F-Scan Evaluation of a New Pointe Shoe Design

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ABSTRACT

The incorporation of synthetic materials into the traditional pointe shoe aesthetic was pioneered by the Gaynor Minden Company. This study evaluated, compared, and contrasted the design properties of this "synthetic" shoe vs. the "traditional" satin, paste and paper pointe shoe.

Twenty professional ballet dancers were evaluated using the F-Scan and MatScan plantar pressure assessment systems. Ten dancers were evaluated wearing the traditional pointe shoe, while ten dancers were evaluated in the synthetic pointe shoe. The F-Scan in-shoe and MatScan devices were used to assess the quantity and distribution of plantar pressures as each dancer performed a series of classical ballet steps.

Statistical analysis revealed that the synthetic shoe exhibits superior motion control and pressure absorption properties when compared to the traditional pointe shoe ($p < 0.05$). Comparison of both groups performing a series of jumps in 5th position revealed an 18% average reduction in overall plantar pressures. Pressure footprints from this series indicate that dancers wearing synthetic shoes have a more even pressure distribution across all of the metatarsal heads vs. the medial pressure shift noted in dancers wearing traditional pointe shoes. Pressure distributions while balancing en pointe reveals that dancers have 38% more useable toe box surface area while wearing the synthetic shoe vs. the traditional pointe shoe.

These results demonstrate that the incorporation of modern, synthetic materials improves the stability and alignment of the foot and ankle while decreasing strain and pressure on dancers' feet which contribute to chronic stress injuries and disability, ultimately shortening a dancers' career.

INTRODUCTION

The majority of the injuries of classical ballet dancers are overuse injuries, resulting from the inability of the body to absorb the forces generated by the repetitive, cyclical loading of the musculoskeletal system. These overuse injuries result from either intrinsic factors, including dance technique or extrinsic factors including the dance floor and shoes. Although many have implicated the dancer and her technique as cause for injury, few have studied her shoes.

The construction of the traditional ballerina's pointe shoe has not changed in the past century. The use of the classical pointe shoe is mandated by ballet tradition, leaving the ballerina with no alternative but to wear shoes that were designed in the early 1800's. The traditional pointe shoe continues to be manufactured from cardboard, paper, glue, satin and leather. These materials degrade quickly with heat and perspiration, failing to provide shock absorption and support, leaving the foot unprotected and vulnerable to injury.

The incorporation of synthetic materials into the traditional pointe shoe aesthetic was pioneered by the Gaynor Minden Company of New York, NY. The founders of this company have attempted to produce a pointe shoe that fits the traditional aesthetic while accommodating the foot (specifically the metatarsals) in the wide, spread out position of normal stance and providing support in the compressed, en pointe position.

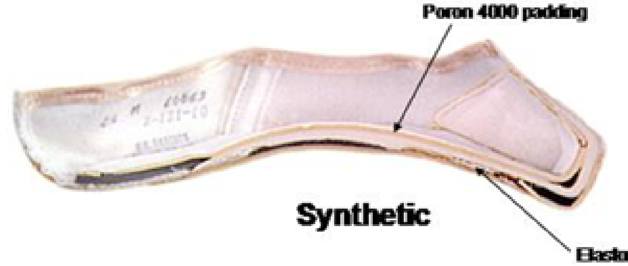

Figure 1. Synthetic pointe shoe cross-section demonstrating multiple layers of different density elastomerics in the shank and toe box with Poron 4000 and Cool-Max lining.

Figure 2. Traditional pointe shoe cross-section showing cardboard shank with paste and paper construction.

This study was designed to quantify pressure forces and determine motion control properties in the synthetic pointe shoe design vs. the traditional pointe shoe design. We hypothesize that the resilient properties of the synthetic materials will afford superior shock absorption and motion control properties for the dancer wearing the synthetic shoe when compared to the traditional materials.

MATERIALS AND METHODS

Twenty professional dancers each participated in two research protocols: one with the F-Scan in-shoe plantar pressure assessment system and one with the MatScan plantar pressure assessment system (Tekscan Boston, MA). Ten dancers were evaluated in the synthetic shoe and 10 dancers were evaluated in the traditional shoe. Two dancers were evaluated in both types of shoes.

F-Scan in-shoe system: Each dancer had paper-thin insole sensors cut and fit into her own pointe shoes (either synthetic or traditional) so that the sensor was placed on the plantar aspect of her foot and curved around the end of her toes. As the subjects performed dance steps, the in-shoe sensors registered pressure readings that were recorded by the Tekscan software.

MatScan system: As the subjects performed dance steps on the surface of the mat, the Tekscan software recorded pressure readings.

Figure 3. A dancer waiting to be tested on the MatScan system.

* Two trials of each step were performed to ensure consistency and accuracy of pressure readings.

Protocol:

F-Scan in-shoe system
1. slow roll through demi-pointe onto pointe
2. arabesque balance en pointe
3. 4th position pirouette
4. quick spring onto pointe in 5th position
5. jumps in 5th position

MatScan system
1. arabesque balance en pointe
2. promenade in arabesque
3. quick spring onto pointe in 5th position
4. jumps in 5th position
5. hops en pointe

Data Analysis

- Jumps in 5th position: The peak pressures recorded by the MatScan system for each jump were averaged across two trials for each subject.
- Arabesque balance: The square area of pointe shoe platform contacting the ground was calculated by the MatScan system and averaged across two trials for each subject.
- Preliminary data analysis was performed by calculating means, averages and percentage differences between the two groups.
- Student's T-test with a significance level of 0.05 was used to compare the data between the synthetic group and the traditional group.

RESULTS

Jumps in 5th position MatScan

Dancer #	Brand	Trial A			Trial B			ave. for dancer
Dancer 1	synthetic	48.00	51.00	52.00	58.00	50.00	54.00	51.50
Dancer 3	synthetic	48.00	50.00	48.00	51.00	45.00	47.00	47.50
Dancer 4	synthetic	29.10	27.30	31.70	31.00	34.20	29.00	30.40
Dancer 5	synthetic	29.20	31.50	28.20	30.50	30.20	33.00	30.27
Dancer 7	synthetic	48.50	44.00	44.50	45.10	49.10	48.70	46.65
Dancer 12	synthetic	37.50	38.00	37.00	40.30	44.40	41.50	39.95
Dancer 13	synthetic	28.90	32.40	28.50	29.70	30.10	28.50	29.75
Dancer 17	synthetic	25.20	24.00	25.00	31.30	27.10	30.00	28.13
Dancer 19	synthetic	23.10	27.80	28.00	28.40	32.10	28.00	27.73
Dancer 23	synthetic	29.70	29.30	33.00	31.10	32.30	32.80	31.47
Dancer 25	synthetic	33.50	29.00	33.30	31.80	33.00	30.40	31.83
							tot ave PSI	35.87
Dancer 2	traditional	59.00	64.00	62.00	58.00	55.00	62.00	60.00
Dancer 6	traditional	34.90	38.30	38.00	33.80	37.30	35.40	36.56
Dancer 8	traditional	48.00	44.50	42.50	42.20	48.00	39.80	43.53
Dancer 10	traditional	38.10	41.10	42.00	37.70	41.10	43.50	40.85
Dancer 11	traditional	37.20	33.80	34.00	39.40	40.10	39.10	37.37
Dancer 14	traditional	52.90	57.80	51.50	51.70	48.00	51.30	51.95
Dancer 15	traditional	35.20	40.00	34.50	38.40	40.70	35.80	37.53
Dancer 16	traditional	48.70	44.00	50.00	45.90	43.20	42.40	45.38
Dancer 18	traditional	47.70	69.00	54.30	42.90	52.10	48.70	50.82
Dancer 20	traditional	24.40	28.20	30.10	24.80	28.10	29.50	27.15
Dancer 21	traditional	49.90	48.00	45.10	47.80	55.50	57.30	50.87
							tot ave PSI	43.83
							tot difference	18.10%

Table 1. Results of Jumps in 5th position MatScan demonstrating an 18% average reduction in plantar pressure for dancers performing repetitive jumps in the synthetic vs. traditional pointe shoe.

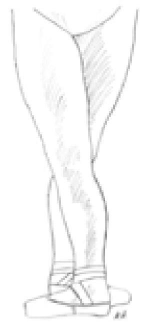

Figure 4. Dancer in 5th position.

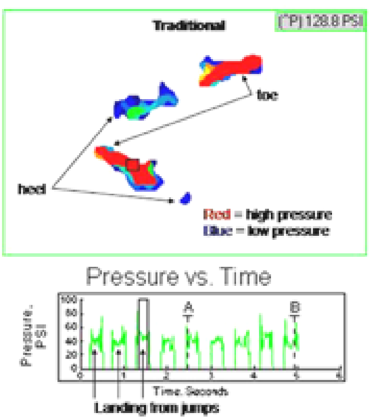

Figure5. Footprint showing concentrated high pressures on the medial aspect of the forefoot as the dancer performs repetitive jumps in the traditional pointe shoe.

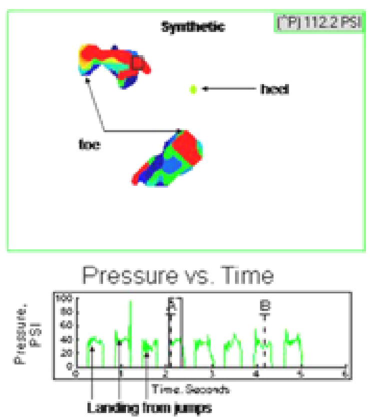

Figure 6. Footprint showing more evenly distributed pressures across the entire forefoot as the dancer performs repetitive jumps in the synthetic pointe shoe.

Arabesque balance MatScan

Dancer #	Brand	trial A	trial B	ave. for dancer
Dancer 1	synthetic	1.85	1.96	1.91
Dancer 3	synthetic	1.63	1.85	1.74
Dancer 4	synthetic	2.29	2.29	2.29
Dancer 5	synthetic	2.40	2.07	2.24
Dancer 7	synthetic	2.18	2.07	2.13
Dancer 12	synthetic	2.50	2.07	2.29
Dancer 13	synthetic	1.84	2.07	1.96
Dancer 17	synthetic	1.63	1.74	1.69
Dancer 19	synthetic	1.74	1.96	1.85
Dancer 23	synthetic	1.74	1.63	1.69
Dancer 25	synthetic	1.74	1.63	1.69
			tot ave sq inches	1.96
Dancer 2	traditional	0.54	0.05	0.30
Dancer 6	traditional	0.98	0.98	0.98
Dancer 8	traditional	1.42	1.42	1.42
Dancer 10	traditional	0.87	1.31	1.09
Dancer 11	traditional	1.03	1.52	1.58
Daner 14	traditional	0.87	0.76	0.82
Dancer 15	traditional	1.74	1.42	1.58
Dancer 16	traditional	0.98	1.20	1.09
Dancer 18	traditional	1.20	1.09	1.15
Dancer 20	traditional	2.07	2.07	2.07
Dancer 21	traditional	0.76	0.76	0.76
			tot ave sq inches	1.19
			tot difference	38.88%

Table 2. Results of Arabesque balance on MatScan demonstrating an average 38% greater surface area to balance en pointe in the synthetic vs. traditional pointe shoe.

Figure 7. Dancer balancing en pointe in arabesque.

Figure 8. Sample footprints showing the greater platform surface area of the synthetic shoe vs. the traditional pointe shoe while balancing en pointe in arabesque.

SUMMARY OF RESULTS

Jumps in 5th position

- The MatScan data revealed an average 18% reduction in overall plantar pressures in dancers wearing the synthetic pointe shoe compared to dancers wearing the traditional pointe shoe.
- A 45% reduction in overall plantar pressures for two dancers wearing the synthetic shoes, each serving as her own control in the traditional shoes.
- Student's T-test reveals that the 18% reduction in plantar pressures in the synthetic shoe group is statistically significant when compared to the traditional shoe group ($P < 0.05$).

Arabesque balance

- MatScan readings of the dancers while balancing en pointe revealed that the dancer is balancing on a larger surface area of the toe box while wearing the synthetic pointe shoe.
- Initial data analysis revealed that the dancer has 38% more surface area to balance on while en pointe in the synthetic shoe.
- Student's T-test reveals that the composition and design difference in the shoes are statistically significant ($p < 0.05$).

STUDY OF LIMITATIONS

- The study design is limited in that there were two groups of dancers in each type of shoe. A more precise analysis of plantar pressures based on pointe shoe design would best be obtained if each subject served as her own control.
- The data gathered with the F-Scan in shoe system was limited by the sensitivity and design of the insole sensors and was therefore inconclusive. More sensitive technology is necessary to determine the in-shoe distribution of forces on the foot while en pointe.

CONCLUSION

- Compared to the traditional pointe shoe, the synthetic pointe shoe demonstrates superior pressure absorption and motion control properties.
  - The pressure reduction and redistribution seen in synthetic shoe tests of jumps in the 5th position decreases stresses on the dancer's legs and feet. These stresses are often involved in overuse injuries to the feet. Further research is necessary to determine if the cumulative effects of this decrease in stresses will reduce the incidence of overuse injuries in ballet dancers.
  - The greater platform area seen in the synthetic shoe tests of arabesque balance provides more stability in the ankle and subtalar joints while the dancer is en pointe. The rapid degradation of the traditional shoe translates into a smaller surface area on which to balance and contributes to improper alignment and instability of the hindfoot joints. This causes abnormal stress on the tendons and joints that cross the ankle into the foot and potentially leads to chronic soft-tissue and joint conditions. Further research is necessary to determine if reducing the cumulative effects of joint misalignment will reduce the incidence of chronic injury patterns in ballet dancers.
- Further study of dancers familiar with both types of shoes is necessary to determine a more precise benefit of synthetic materials as each subject serves as her own control.
- More sensitive technology will allow further study to analyze in-shoe pressures while the dancer is en pointe.

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