Stick	Flexibility (cm)	Rigidity (n/cm)	
	End Clamp Force at C. of M.	End Clamp Force at Heel	
Wood (n = 72)	5.32	16.6	30.07
Aluminum (n = 10)	5.43	16.5	29.50

Shaft flexibility and coefficient of rigidity values are presented in Table **2.** No statistically significant differences occurred in either flexibility of the shaft or coefficient of rigidity. The data in Table 2 reveals that when a stick is clamped at the end and subjected to a force at its' centre of mass, approximately 30 newtons of force is required to produce a one centimetre deviation of the shaft for both wood and aluminum hockey sticks. Therefore, each type of shaft should respond in a similar manner when subjected to forces during the shooting of a puck. The nature of the game of hockey is such that the stick shaft occasionally fractures. Apart from the performançe aspects and the strategic disadvantage of having to secure another stick during the course of play, there are obvious safety concerns associated with broken sticks. Table **3** presents a summary of tests done on the force tolerance of hockey stick shafts under conditions where the shaft was clamped and then subjected to a shear force along the shaft at a predetermined location away from the clamped section. Although the aluminum shaft sticks consistently revealed higher force tolerance limits prior to fracture of the shaft, the differences were not statistically significant.

Table 3

Force Tolerance of the Shaft to Forces at the Centre of Mass and the Heel of the Stick

Stick	Maximum Force Tolerance (n)	
	End Clamp C. of M. Force	C. of M. Clamp Force at Heel
Wood (n = 72)	396.5 (48.4)	556.8 (57.6)
Aluminum (n = 10)	543.0 (39.2)	623.6 (44.8)

Although the strength factor would tend to make aluminum sticks somewhat more durable, they still must fall in the same range as wooden sticks because under certain circumstances in the game of hockey it is necessary for the shaft of the stick to break to ensure the safety of both the user and opponent. A second test of shaft strength or force tolerance included the application of a shear force in the centre of the shaft of a stick supported at two locations 76.2 cm apart. The results of this test are listed in Table 4. It is apparent-that aluminum shafts tolerate slightly higher shear forces when clamped in two locations. However, due to the relatively large variability particularly among wooden sticks, the between group differences are not statistically significant.

Ten highly skilled hockey players were assigned both wooden and aluminum sticks and were allowed to practice with them until they felt comfortable in their use. They were then required to complete 5 slap shots with each of the sticks in their possession. The mean values of the slap shots using both wood and aluminum sticks are listed in Table 5.

As is evident from the results of the slap shot test, there is no significant difference in the performance level of skilled players using wooden versus aluminum hockey sticks.

CONCLUSIONS

Eighty-two professional quality hockey sticks were evaluated in a battery of tests designed to look at the static characteristics of the stick shafts as well as onice shooting performance of skilled players using the sticks. Seventy-two of the sticks were more traditional wood/wood-fibreglass models and ten were recently developed aluminum shaft models. The study was carried out to ascertain the differences between wood and. aluminum sticks. No statistically significant differences were found between the two samples although several differences were noted between brand names in each sample. It would appear that aluminum sticks would not provide a significant performance advantage nor a significantly greater safety risk in comparison to wooden shafted sticks. The "feel" of the stick will likely to continue to be the determining factor in stick selection by skilled players in the game of ice hockey. Looking at the variability in the data particularly between brand names in each sample of sticks, it would appear that future developments could include the development or even lighter aluminum sticks with similar strength and rigidity characteristics as traditional wood sticks. This might facilitate ease of handling without an appreciable decrement in shooting performance.

Table 4

Shear Force Limits of the Shaft Supported at Two Locations 76.2 cm Apart

Stick	Fracture Force (n)
Wood (n = 72)	1835.3 (278.8)
Aluminum (n = 10)	2049.1 (174.5)

Table 5

Shooting Velocity of Slap Shots Using Both Wood and Aluminum Hockey Sticks

Stick	Slap Shot Velocity (kph)
Wood (n = 72)	104.84 (10.36)
Aluminum (n = 10)	107.17 (11.56)

In summary, although several significant differences in weight and flexibility were found within each of the wooden and aluminum samples, no significant differences were found between wooden and aluminum sticks in any or the flexibility/rigidity tests or in the slap shot velocity test. Within the limitations of this study it would seem that the following conclusions are warranted:

1 - Aluminum hockey sticks are somewhat lighter than wooden sticks with some brands being significantly lighter.

2 - There is no significant difference in the coefficient of rigidity of aluminum versus wooden hockey sticks.

3 - Aluminum hockey sticks tolerate somewhat higher shear forces than wooden sticks at all locations tested.

4 - There is no significant difference in slap shot velocity when using aluminum versus wooden hockey sticks.

5 - However, it would appear that aluminum hockey sticks would not produce any significant performance advantage nor any significantly larger safety risk when compared to sticks with other types.