MOTION OF THE FOOT INSIDE A HOCKEY SKATE: AS MEASURED FROM BONE, SKIN, AND BOOT MARKERS

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INTRODUCTION

In filming and digitizing human segmental motion, external markers do not necessarily represent a true picture of the actual bone movement. When surface markers are placed on the skin or skate boot (in ice hockey) they move according to skin or boot movement, which does not exactly match bone movement. This results in a greater margin of error in motion measurement and analysis. Variability amongst bone, skin, and shoe markers has been identified in the literature. Markers placed on the shoe tend to overestimate tibiocalcaneal rotations[1]. However, in the case of the skate boot, the restriction of the foot movement is greater than in the shoes, which introduces a variable with unknown influence on the nature of the motion and cannot be considered identical to the shoe. The present study aims at exploring the relationship between motion measured by bone and skin markers and motion measured by skate-boot surface markers.

MATERIALS AND METHODS

Three holes were made in a right hockey skate above the tarsal bones, and three lead markers were attached to the tops of plastic screws which were fixed to a piece of thermoplastic moulded to the skin below the holes. The lead markers protruded from the skate. Three other lead markers were attached to the skate boot. The foot inside the skate was x-rayed within a calibration cage with lead markers impeded in two of its sides and a mobile platform for different positions of the foot in the middle. Two shots with 30^{o} angle between them were taken of the foot in three different positions; full dorsiflexion, neutral, and full plantar flexion with eversion. Three bony landmarks were established on the tarsus in each image. The lead markers and the three bony landmarks were digitized using APAS. Distances between pairs of markers (bone-skate, bone-skin, skin-skate, and skate-skate) were established in each position in order to examine whether the markers on the skate provide an accurate representation of the bonny segment of the foot.

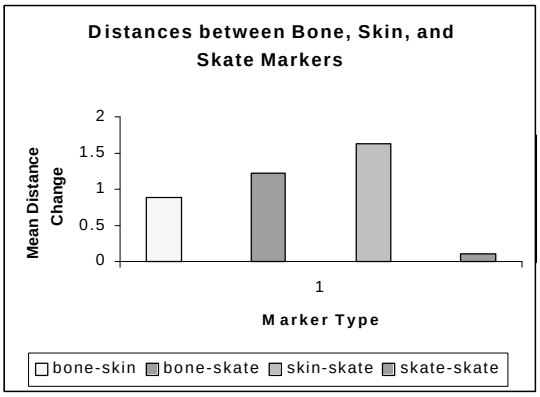
RESULTS

As the Coefficient of Variation ((std/mean)*100) calculations show in table 1, the distances between bone-skin (B#S#), bone-skate (B#ST#), skin-skate (S#ST#) markers varied up to 10%, 20%, and 24% more than the skate-skate (ST#ST#) markers. Standard deviations of 0.82, 1.22 and 1.32 were observed in bone-skin, bone-skate and skin-skate marker distances respectively. As for the skate-skate marker distances, the highest STD was 0.08. Average differences between minimum and maximum values of distances for each set of markers is shown in figure 1. The average difference in distance was 0.88 cm for bone-skin, 1.21 cm for bone-skate, and 1.62 cm for skin-skate. However, the average difference for skate-skate distance was 0.11 cm.

Table 1. Coefficients of Variation for distances between markers.

Markers	Mean Distance	STD	CV%
B1S1	6.70	0.13	2.0%
B2S2	6.90	0.37	5.3%
B3S3	7.83	0.82	10.5%
B1ST1	7.05	0.36	5.2%
B2ST2	7.80	0.38	4.9%
B3ST3	5.85	1.22	20.9%
S1ST1	9.55	0.86	9.0%
S2ST2	4.77	0.49	10.4%
S3ST3	5.43	1.32	24.5%
ST1ST2	5.34	0.05	0.99%
ST2ST3	5.24	0.08	1.54%
ST3ST1	9.77	0.03	0.36%

Figure 1. Marker distances



DISCUSSION AND CONCLUSION

The change in the distance between bone and skate markers indicates a difference between the motion calculated from the skate markers and the actual foot motion as represented by the bony segments. There is also a difference between motions calculated from skate and skin markers. The distances between the skate markers were used as a validation for the method, since they are supposed to be constant. The results of this study support the notion that three-dimensional reconstruction of motion during skating based on external markers should be interpreted carefully with allowance to the fact that this is not the accurate representation of the real motion.

REFERENCES

[1] Reinschmidt, C, van den Bogert, AJ, et al. (1997). *Tibiofemoral and tibiocalcaneal motion during walking: external vs. skeletal markers.* Gait and Posture 6: 98-109.