PLANTAR FORCE MEASURES DURING FORWARD SKATING IN ICE HOCKEY

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The purpose of this project was to measure plantar pressure patterns during forward skating with ice hockey skates. Six elite ice hockey inter-university players volunteered to participate in the study. There was no significant change in push off force with velocity, but there was a decrease in contact time with increasing velocity. Given the decreased impulse with increasing speed, the increase in propulsion was the result of increasing stride rate. Comparison between anterior and posterior plantar regions as well as the medial and lateral regions revealed proportional loading changes with different speeds.

KEY WORDS: skates, ice hockey, plantar pressures, impulse, stride rate

INTRODUCTION: The purpose of this study was to measure plantar pressure patterns during forward skating with ice hockey skates. Three velocities were measured (slow, medium and fast velocities), and their pressure patterns were recorded. Currently there is limited data on pressure patterns under such conditions. This study provides an opportunity to document one kinetic aspect of ice hockey skating skills during on-ice conditions.

METHODS: Six elite ice hockey inter-university players volunteered to participate in the study (Table 1). Each player skated forward at slow, medium, and fast velocities with pressure sensors (Tekscan™) placed on the insole of the skate of each skater. The sensors were cut to conform to the shape of the insole used by each skater (Fig 1a). Sensors were attached to cuffs fastened around the lower leg of the skater (Fig 1b). Eighteen-meter cables were connected to a Pentium PC with F-Scan software for recording pressures generated by the skater during the execution of each skill. Calibration protocols of sensors similar to those described by Fewster et al. (1998) were adopted. After a parallel cross over start, the player accelerated forward between the blue lines (approximately 24 m) with steady state speed reached during the 4^{th} or 5^{th} strides. Each player repeated the skating task three times. In the present study the sensors' areas were examined as a whole and in six discrete regions of the foot (Fig 2). These areas included: the anterior foot (A, including the toes), the medial anterior (MA, including the head of 1^{st} metatarsal), the lateral anterior (LA), the mid foot (MF), the medial posterior (MP) heel, and the lateral posterior heel (LP) regions. For this report, only four regions will be discussed. These regions were defined by grouping the regions into four areas; anterior, posterior, medial, and lateral. The anterior area included the sum of the A, MA, LA regions, and the posterior region the MP and the LP regions. The medial area was calculated as the sum of the MA and MP regions, and the later region was calculated as the sum of the LA and LP regions.

Table 1 General Subject Descriptors

Mean mass (kg) ± SD	Mean Height (cm) ± SD
83.0 ± 12.1	178.2 ± 6.3

Figure 1 - The top (a), side (b) and rear (c) views of the sensor placement during testing.

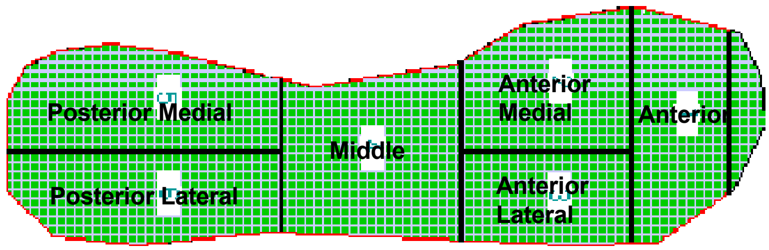

Figure 2 - Regions of the foot.

RESULTS AND DISCUSSION: Figures 3 and 4 show the average plantar force-time measures of the right foot for one stride from heel strike to heel strike. In general, the total force rose quickly to an initial plateau (i.e. gliding phase) before rising to a peak force (i.e. toe off). A decrease in the plateau duration was seen as speed increased (Fig 3 a-c). These results are consistent with observation made by Marino (1977) showing a decrease in gliding time with velocity. All peak forces were similar within one standard deviation regardless of the speed of skating (Table 2). However, the contact time decreased with increasing velocity, yielding lower impulse generation per stride. Thus, the increases in velocity were a direct result of increases in stride frequency. These were similar to finding reported by Eils et al. (1998) during inline skating.

Table 2 Summary of Average Stride Measures

Velocity	Stride Frequency (strides/s)	Peak Push Off Force (N) ± SD	Contact time (sec/stride) ± SD	Impulse (Ns)
Slow	0.9	896.3 ± 136.0	1.11	387.2
Medium	1.3	981.1 ± 118.4	0.77	272.1
Fast	1.7	1000.2 ± 140.1	0.60	204.1

Figure 3 (a-c) compares the anterior and posterior portions of the foot at the three speeds. The posterior foot showed a greater overall force from heel-strike to toe off, which is concurrent with the predominantly dorsiflexed ankle position throughout the support phase (Pearsall et al. 2001). Forces were shown to shift from posterior to anterior coinciding with the heel strike to toe off support phases. The anterior foot showed a greater peak force at higher speeds. However, this did not lead to a greater impulse generation because the posterior foot peaked sooner at higher speeds, resulting in less force at toe-off.

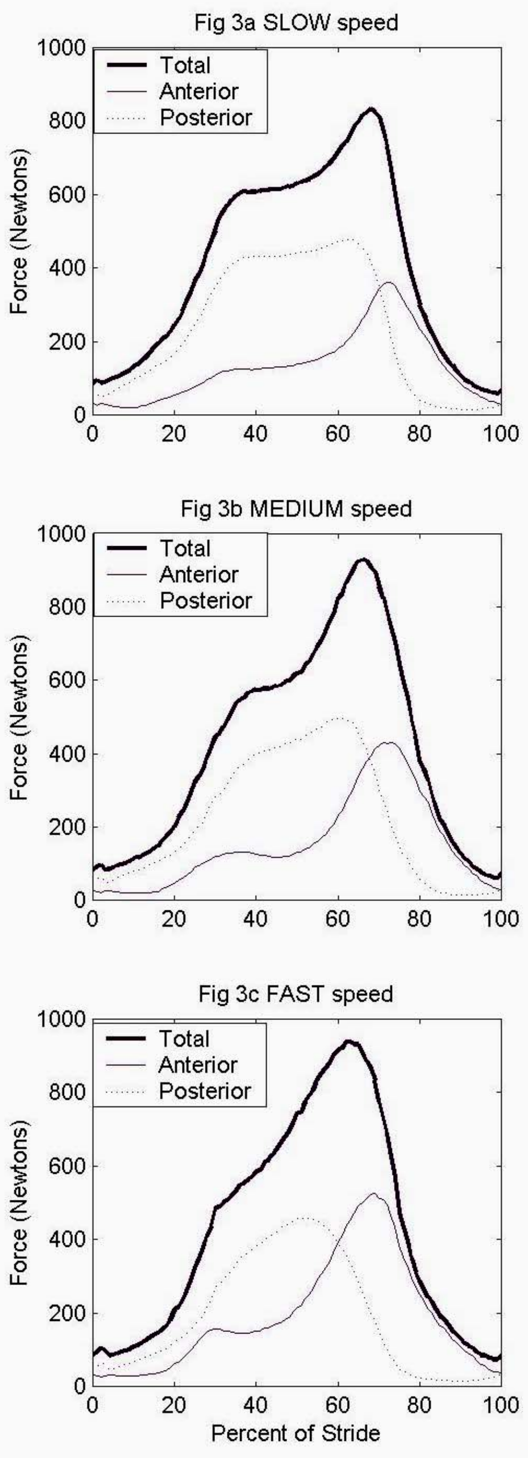

Figure 3 - Comparison of forces measured in the anterior and posterior regions of the foot during slow (a), medium (b) and fast (c) forward skating.

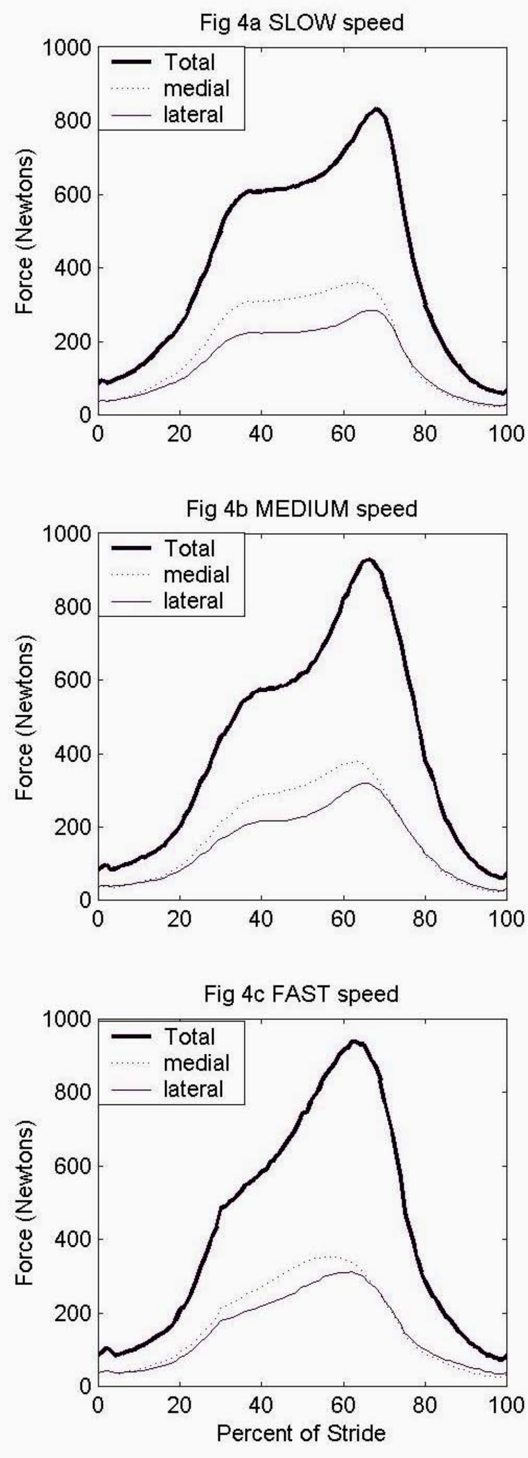

Figure 4 - Comparison of forces measured in the medial and lateral regions of the foot during slow (a), medium (b) and fast (c) forward skating.

Figure 4 (a-c) compares the medial and lateral foot forces experienced. During the entire support phase, the medial foot showed either a greater or equal force when compared to the lateral side of the foot. This difference was most evident during the middle support phase. The larger medial force may be related to the predominant ankle eversion during skating support.

CONCLUSION: The examination of the total foot force showed decreased impulse and glide time with increases in velocity. The ability to study the forces in different regions on the foot gives rise to questions about the relationship between plantar pressure and kinematics. Thus further study is necessary to link the kinetics to the kinematics of ice hockey skating as well as the need to examine the mechanics of many other foundation skating skills in ice hockey.

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