Ankle Injury Prevention in Ballet Through Altered Pointe Shoe Ribbons

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Background

- Ballet combines athleticism and artistry
- Ballerinas experience high loads on lower extremities
- Ankle injuries account for 15-22% of all ballet injuries
- Female dancers show more ankle injuries than male dancers as a result of pointe shoes
Current Pointe Shoe and Ribbon Anatomy

- The box of a pointe shoe is made with cardboard and glue.
- Currently ribbons are just used to hold the shoe in place and are sewn by hand.
- There have been some shoes that use elastomeric polymers as shock absorbers, but no advancements to the ribbon.
Ankle Moments During Pointe

Fig 1: Ankle Excursion Pattern

Fig 2: Ankle Angular Velocity Excursion Pattern

Fig 3: Ankle Moment Excursion Pattern
Previous Investigations

- GRFs and peak plantar pressure were observed during: *sauté, grande jeté, and standing en pointe*
  - GRFs were measured by a piezoelectrical force platform
  - GRFs and joint angular variation were tested
- F-Scan insoles were used to collect peak pressure for *en pointe* position
  - Peak pressures at 50 Hz for 8 seconds of standing *en pointe*
- Results of one ballet dancer are presented
  - Presented in terms of mean values, standard deviations and coefficient of variation
Results of Previous Investigations

- Standing *en pointe*: peak pressure over the toes was higher than over the forefoot
- Short jumps (sauté) produced greater peak pressure and higher loads over the anterior part of the foot
- Vertical forces show that the ballet dancer deals with very high external loads when wearing the pointe shoes

<table>
<thead>
<tr>
<th></th>
<th>Grand jete</th>
<th>Saute 1st pos.</th>
<th>Saute 5th pos.</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>3</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>Mean ± sd (BW)</td>
<td>4.52±0.15</td>
<td>5.26±0.41</td>
<td>4.60±0.22</td>
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<tr>
<td>CV (%)</td>
<td>3.32</td>
<td>7.79</td>
<td>4.78</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Toes</th>
<th>Forefoot</th>
<th>Midfoot</th>
<th>Heel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean (kPa)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Right</td>
<td>206.6±44.2</td>
<td>306.2±71.1</td>
<td>150.8±7.3</td>
<td>177.3±42.9</td>
</tr>
<tr>
<td>Left</td>
<td>206.6±44.2</td>
<td>306.2±71.1</td>
<td>150.8±7.3</td>
<td>177.3±42.9</td>
</tr>
<tr>
<td>CV (%)</td>
<td>21.4</td>
<td>23.2</td>
<td>4.8</td>
<td>24.2</td>
</tr>
</tbody>
</table>


Biomechanics: Standing *En Pointe*

- Walking in pointe shoes doubles the peak pressure acting on the foot
  - Pointe shoes versus barefoot: (41 N/cm² vs. 86 N/cm²)
  - Rising into releve position from a flat footed position increases the peak pressure to 115 N/cm²
- Pointe shoes absorb some of the impact from jump landings, but load greatly impacts the foot-ankle complex
  - A study found that the compressive strength of the shoes were 4300 N or less by testing 5 popular pointe shoe styles
  - A 60 kg ballerina landing on pointe from a height of one meter creates an impact force that is about 4950 N
**Problem**

- Studies show the components that cause ankle injuries but nothing that prevents ankle injuries
  - There are no current studies that are working on improving the pointe shoe ribbon and strapping technique
  - Rate of reported injuries has increased from 67% to 95% among professional dancers
- Pointe shoe designs have remained unchanged
  - Lack support and shock absorption
- Previous study: tested the effects of textured insoles in ballet shoes to see if the adjustment would improve ankle inversion moment discrimination (AIMD)
  - Textured insoles decreased the likeliness of ankle injury
  - Problem: insoles cause arch discomfort which could limit the shoes’ effectiveness, cause the dancers to not perform as well, and create other injuries
Proposed Solution

- Ribbon integrated with a material similar to kinesiology tape
- Ribbon has a wider base and is sewn into a different position
- New ribbon wrapping technique similar to ankle sprain kinesiology taping technique
- Light pink colored tape with ribbon edges, so aesthetic is kept
- Should lead to more stabilization
Significance of Design

- First change to pointe shoe ribbons
- Ankle injuries are the most common form of injury in female dancers, so a product that can help decrease ankle injuries is essential
- Design will still look aesthetically pleasing
- Shoe itself is not changing, so the dancer’s movement integrity is not compromised unlike previous investigations
- Ultimately, the design will be significant as it will increase ankle stability while still allowing the dancers to perform at their best
Methods and Materials

- 4 test groups
  - Control - regular ribbons with no previous ankle injury
  - Regular ribbons with previous ankle injury
  - Re-designed ribbons with no previous ankle injury
  - Re-designed ribbons with previous ankle injury

- Test Dancer’s ankle moment through wearable sensors
- Tests should show a decreased ankle moment
- Interview dancers to see if ribbons provide more ankle stability and do not decrease performance
- Observe both groups of dancers over long term to see if ankle injuries decrease
Timetable of Research

**Initial Moment Testing (1 Year)**
Initial moment measurements will be taken for all dancers.

**Final Moment Measurement (10 years)**
Our research will end in 10 years. This will give us ample time to observe the effects of our ribbon over time to see if it really does decrease ankle moments among dancers. At the end of the 10 years, each dancer will be brought in for more testing.

**Intermittent Check-Ins**
Check in on the dancers periodically. These check-ins will include a survey for them to complete. If a dancer has an ankle injury while using our designed straps we will bring them back to the lab for more moment testing. We will analyze if we can change the strap positioning or material so the dancer will have more support.
Funding

- Redesigned ribbon material
- Wearable motion sensors
- Force plate
- Facility
- Research staff
  - Graduate students
  - Dance specialist
  - Physical Therapist
Possible Complications

- Design improves ankle support but not ankle strength
  - Dance specialists recommends exercises for every dancer on pointe
  - Cross training and injury prevention techniques could be incorporated to improve overall strength and stamina

- Skin may degrade if a dancer wears the straps for too long
  - Prolonged wear of the tape-like material could cause the dancer to lose the mechanoreceptor input that could come from the skin
  - Dancers need to allow resting time for their feet and skin so they can “breathe”
Future Directions

- Mass produce the ribbon
- Create an easy tutorial that is accessible for dancers to learn how to properly tie our new and improved ribbon design
- Investigate adding different textures to the ribbon
- Research insole and toe box materials that could decrease ankle injuries and be generally more comfortable for the dancers
  - Toe box provides balancing support while dancing: improvements and adjustments could help improve the overall pointe shoe
Summary

- Ankle injuries account for 15-22% of all ballet injuries
- Wearing pointe shoes doubles the peak pressure exerted on the foot
- There are currently no studies that are working on the improvement of ballet shoes/ribbons in order to lessen ankle injuries
- Our solution is to create a ribbon which is integrated with kinesiology tape and wrapped in a new manner in order to support the ankle, and thus reduce ankle moment
- Testing will occur over the span of 10 years, with four different test groups
- Ultimately, our product will allow dancers to maintain their artistic integrity while decreasing ankle injuries
References

1. Dance Anatomy and Kinesiology, 2E. (n.d.). Retrieved from https://books.google.com/books?id=qI3jCgAAQBAJ&pg=PA379&lpg=PA379&dq=Ankle biomechanics of ballet Dancers in relevé en pointé dance&source=bl&ots=5dj_rkRIY&sig=BDgIH3y7_YmsUbsKK0Nh2zx0&hl=en&sa=X&ved=2ahUKEwi0nYl2vtLeAhVEZ6KHUujCeIQ6AEwBHoECAUQAO#v=onepage&q=Ankle biomechanics of ballet Dancers in relevé en pointé dance&f=false


Questions?