ISB 2013 BRAZIL
24th CONGRESS OF THE INTERNATIONAL SOCIETY OF BIOMECHANICS

EFFECTIVENESS OF CUSTOM-MADE ORTHOSES IN IMPROVING BALANCE AMONG FIGURE ICE-SKATERS

[1]Rachel Baisch, [2]Gurtej Singh Grewal, [1]Stephanie Wu, [1]Beth Jarrett, [3]R. Neil Humble and [2]Bijan Najafi
[1]Center for lower extremity ambulatory research
W.M. Scholl College of Podiatric Medicine at Rosalind Franklin University of Medicine and Science, N. Chicago, IL.
[2]interdisciplinary Consortium on Advanced Motion Performance (iCAMP)
University of Arizona, College of Medicine, Tucson, AZ.
[3]Division of podiatric surgery, Department of surgery, University of Calgary, Calgary, Alberta.
Email: bnajafi@surgery.arizona.edu Web: www.surgery.arizona.edu/icamp

SUMMARY
Improvements in balance among ice skaters can play a significant role in their performance as well as reducing the chance of injury. No study to our knowledge has explored the effect of custom foot orthoses on static balance and joint range of motion during gliding in an actual ice skating rink. Using body worn sensors, we assessed postural control changes by recruiting 9 advanced figure skaters from Chicago, IL. Significant improvements in static postural control were observed from use of Orthoses based on reductions in ankle sway (66%, $p<0.05$). On the same note, center of mass sway was reduced by 51.5% ($p=0.09$) after wearing orthoses. Use of orthoses also revealed noticeable reductions of 12.8% ($p=0.24$) in ankle joint range of motion (ROM) in medial lateral (ML) direction and knee joint internal external rotation by 25.6% ($p=0.13$) during actual skating condition (Gliding). The results demonstrate that use of custom-made orthoses may improve stability by reducing knee joint internal-external rotation and ankle joint medial-lateral range. This in turn may reduce the risk of injury during skating. Further study is required to validate the above observation in a larger sample size.

INTRODUCTION
A heightened focus on off-ice balance training in figure skaters suggests that there is an advantage in improving postural control for performance enhancement [1-4]. Kinetic and kinematic studies have exemplified improved postural stability upon the use of orthoses during walking and running [5]. To our knowledge, there is no study exploring the benefit of orthoses in improving stability and balance in figure skaters and in the field. We hypothesize that use of custom-made orthoses will improve postural control during on ice measurements. This study will be the first in the field to implement body-worn sensors to examine postural control and center of mass sway in figure skaters to explore the potential benefits of custom skate Orthoses.

METHODS
The current study implemented state-of-the-art wearable sensors for data acquisition (Biosensics, LLC, Cambridge, USA). The sensors were attached to different body segments as shown in Figure 1(a). The sensors transmit data using an ad-hoc wireless connection at 100Hz, making them suitable for out of laboratory measurements. One sensor was attached to the shoe, one to shank; one to thigh and one to the lower back. Orthoses were custom designed and fabricated for each participant (College of Podiatric Medicine at Rosalind Franklin University of Medicine & Science and Division of Podiatric Surgery at University of Calgary). Nine advanced figure skaters were recruited. In order to assess the effectiveness of orthoses in an actual ice skating rink, static measurements on ice and dynamic measurements during actual gliding were assessed at baseline without orthoses and six week after the participants were accustomed to the custom-made orthoses. During static balance measurements participant stood on their dominant foot in single stance and during dynamic measurements participants glided in an S-shape pattern on dominant foot. Standing balance was quantified by measuring the ankle sway, hip sway and center of mass (COM) sway [6]. Dynamic balance was quantified by measuring the ankle and knee joint range of motion (ROM) during gliding. All the measurements were performed in the ice skating rink.

Figure 1: (a) Casting of orthoses for fabrication. (b) Mounting of wireless wearable sensors on different body segments in order to collect data during balance and gliding trials.

RESULTS AND DISCUSSION
Two out of nine participants could not complete the study; therefore data from only 7 participants was available for analysis. The mean age and height of participants was 37.7±18.6 and 163.3cm±4.3, respectively. Wilcoxon signed-rank test was used to compare baseline and follow up data, with significance set to $p<0.05$. ANOVA test revealed that

age did not have significant effect on any of the above mentioned parameters (p>0.22).
Balance assessment revealed that orthoses had a significant role in reducing sway of ankle joint (p=0.04, 2-tailed, 66%). Notable reductions in sway of hip joints and COM (p=0.09, 2-tailed, 51.5%) were also observed.

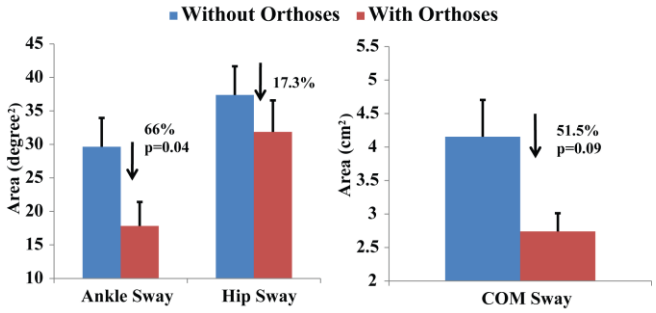

Figure 2: Reductions in ankle sway, hip sway and COM sway from use of custom-made orthoses.

A trend of improvements in balance is observed by use of orthoses. Performing a single-tailed test revealed significant changes for both ankle joint and COM sway (p<0.05).

During comparison of gliding trials between baseline and follow-up, it was observed that by wearing custom orthoses participants were able to reduce the ankle joint range of motion in ML direction by 12.8%, and still able to increase knee joint ROM by 21.4% in the same direction, Figure 3. The reduction of ankle joint range however was not significant (p=0.24).

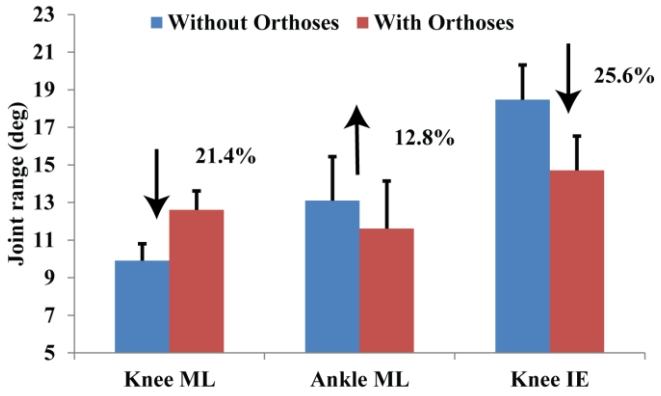

Figure 3: Changes in range of motion for knee and ankle joint. (ML-medial-lateral; IE-internal external rotation)

Orthoses also helped decrease range of knee joint internal-external rotation by 25.6% (p=0.13). The ankle and knee joint flexion-extension was also increase from use of orthoses by around 20.8% and 20.9% respectively.

Results from both balance and gliding measurement suggest that use of custom-made orthoses does improve postural control. The participants have better stability of ankle joint as suggested by reduced sway of both ankle and COM as well as reduced medial-lateral movement range of ankle joint. Orthoses also seem to stabilize the knee joint by reducing internal-external rotation range, all the while increasing flexion-extension range of both ankle and knee joint.

CONCLUSIONS

The current is the first study to assess the effect of custom-made orthoses on changes in static balance and joint range of motion during gliding on ice skating ring. State-of-the-art wearable sensors were used to collect three-dimensional kinematic data from different body segments to estimate ankle and knee joint stability. The results so far suggest improvements as hypothesized, however results were limited by the number of participants recruited. Further studies with larger sample size should be conducted to explore the effect of orthoses in figure skating athletes.

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