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ORIGINAL

The Effects of the Foot Types and Structures of the Inner Arch Support Bands on Ground Reaction Force Variables and Sensations during 2nd Vertical Ballet Jump

Juhyun Kim[1], Kyungock Yi[2]

[1]Major in physical Education The Graduate School of Education Ewha Womans University, Seoul, South Korea
[2]Division of Kinesiology and Sports Studies College of Science and Industry Convergence Ewha Womans University, Seoul, South Korea

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Corresponding Author
Kyungock Yi
Division of Kinesiology and Sports Studies, College of Science and Industry Convergence, Ewha Womans University, Seoul, 03760, South Korea
Tel : +82-10-8940-1215
Fax : +82-02-3277-2846
Email : yikok@ewha.ac.kr

Objective: The purpose of this research was to establish the differences of ground reaction force variables and sensations according to the foot types and the structures of the inner arch support band during 2nd vertical ballet jump.

Method: 12 Female ballet majors in their twenties who have danced for more than 10 years and had no injuries were selected for this research. Independent variables consist of the foot type (pes rectus, pes planus) and the structure of the inner arch support band (no band, x-shaped, linear shaped). Dependent variables consist of ground reaction force variables and relative wearing sensation.

Results: The impact decreased the most when x-shaped bands were used on pes rectus and rigid pes planus. When linear-shaped bands were used on flexible pes planus, the impact decreased.

Conclusion: The bands also helped reduce the impact on pes rectus. Furthermore, it is clear that according to the foot type, the impact reducing band structures perform differently. The inner arch support bands were necessary for jump training for any foot type.

Keywords: Foot type, Inner arch support band, Second vertical ballet jump

INTRODUCTION

Dance is the body's response to the feelings created by a particular situation and can be said to be the most basic form of expression for humans (Jang, 2007). The jumping movement in dance is an essential part of every piece and as a basic movement technique, makes possible various forms of expression (Choi, 2001). According to advanced research, it is apparent that the foot type affects how the jumping technique was performed (Yoo, 2015). The shape of the foot can be divided into three forms according to the height of the medial arch: pes rectus, pes cavus, and pes planus. Among the pes planus form, there is a flexible pes planus that occurs due to the over-pronation through weight-bearing (Kadakia & Haddad, 2003; Ker et al., 1987), and a rigid pes planus (Rodriguez, Choung, & Dobbs, 2009). That has no relation to weight-bearing. The inner arch of the foot is higher, and has a more flexible and elastic structure than the outer arch, and it plays an important part in absorbing the impact upon touching ground (Park, 2008; Richie, 2007). Furthermore, being the primary support structure for weight-bearing, the inner arch of the foot plays an important role in absorbing impact during various movements, such as walking or running (Nawoczenski & Flemister, 2006).

There are various treatments for the collapsed arch in the case of pes planus (Jacobs, 2007), but among them, the taping method has the positive sides of being economical, convenient and standardized (Kim, 2011). Recently there have been many studies where elastic bands have been used, but they have been limited to determining the use of the elastic bands and to physical workout programs. The inner arch support band has been produced in two structures by grafting the taping method for holding the inner arch of the foot onto the elastic band.

Thus, the purpose of this study establishes the differences of ground reaction force variables and relative sensations according to the second position vertical jump in ballet.

METHODS

1. Participants

The subjects of this study were made up of 12 ballet majors who have danced professionally for more than ten years (age: 24.33±2.96 years, height: 165.33±3.75 cm, weight: 49.83±4.47 kg). Before the experiment, the purpose of the research, the sequence of the experiment and movements were explained to the subjects and after confirming in-

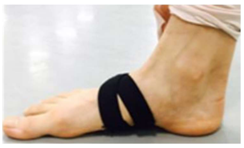
	Band structure	Features
Linear band	 	Material: Three-ply rubber band Production Method: A 3 cm wide band cut into 18 cm pieces, with a 1 cm overlapping area sewn together Circumference: 17cm, Diameter: 5.41
X-shaped Band	 	Material: Three-ply rubber band Production method: Two 2 cm wide bands cut into 18 cm pieces, with a 0.5 cm overlapping area sewn together on each, sewn together Circumference: 17.5cm, Diameter: 5.57

Figure 1. Structure and features of the inner arch support band

Table 1. Ground reaction force variables

Time required	Total time required
	Take off phase time required
	Flight time required
	Landing phase time required
Take off phase	Flexive active loading rate
	Flexive active impulse
	Active maximun force
	Extensive active decay rate
	Extensive active impulse
	Z-Y maximum force time difference
	Z-X maximum force time difference
Landing phase	Number of passive peaks
	Passive loading rate of ball of foot
	Passive loading rate of heel
	Passive maximum force
	Flexive impulse
	Extensive impulse
	Flexive impulse
	Extensive impulse
	Z-Y maximum force time difference
	Z-X maximum force time difference

tention to participate and receiving consent forms, the experiment was carried out.

2. Variables

In this research, the independent variables were the foot type (pes rectus: ±2°, pes planus: <±3°) and the structure of the inner arch support band (no band, linear shaped, x-shaped). The inner arch support bands used were the linear shaped band used in Lee's 2016 study and the x-shaped band which has a structure with a wider area that helps prop up the arch. Furthermore, in the Low-dye taping method, only the method of the sixth stage, offering lifting support to the arch was chosen. The displacement control of the used support bands was 50 mm/min, the tensile strength 12.92 MPa, and the fracture elongation 928.7% (Figure 1).

The dependent variables were ground reaction force variables and sensations according to phases.

The ground reaction force variable (Table 1, Figure 2) measured the

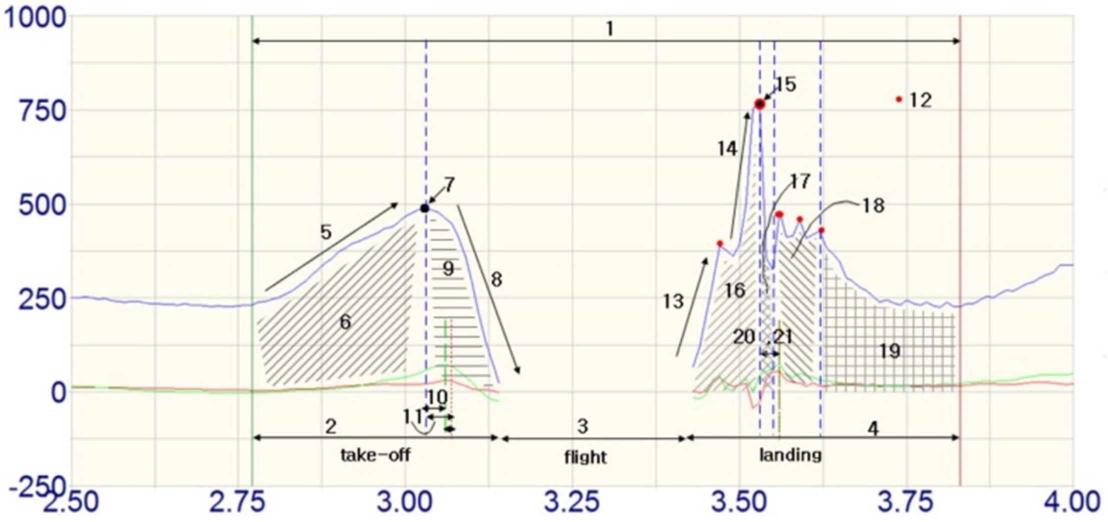


Figure 2. Ground reaction force variables

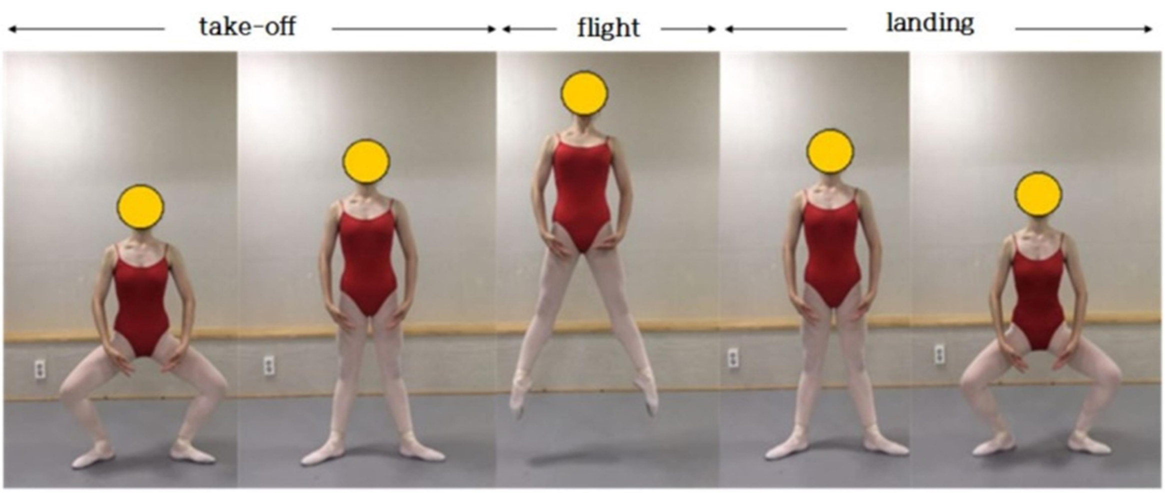


Figure 3. Three phases of the second vertical ballet jump

right foot using the force platform (Kistler, 9281B, Switzerland).

3. Measurement

The necessary experiment equipment for this research could be found at the E University gymnasium's dynamics laboratory, located in Seoul. First, the foot type of each subject was measured. After doing some light stretching to perform the jumping technique properly, the subjects began the experiment. To ensure consistency during every movement, the movements were carried out matching the 3/4 time 120 tempo (Allegro) of the metronome. Having divided the inner arch support bands into no band, linear-shaped band and x-shaped band, each was measured three times, all together nine times. Only the right foot was measured, but the movements were performed while wearing the bands on both feet.

4. Data Processing

This research analyzed the three phases of the second vertical ballet jump, the take-off, the flight extensive and landing phase (Figure 3).

5. Statistical analysis

Data processing utilized Windows IBM SPSS Statistics 22.0. To measure the ground reaction force variables differences according to the foot type the structures of the inner arch support bands, and, wearing sensations according to the structures of the inner arch support bands, a one-way ANOVA was carried out. Statistical level of significance was set at $p<.05$ and post hoc analysis was conducted using Bonferroni correction.

Table 2. Ground reaction force variables according to foot type

		N	Mean	±SD	*F*	*p*	Post-hoc
Total time required (sec)	Pes Rectus	5	1.13	.05	.97	.416	
	Pes Planus-Rigid	4	1.11	.01			
	Pes Planus-Flexible	3	1.16	.09			
Take off time required (sec)	Pes Rectus	5	.40	.00	.00	1.000	
	Pes Planus-Rigid	4	.40	.00			
	Pes Planus-Flexible	3	.40	.00			
Flexive - active loading rate (BW/sec)	Pes Rectus	5	1035.07	521.80	.12	.888	
	Pes Planus-Rigid	4	935.20	183.23			
	Pes Planus-Flexible	3	1073.50	327.98			
Flexive - active impulse (BW*sec)	Pes Rectus	5	113.71	34.97	.71	.519	
	Pes Planus-Rigid	4	109.26	17.37			
	Pes Planus-Flexible	3	139.90	54.13			
Active maximum force (BW)	Pes Rectus	5	536.40	64.47	1.16	.357	
	Pes Planus-Rigid	4	521.51	88.51			
	Pes Planus-Flexible	3	602.43	63.00			
Extensive - active loading rate (BW/sec)	Pes Rectus	5	-5056.92	1037.36	.14	.873	
	Pes Planus-Rigid	4	-4900.44	1101.93			
	Pes Planus-Flexible	3	-5404.32	1816.09			
Extensive - active impulse (BW*sec)	Pes Rectus	5	37.07	12.44	.96	.420	
	Pes Planus-Rigid	4	36.08	6.64			
	Pes Planus-Flexible	3	45.61	7.51			
Z-Y maximum force time difference (sec)	Pes Rectus	5	.02	.01	.68	.531	a<c*
	Pes Planus-Rigid	4	.03	.01			
	Pes Planus-Flexible	3	.03	.02			
Z-X maximum force time difference (sec)	Pes Rectus	5	.05	.03	.34	.722	
	Pes Planus-Rigid	4	.04	.04			
	Pes Planus-Flexible	3	.06	.05			
Flight time required (sec)	Pes Rectus	5	.34	.03	3.46	.077	
	Pes Planus-Rigid	4	.33	.02			
	Ped Planus-Flexible	3	.34	.05			
Landing phase time required (sec)	Pes Rectus	5	.38	.01	2.74	.118	
	Pes Planus-Rigid	4	.35	.03			
	Pes Planus-Flexible	3	.40	.04			
Number of passive peaks (times)	Pes Rectus	5	4.40	.55	1.42	.291	
	Pes Planus-Rigid	4	4.00	.47			
	Pes Planus-Flexible	3	3.89	.19			
Passive loading rate of ball of foot (BW/sec)	Pes Rectus	5	1796.32	2801.43	.07	.935	
	Pes Planus-Rigid	4	2293.60	2692.52			
	Pes Planus-Flexible	3	2641.43	4536.89			

Table 2. Ground reaction force variables according to foot type (Continued)

		N	Mean	±SD	*F*	*p*	Post-hoc
Passive loading rate of heel (BW/sec)	Pes Rectus	5	2541.88	2249.94	.57	.586	
	Pes Planus-Rigid	4	4068.71	1787.74			
	Pes Planus-Flexible	3	2838.02	2634.75			
Active maximum force (BW)	Pes Rectus	5	786.51	139.16	2.88	.108	
	Pes Planus-Rigid	4	636.63	84.53			
	Pes Planus-Flexible	3	847.25	134.53			
Flexive impulse (BW*sec)	Pes Rectus	5	28.07	7.43	1.10	.373	
	Pes Planus-Rigid	4	23.17	13.19			
	Pes Planus-Flexible	3	33.68	4.04			
Extensive impulse (BW*sec)	Pes Rectus	5	14.60	6.74	.19	.830	
	Pes Planus-Rigid	4	12.20	7.66			
	Pes Planus-Flexible	3	14.76	3.61			
Flexive impulse (BW*sec)	Pes Rectus	5	27.74	5.18	.62	.560	
	Pes Planus-Rigid	4	23.31	6.58			
	Pes Planus-Flexible	3	24.69	7.05			
Extensive impulse (BW*sec)	Pes Rectus	5	71.18	14.18	5.04	.034*	a<c*
	Pes Planus-Rigid	4	61.32	10.60			
	Pes Planus-Flexible	3	94.13	16.65			
Z-Y maximum force time difference (sec)	Pes Rectus	5	.01	.01	.26	.774	
	Pes Planus-Rigid	4	.02	.02			
	Pes Planus-Flexible	3	.01	.01			
Z-X maximum force time difference (sec)	Pes Rectus	5	.01	.02	3.46	.077	
	Pes Planus-Rigid	4	.05	.02			
	Pes Planus-Flexible	3	.03	.02			

*p<.05, **p<.01, ***p<.001
a=Pes Rectus, b=Rigid Pes Planus, c=Flexible Pes Planus

RESULTS

1. Difference in ground reaction force according to foot type

The extensive impulse during landing (F=5.04*) according to foot type was significantly bigger in the case of flexible pes planus (94.13, ±16.65) than pes rectus, however other variables did not reveal statistically significant difference (Table 2).

2. Difference in ground reaction force variables according to inner arch support band structure

According to the results of the one-way ANOVA, the time required according to the structure of the band (F=6.01**) was significantly longer when wearing an x-shaped band (1.20, ±.05) than when the subject was not wearing a band (1.13, ±.05). The take-off time required (F=12.29***) was significantly longer for the linear-shaped band (.45, ±.03) and the x-shaped band (.46, ±.05), when compared to no band (.40, ±.00). The landing phase time required (F=4.11*) was significantly longer for the x-shaped band (.42, ±.04) when compared to no band (.38, ±.03). The active maximum force during landing (F=7.85**) for the x-shaped band (519.52, ±82.25) and linear-shaped band (593.13, ±192.89) was significantly smaller than with no band (751.74, ±141.91). The flexive impulse (F=7.64**) for the x-shaped band (15.10, ±8.01) and the linear-shaped band (17.04, ±8.37) was also significantly smaller than for no band (27.84, ±9.37). However, for the flexive impulse (F=3.83*) for the x-shaped band (36.23, ±11.93) was significantly higher than that of no band (25.50, ±5.90). On the other hand, during the take-off phase flexive section's active loading rate, flexive section's active impulse, active

Table 3. Ground reaction force variables according to inner arch support band structure

		N	Mean	±SD	*F*	*p*	Post-hoc
Total time required (sec)	No Band	12	1.13	.05	6.01	.006**	a<c**
	Linear-shaped Band	12	1.16	.04			
	X-shaped Band	12	1.20	.05			
Take off time required (sec)	No Band	12	.40	.00	12.29	.000***	a<b**, a<c***
	Linear-shaped Band	12	.45	.03			
	X-shaped Band	12	.46	.05			
Push - active loading rate (BW/sec)	No Band	12	1011.39	362.14	.50	.609	
	Linear-shaped Band	12	899.01	270.88			
	X-shaped Band	12	886.50	365.38			
Push - active impulse (BW*sec)	No Band	12	118.77	35.01	.26	.776	
	Linear-shaped Band	12	125.31	24.04			
	X-shaped Band	12	126.22	22.81			
Active maximum force (BW)	No Band	12	547.94	74.12	.06	.944	
	Linear-shaped Band	12	545.35	74.97			
	X-shaped Band	12	537.43	87.46			
Extensive - active loading rate (BW/sec)	No Band	12	-5091.61	1167.32	1.85	.173	
	Linear-shaped Band	12	-6942.05	5061.23			
	X-shaped Band	12	-4677.42	1131.17			
Extensive - active impulse (BW*sec)	No Band	12	38.88	9.76	.03	.970	
	Linear-shaped Band	12	38.14	7.98			
	X-shaped Band	12	39.04	10.75			
Z-Y maximum force time difference (sec)	No Band	12	.03	.01	2.27	.119	
	Linear-shaped Band	12	.02	.01			
	X-shaped Band	12	.02	.01			
Z-X maximum force time difference (sec)	No Band	12	.05	.03	.73	.488	
	Linear-shaped Band	12	.04	.03			
	X-shaped Band	12	.05	.02			
Flight time required (sec)	No Band	12	.34	.03	1.98	.154	
	Linear-shaped Band	12	.31	.03			
	X-shaped Band	12	.32	.03			
Landing phase time required (sec)	No Band	12	.38	.03	4.11	.025*	a<c*
	Linear-shaped Band	12	.40	.04			
	X-shaped Band	12	.42	.04			
Number of passive peaks (times)	No Band	12	4.14	.48	1.25	.301	
	Linear-shaped Band	12	4.00	1.09			
	X-shaped Band	12	3.64	.70			
Passive loading rate of ball of foot (BW/sec)	No Band	12	2173.36	2950.09	.54	.588	
	Linear-shaped Band	12	1562.50	2139.63			
	X-shaped Band	12	2650.83	2562.27			

Table 3. Ground reaction force variables according to inner arch support band structure (Continued)

		N	Mean	±SD	*F*	*p*	Post-hoc
Passive loading rate of heel (BW/sec)	No Band	12	3124.86	2115.53	1.88	.169	
	Linear-shaped Band	12	2717.78	2049.12			
	X-shaped Band	12	4393.37	2442.27			
Passive maximum force (BW)	No Band	12	751.74	141.91	7.85	.002**	b<a*, c<a**
	Linear-shaped Band	12	593.13	192.89			
	X-shaped Band	12	519.52	85.25			
Flexive impulse (BW*sec)	No Band	12	27.84	9.37	7.64	.002**	b<a*, c<a**
	Linear-shaped Band	12	17.04	8.37			
	X-shaped Band	12	15.10	8.01			
Extensive impulse (BW*sec)	No Band	12	13.84	6.03	2.36	.111	
	Linear-shaped Band	12	10.52	5.32			
	X-shaped Band	12	9.25	4.63			
Flexive impulse (BW*sec)	No Band	12	25.50	5.90	3.83	.032*	a<c*
	Linear-shaped Band	12	29.87	9.79			
	X-shaped Band	12	36.23	11.93			
Extensive impulse (BW*sec)	No Band	12	73.63	18.07	.82	.448	
	Linear-shaped Band	12	81.05	11.63			
	X-shaped Band	12	81.91	21.11			
Z-Y maximum force time difference (sec)	No Band	12	.01	.01	.71	.497	
	Linear-shaped Band	12	.03	.06			
	X-shaped Band	12	.03	.04			
Z-X maximum force time difference (sec)	No Band	12	.03	.02	.22	.803	
	Linear-shaped Band	12	.03	.05			
	X-shaped Band	12	.02	.02			

*$p<.05$, **$p<.01$, ***$p<.001$
a=Pes rectus, b=Rigid Pes Planus, c=Flexible Pes Planus

maximum force, extensive section's active decay rate, extensive section's active impulse, Z-Y maximum force time difference, Z-X maximum force time difference, required time for flight, number of passive peaks, passive loading rate of heel, extensive impulse, extensive impulse there was no significant difference (Table 3).

3. Survey regarding wearing sensation, jumping sensation, and landing sensation

The wearing sensation according to structure of band (F=3.46*) was significantly higher for the linear-shaped band (3.75, ±.45) than no band (3.25, ±.45). Jumping sensation (F=6.95**) was significantly higher for the linear- (3.75, ±.45) and x-shaped bands (3.92, ±.67) than with no band (3.17, ±.39). Landing sensation (F=18.53***) was significantly higher for the x-shaped band (4.25, ±.62) than for no band (2.83, ±.58) and linear-shaped band (3.42, ±.51) (Table 4).

DISCUSSION

The extensive impulse during landing according to the foot type was significantly bigger for flexible pes planus than for pes rectus (Kim, 2013). This shows that the extensive impulse during extension is bigger for pes planus than for pes rectus, and within pes planus it is bigger for rigid pes planus than for flexible pes planus. This kind of big extensive impulse means flexing down, and because of this, instead of lightly rising, the movement might appear more sluggish. When connecting it to the next movement, the ability to lightly and gracefully link the movements is reduced. Thus, it is recommended, especially for flexible pes planus, to use inner arch lifting bands during training or performances to overcome the posterior tibial tendon dysfunction with pes

Table 4. Survey regarding wearing sensation, jumping sensation, and landing sensation

		N	Mean	±SD	*F*	*p*	Post-hoc
Wearing sensation	No Band	12	3.25	.45	3.46	.043*	a<b*
	Linear-shaped Band	12	3.75	.45			
	X-shaped Band	12	3.42	.51			
Jumping sensation	No Band	12	3.17	.39	6.95	.003**	a<b*, a<c**
	Linear-shaped Band	12	3.75	.45			
	X-shaped Band	12	3.92	.67			
Landing sensation	No Band	12	2.83	.58	18.53	.000***	a<c***, b<c**
	Linear-shaped Band	12	3.42	.51.			
	X-shaped Band	12	4.25	.62			

*p<.05, **p<.01, ***p<.001
a=No Band, b=Linear-shaped Band, c=X-shaped Band

planus (Erol et al., 2015, Kohls-Gatzoulis et al., 2004).

The total time required, take-off time required, landing time required according to the structure of the band were all significantly longer for the x-shaped band than for linear-shaped band or no band. The longer time required during the time-limited performance experiment means that the jumps performed by subject with x-shaped bands were high and graceful (Linthorne, 2001).

During landing the active maximum force was significantly lower for the x-shaped band and the linear-shaped band than for no band (Lee & Hong, 2005). The flexive impulse, as well, was significantly lower for the x-shaped band and the linear-shaped band than for no band (Chen, 2011; Chiu & Wang, 2007).

However, the flexive impulse was significantly higher for the x-shaped band than for no band. The x-shaped band reduces the impact, helps with progressing the active force in the flexive phase and contributes to a light descent.

The x-shaped band showed the longest time required for pes rectus in the difference in the ground reaction force according to the shape of the foot and structure of the band (Linthorne, 2001). The impact that occurs during landing was statistically significantly reduced when x-shaped bands were worn on pes rectus and rigid pes planus. The impact was lowest for flexible pes planus when linear-shaped bands were used. This shows that both types of bands reduce impact and that there is a difference in which band structure reduces the impact according to the shape of the foot.

Jumping sensation was significantly higher for the linear and x-shaped bands than with no band. Landing sensation was significantly higher for the x-shaped band than for no band and linear-shaped band.

CONCLUSION

The purpose of the vertical jump in dance is to leap high and land lightly. The function of the interior arch lifting elastic bands is to extend the time required for take-off and enlarge the manifestation of active force, as well as reduce impact during landing. Furthermore, impact was not only reduced for rigid pes planus, it was also reduced when interior arch lifting elastic bands were used on pes rectus. The x-shaped bands are effective for pes rectus and rigid pes planus, while linear-shaped bands are effective for flexible pes planus. Thus, regardless of foot shape, arch lifting elastic bands are essential for jumping training in dance.

REFERENCES

Chen, S. J. & Gielo-Perczak, K. (2011). Effect of impeded medial longitudinal arch drop on vertical ground reaction force and center of pressure during static loading. *Foot & Ankle International*, *32*, 1, 77-84.

Chiu, M. C. & Wang, M. J. (2007). Professional footwear evaluation for clinical nurses. *Applied Ergonomics*, *38*, 2, 133-141.

Choi, S. Y. (2001). The Segment Coordination in Different Types of Jumping Movement. *Official Journal of Korea Society of Dance Science*, *3*, 57-70.

Erol, K., Karahan, A. Y., Kerimoğlu, Ü., Ordahan, B., Tekin, L., Sahin, M. & Kaydok, E. (2015). An important cause of pes planus: the posterior tibial tendon dysfunction. *Clin Pract*, *5*(1), 699.

Jacobs, A. M. (2007). Soft tissue procedures for the stabilization of medial arch pathology in the management of flexible flatfoot deformity. *Clin Podiatr Med Surg*, *24*(4), 657-665.

Jang, S. Y. (2007). *Ballet. 2nd edition*. Chungnam National Univrtsity Publication, Daejeon Metropolitan City.

Kadakia, A. R. & Haddad, S. L. (2003). Hindfoot arthrodesis for the adult acquired flat foot. *Foot Ankle Clin*, *8*(3), 569-594.

Ker, R. F., Bennett, M. B., Bibby, S. R., Kester, R. C. & Alexander, R. M. (1987). The spring in the arch of the human foot. *Nature*, *8*(14), 47-49.

Kim, H. L. (2013). *The Effects of Foot type and Shoes on Gait Biomechanics*. Un- published Master's Thesis. Graduate School of Sports Science, Ewha womans University.

Kim, M. S. (2011). *Change in lower muscle activation and fatigue in accordance with treadmill walking and the time after application of low-dye taping for the flatfoot adults*. Un- published Doctor's Dissertation. Graduate School of Life Sciences Catholic University of Busan.

Kohls-Gatzoulis, J., Angel, J. C., Singh, D., Haddad, F., Livingstone, J. & Berry, G. (2004). Tibialis posterior dysfunction: a common and treatable cause of adult acquired flatfoot. *BMJ*, *4*(329), 1328-1333.

Lee, Y. H. & Hong, W. H. (2005). Effects of shoe inserts and heel height on foot pressure, impact force, and perceived comfort during walking. *Applied Ergonomics*, *36*(3), 355-362.

Nicholas, P. & Linthorne, N. P. (2001). Analysis of standing vertical jumps using a force platform. *American Journal of Physics*, *69*(11), 1198-1204,

Napolitano, C., Walsh, S., Mahoney, L. & McCrea, J. (2000). Risk factors that may adversely modify the natural history of the pediatric pronated foot. *Clin Podiatr Med Surg*, *17*(3), 397-417.

Nawoczenski, T. J. & Flemister, A. (2006). Comparison of foot Kinematics between subjects with Posterior tibialis tendon dysfunction and healthy controls. *Journal of Orthopaedic & Sport Physical Therapy*, *36*(9), 635-644.

Park, K. Y. (2008). *Study on changing the angle of ankle to the sagittal plane with F. F. O before and after wearing during the walk*. Un-published Doctor's Dissertation. Graduate School of Alternative Medicine Kyonggi University.

Richie, D.H. Jr. (2007). Biomechanics and clinical analysis of the adult acquired flatfoot. *Clin Podiatr Med Surg*, *24*(4), 617-644.

Yi, K. O. (2016). The Immediate Effects External kinesio-tape Wrapping for Inner Arch Support on the Lower Leg EMG for Gait in Stietto Heels. *Korean Journal of Sport Biomechanics*, *26*(1), 127-133.

Yoo, C. R. (2015). *The Analysis of Vertical Ground Reaction Force During the Ballet Second Position Jump According to Foot Types*. Un-published Master's Thesis. Graduate School of Education, Ewha womans University.