ANKLE KINEMATICS DURING FORWARD HOCKEY SKATING: ACCELERATION TO CONSTANT VELOCITY

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Kinematic measures of the foot and ankle are of relevance to footwear manufacturers and to rehabilitative professionals. Difficulties undertaking such measurements have been summarized previously (Milani & Hennig, 2000). This paper presents the kinematic profile of the ankle in both sagittal (plantar dorsi) and frontal (inversion eversion) planes. Penny & Giles electrogoniometers (Blackwood, UK / Biometrics Ltd.) collected data from 5 elite subjects at 1000 Hz. Similar kinematic profiles were observed between 3 accelerating strides and constant velocity strides. Despite the absence of significant differences between strides there was a trend for increased range of motion at the ankle as the skaters accelerated to a high velocity.

KEYWORDS: ice hockey, ankle, kinematics, goniometer.

INTRODUCTION: In athletics, ankle kinematics are quite pertinent to performance. It is believed that during movement and dynamic balance, humans sometimes behave as an inverted pendulum and ankle proprioception is critical to the establishment of an internal reference, allowing stabilization of the body with respect to an external gravitational reference. In addition, knowledge of the ankle motion predominantly produced during hockey skating has relevance in establishing rehabilitative regimes for recovering ice hockey players. This paper presents the kinematic results obtained from five elite varsity level ice hockey players during three acceleration strides and at constant velocity skating. Given the reported inaccuracies of kinematic analysis using current filming techniques compared to goniometric measurements (Milani & Hennig, 2000), and due to the high volume necessity goniometry, the best practical method available to measure ankle kinematics during hockey skating, goniometric data were collected.

METHODS: A total of 5 subjects participated in the study. All of the subjects were varsity hockey players from McGill University. Goniometric signals measured kinematic parameters of the right ankle; the device was placed on the posterior aspect of the leg and foot, along the long axis of the Achilles tendon. Height of the placement was adjusted so that the approximately the lower third portion of the lower end block was placed at the height of the calcaneal tuberosity. The goniometers were secured to the subjects with athletic tape. All subjects skated in the same skate model, the Bauer Vapor XX. The raw signals were recorded at 1000 Hz and the data were stored on a portable data logger (Multi Signal System ME3000P8; Mega Electronics, Finland). The stored data were subsequently downloaded onto a PC via a serial port connection. Before skating trials were conducted subjects remained in a standing 'neutral' position to identify a reference position. See figure 1 for a schematic of the steps involved in data collection and data processing.

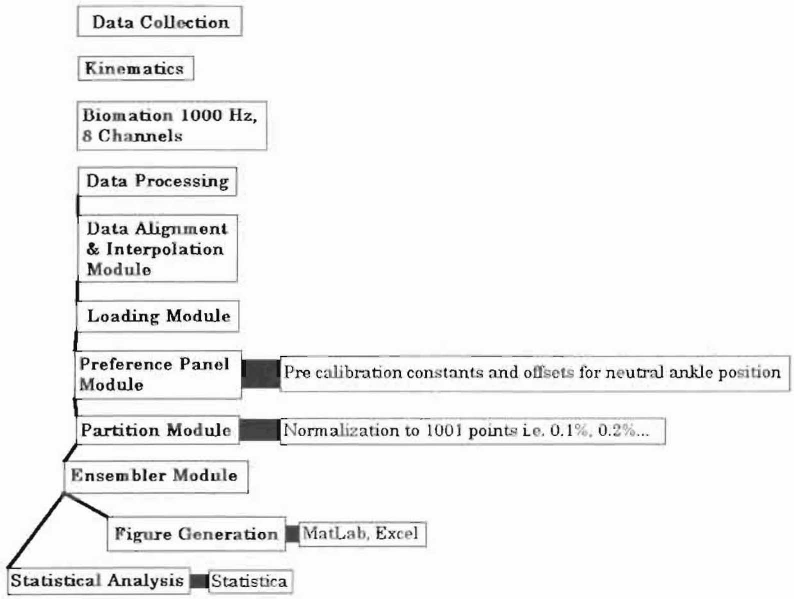

Figure 1: A flow chart of the data collection and data processing steps performed.

RESULTS: The following figures (2 - 4) depict ankle kinematics during accelerating and constant velocity strides. From the first step during acceleration to constant skating velocity, plantar flexion was observed to increase while the eversion-inversion motion shifted downward.

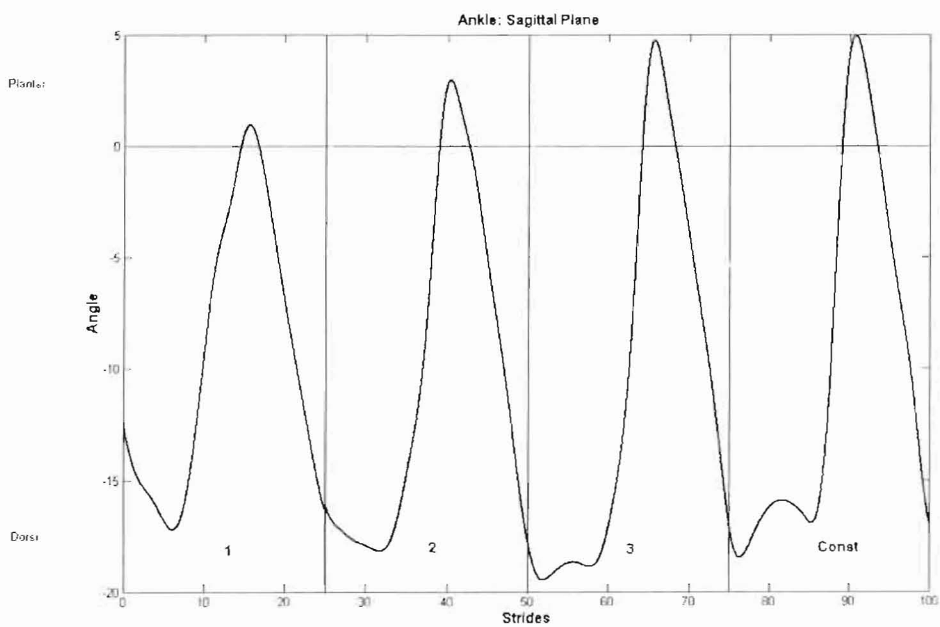

Figure 2: The sagittal plane ankle kinematics through successive acceleration strides (1, 2, 3) and at constant velocity (Const).

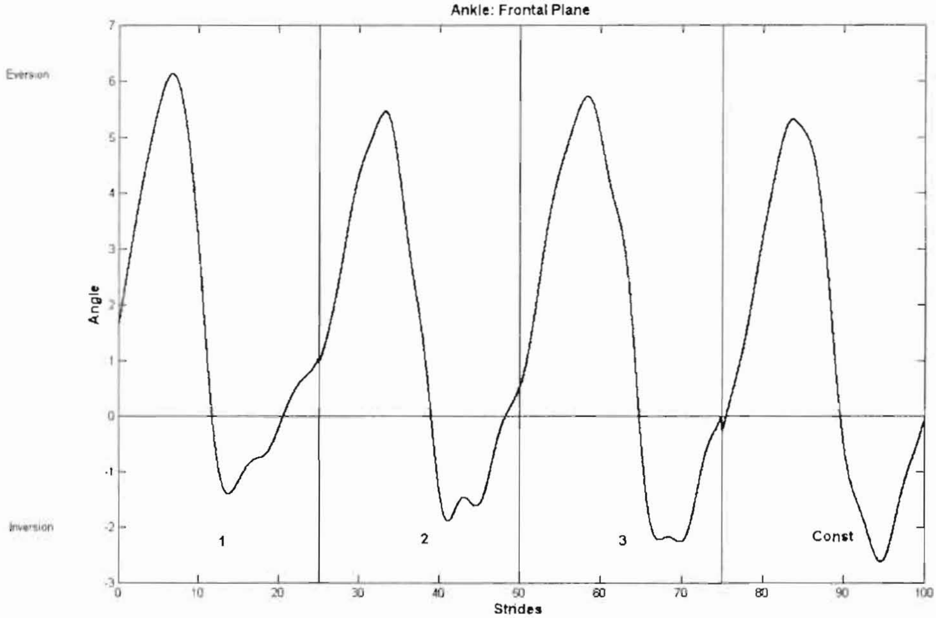

Figure 3: The frontal plane ankle kinematics through successive acceleration strides (1, 2, 3) and at constant velocity (Const).

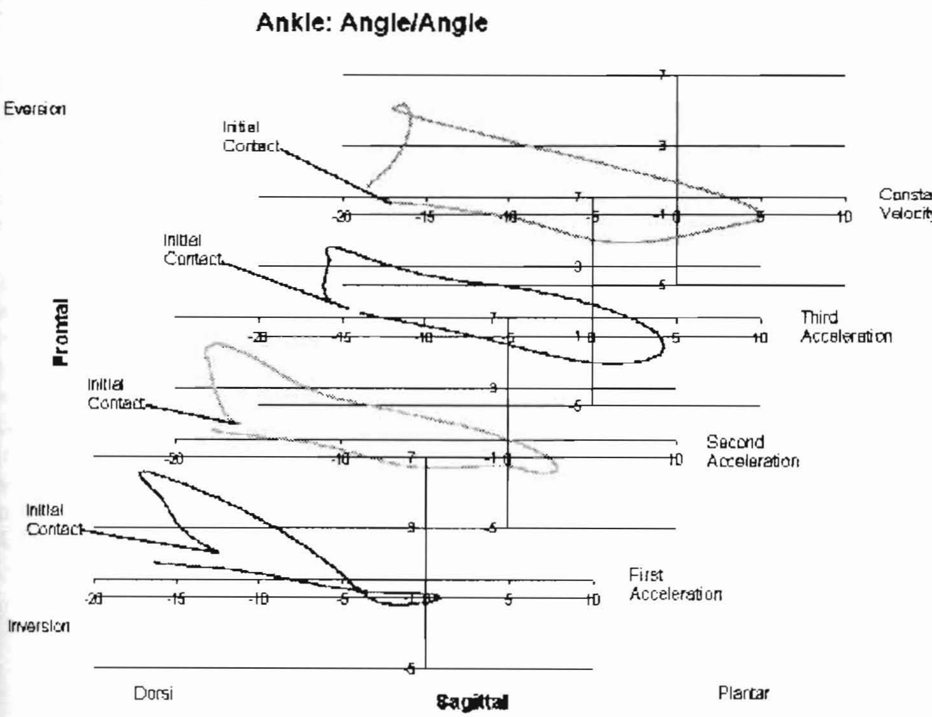

Figure 4: An angle/angle graph showing the coupled motions of ankle plantar-dorsi flexion with ankle inversion-eversion of successive acceleration strides (1, 2, 3) and at constant velocity (Const). The grey shaded regions depict the end of foot contact and the beginning of swing.

DISCUSSION: Sagittal and frontal plane ankle kinematic data were similar in that there were no extreme variations between strides. There was a trend for the ankle in invert more through strides A1 - A3, and Const. The occurrence of peak ankle inversion was during the swing phase of stride and as such mirrored ankle plantar flexion. Due to the coupling actions of ankle plantar flexion and inversion this finding is not surprising.
The eversion data of the ankle showed no significant differences between strides and revealed that the ankle was near maximally everted at the time of push-off. These data are consistent with the results of Chang et al. (2002) and Hoshizaki et al. (1989). The swing phase data were relatively consistent, however, the differences show the stride to stride complexity in the task requirements of the prime movers of the ankle muscles during this seemingly simple transition. The measurement of ankle eversion is especially revealing in the ice hockey context. Due to the torsional rigidity of the foot bed of the ice hockey skate, the relative subject specific movement of the forefoot and rearfoot needs to be addressed. Further investigation should evaluate the extent of coupled calcaneal inversion/eversion with external/internal rotation of the tibia. As well, the effect of anthropometric factors such as the height of plantar arch of the foot and the stiffness property of the arch on rearfoot movement needs to be studied.

CONCLUSION: The data reported in this paper outline the range of motion observed at the ankle during forward skating in ice hockey. Kinematic profiles were shown to be altered from acceleration to constant velocity. Though not statistically significant, plantar flexion was observed to increase while the eversion-inversion motion shifted downward.

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