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Injuries in Preprofessional Ballet Dancers*:
An Epidemiological Study

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This study collected the ballet injury characteristics of 170 preprofessional ballet dancers. Data was collected three times a year using a web-based system. The statistical analysis was performed via Statistical Package for the Social Sciences, version 23.0 (IBM Corp., Armonk, NY, USA) and Microsoft Excel (Microsoft Corp., Redmond, WA, USA). Injury profiles and mechanisms were calculated as incidence rate/1,000 h, acute/chronic, recurrence, injury location, type, and mechanisms. The 170 dancers sustained 282 injuries over 96,717 h of overall dance exposure at an estimated incidence rate (IR) of 2.92/1,000 h (95% confidence interval, 2.59–3.27). Chronic and acute injuries were calculated at 40.4% and 37.4%, respectively. First and second recurrence were 19.5% and 2.8%, retrospectively. Ankles, feet/toes, and knees were the most frequently injured body parts. Most common injury types were included sprain, cartilage damage, and tendinopathy. The major mechanisms of injuries comprised landing after jumping, take off/jumping, and hip joint movement. The lower leg injuries occurred more frequently when dancers wore pointe shoes.

Keywords : epidemiology, injury surveillance system, ballet dancers, injury

Ⅰ. Introduction

In comparison to other sports, dance, especially ballet, Dance is one of the most demanding physical activities and ballet is among the most strenuous dance forms(Grahame, Saunders, & Maisey, 1979; Hamilton, 1978). This is because ballet not only expresses artistic elements with the body but also physical conditioning similar to that of athletes(Allen & Nevill, 2012; Milan, 1994). Young students who decide to major in dance engage in full-time preprofessional training by age 15. Such preprofessional training requires both technique and intensity to be imparted according to the prescribed system for professional dancers. Previous studies reported that preprofessional ballet dancers' clinical incidence of injury was 1.42 (SD 1.24, range 0–7) per

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dancer and the rate of injury was 1.38 per 1,000 hours (95% CI, 1.24–1.52)(Ekegren, Quested, & Brodrick, 2014). From the biomechanics perspective, basic ballet movements, such as turnout(Ryan & Stephens, 1987), pointe/demi-pointe work(Kim, 2019), and jump/landing(Moita, Nunes, Esteves, Oliveira, & Xarez, 2017) are key cause of ballet injuries.

However, although ballet dancers are always exposed to the risks of injury, studies on diverse injury-related characteristics of dance is remarkably limited in comparison with the field of athletics. Only a few quantitative, longitudinal studies have tracked risk factors for various dance-related injuries(Biernacki, Stracciolini, Fraser, Micheli, & Sugimoto, 2021; Ekegren et al., 2014; Hincapié, Morton, & Cassidy, 2008; Kenny, Palacios-Derflingher, Shi, Whittaker, & Emery, 2019; Jacobs & Hincapié, 2012; Yau, Golightly, Richardson, Runfola, Waller, & Marshall, 2017). The epidemiology of ballet injury is also not an adequately studied subject. In addition, to prevent injuries, it is necessary to improve the dancing techniques and develop an effective injury prevention program, including using the injury prevention model described by Van Mechelen(Van Mechelen, Hlobil, & Kemper, 1992) for further studies.

Therefore, this study purposes to scrutinize injuries sustained by preprofessional ballet students in Korea over the course of one year and aims to examine injury characteristics such as incidence, dance exposure, type of injury, injured body parts, injury mechanisms, injury occurrences, and the relationship between injuries and pointe shoes.

Ⅱ. Methods

1. Subjects

In the first survey, a total of 174 preprofessional Korean ballet students participated, and four of them dropped out, so 170 subjects (age = 19.72 ± 0.21 years, height = 165.24 ± 5.6cm, weight = 50.84±5.7kg, number of performances = 2.95+4.18/year) voluntarily participated in this study. The number of subjects in this study was determined using Ekegren et al.'s epidemiological study of preprofessional ballet dancers(Ekegren et al., 2014). The study's subjects were recruited from eight four-year colleges (H, S1, S2, D, I, S3, K1 and K2) in Seoul using flyers and communications over the phone or email. The subjects who were under the age of 18 years or enrolled in other dance majors other than ballet were excluded.

2. Instruments

This study utilized a web-based survey based on the modified injury surveillance system (ISS) of the International Olympic Committee(Son, Cho, Jeong, & Lee, 2020). The ISS comprised two sections: the first segment gathered general information such as age, value of anthropometric measurement, and years of experience; the second part sought information about ballet-related

injuries such as the rate of incidence of injuries, body parts that were injured, types of injuries, chronic vs. acute injuries, the mechanism of injuries, dance exposures, assisted exercises, treatments received after sustaining the injuries, and the periods of recovery. Injury was defined as any physical complaint resulting from class, practice, rehearsal, or performance that required for medical treatment or resulted in time-loss from the dance activities.

3. Study Procedures

Each subject read and signed a written consent form for the use and protection of human subjects in compliance with the Yonsei University's Institutional Review Board (protocol code: 7001988-201807-HR-268-07). Each individual filled out a questionnaire on Google Forms every four months according to their dance performance seasons; preseason, on-season, and postseason. On-season is defined as March to June, the time when essential performances are typically held during the year; November to February as preseason; and July to October as postseason. After all the subjects had completed the survey thrice, the researcher conducted a telephone interview with every respondent to ensure that the collected data were accurate and detailed, and to add missed information about the number of recurrent injuries, types of injuries, injured body parts, and any other aspects. The obtained data could only be accessed by the researcher to download and code them for data analysis.

4. Definition of Dance Exposure

Dance exposure (DE) was defined as "one dancer participating in one class, rehearsal, or performance is exposed to the possibility of dance injury regardless of the time associated with that participation"(Liederbach, Hagins, Gamboa, & Welsh, 2012). Total DE (hour) was calculated from the weekly schedules that the subjects reported.

5. Statistical Analysis

All descriptive statistical analyses were performed using Statistical Package for the Social Sciences, version 23.0 (IBM Corp., Armonk, NY, USA) and Microsoft Excel (Microsoft Corp., Redmond, WA, USA). A frequency analysis was performed to identify higher-ranked items in terms of injured body parts, injury types, acute and chronic injuries, injury mechanisms, cause of injury, injury occurrences, and injuries sustained with/without pointe shoes. Clinical incidence was defined as the number of in-juries per number of dancers. DE was calculated from the total hours that the subjects participated in class, rehearsal, or performance. Incidence rate (IR) was calculated using the number of reported injuries per 1,000 h of DE (hr). A chi-square test was employed to compare the characteristics of injured body parts and injuries sustained with and without pointe shoes.

Ⅲ. Results

1. Overall Injury Characteristics

In the 170 subjects, 282 injuries occurred in a year. In the characteristics of injury by seasons, the most frequent injury period occurred in preseason, and the DE was the most frequent in the on-season period. The total clinical incidence was 1.66 (95% CI, 1.47-1.86) in a year. The total DE was 96,717, and the total IR was 2.92 (95% CI, 2.59-3.27) (Table 1).

Table 1. Estimates of the number of injured students and injuries, clinical incidence, dance exposures, and incidence rates by seasons

	Preseason	On-season	Postseason	Total
No. of injured persons	99	71	53	223
No. of injuries	125	90 (55)*	67 (8)*	282 (63)*
Clinical incidence [a]	7.35 (95% CI, 6.15-8.73)	5.29 (95% CI, 4.28-6.48)	3.94 (95% CI, 3.08-4.97)	1.66 (95% CI, 1.47-1.86)
Dance exposures (hr)	32,482	33,091	31,144	96,717
Incidence rate/1,000 DEs [a]	3.85 (95% CI, 3.22-4.57)	2.72 (95% CI, 2.20-3.33)	2.15 (95% CI, 1.67-2.72)	2.92 (95% CI, 2.59-3.27)

Note: a 95% confidence interval. DEs: dance-exposures, (n)*excluding recurrent injuries.

2. Acute, Chronic, and Recurrent Injuries

The number of acute injuries that occur suddenly as a result of physical activity over one year was 37.2% (n = 105). The chronic injuries that happen slowly and last a long time (n =114) was 40.4%. The data revealed a substantial proportion of recurrent in which the recovered injuries occurred in the same location (22.3%): the first recurrence (n = 55) was computed at 19.5% and the percentage of second recurrence (n = 8) was 2.8%.

3. Injured Body Parts and Injury Types

Most injuries involved the lower limbs (82.3%, n = 232), and the five most frequently injured body parts were the ankle (35.8%, n = 101), foot/toe (15.6%, n = 44), knee (14.2%, n = 40), lumbar area (lower back) (13.8%, n = 38), and groin (6.7%, n=19) (Figure 1). The most common injury types were as follows: sprains (27%, n = 76), lesions of the meniscus or cartilage (18.4%, n = 52), tendinosis/tendinopathy (13.1%, n = 37), strain/muscle rupture/tear (12.8%, n = 36), ligamentous rupture (6%, n = 17), fracture (4.3%, n = 12), and stress fracture (4.3%, n = 12) (Figure 2).

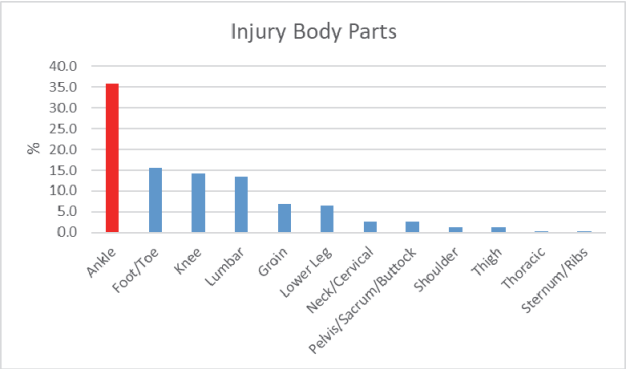

Figure 1. Injured body parts

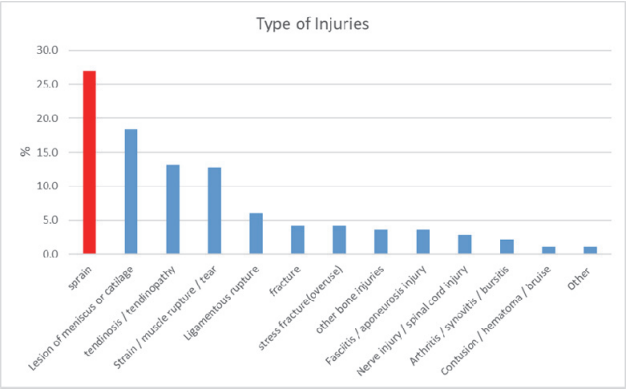

Figure 2. Types of injuries

4. Injury Mechanisms

The most common injury mechanisms were landing (37%, n = 106), taking off (19.9%, n = 56), hip flexion and extension (18.4%, n = 52), turns (8.2%, n = 23), relevés/pointes (5.7%, n = 16), and stretching (3.2%, n = 9) (Figure 3).

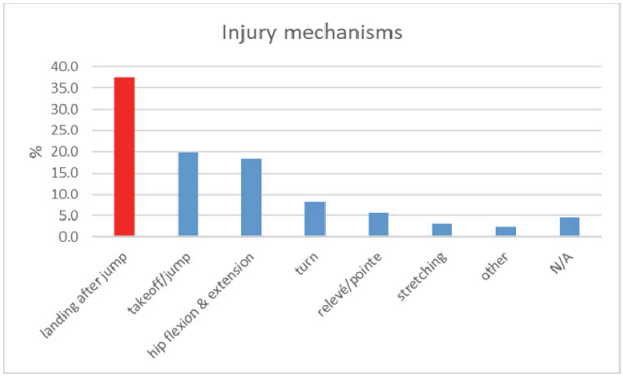

Figure 3. Injury mechanisms

5. Cause of Injury

The most common cause of injury was excessive training (44%, n = 124), followed by personal conditions (19.9%, n = 56), insufficient warm-ups (6.7%, n =19), lack of physical strength (6.7%, n = 19), pointe shoes (4.6%, n = 13), incorrect positioning (3.9%, n = 11), the auditorium environment (3.2%, n = 9), and extreme stress (2.8%, n = 8) (Figure 4).

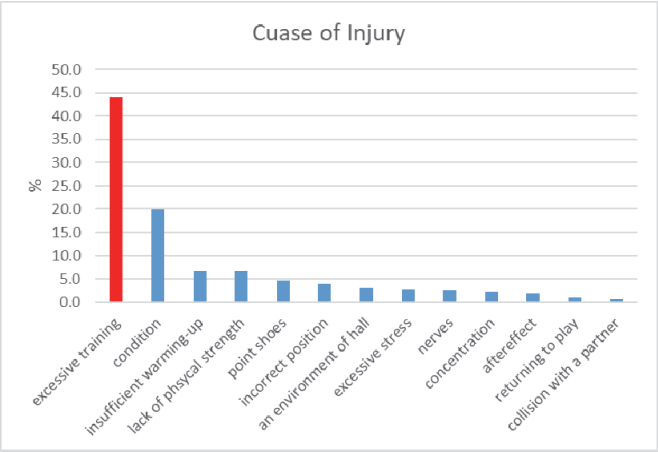

Figure 4. Cause of Injury

6. Injury Occurrences

Most of the preprofessional dancers' injuries occurred during class (56.0%, n = 158), followed by during practice for performance (19.9%, n = 56), during individual practice (16.3%, n = 46), during performance (3.2%, n = 9), and during stretching (3.2%, n = 9).

7. Injury with/without Pointe Shoes

The comparison of injuries sustained with and without pointe shoes yielded the result that students were injured more when they danced without pointe shoes (63%, n = 177) than when they danced with pointe shoes (37%, n = 105). However, the frequency analysis of injured body parts revealed that a higher proportion of lower leg injuries occurred when students wore pointe shoes. A chi-square test was used to specifically compare the proportions of injuries to the lower leg, Achilles' tendon, and ankle, and significant differences were found for all three body parts, except for the ribs. The results were significant that lower leg injuries showed x^2 = 4.69 (p = 0.04), Achilles tendon injuries showed x^2 = 5.13 (p = 0.03), and ankle injuries showed x^2 = 7.89 (p = 0.01). Alternatively, rib injuries showed x^2=1.69 (p = 0.37).

Ⅳ. Discussion

This epidemiological study of injury was conducted over one year for preprofessional ballet students. This study was a thesis that collected data using a web-based system, so lot of subjects from the diverse schools could participate. In addition, since the data was automatically collected it was impossible for researchers to intervene, so it can be said to be a more accurate research result. The total clinical incidence was 1.66 (95% CI, 1.47-1.86) and total IR per 1,000 DEs was 1.92 (95% CI, 2.59-3.27) over a year. This outcome was higher than that observed in previous studies for participants under similar conditions(Ekegren et al., 2014; Gamboa, Roberts, Maring, & Fergus, 2008). Unlike other studies, wherein physical therapists acquired information from registered injuries, here, study participants directly reported their injuries. It is possible that injuries were therefore reported more frequently. There is one study that showed a higher incidence rate of 4.14 (95% CI, 3.57-4.81); however, the results may have been biased owing to a small sample (n = 27)(Allen & Nevill, 2012).

The results of injury body parts in this study conform to the findings of previously conducted studies. The lower extremities are the most common injury sites, followed by the lumbar region(Ekegren et al., 2014). Thus, although a slight difference may be observed in the rankings accorded to injury sites by individual studies, including the present investigation, spine injuries and ankle, foot, and knee joints marked the most vulnerable body parts.

Unlike athletes, who have set seasons, professional dancers perform throughout the year. However, preprofessional dancers do not have as many performances as professional dancers, although they do have performances in which all students must participate as part of their college graduation requirements. In this study, the period was defined as on-season, and the highest number of injuries were reported during preseason. This result means that many injuries occurred in preparation for the on-season performance. The characteristic of the preseason is that the cold weather in winter and the end of semester and beginning of semester overlap. It means that the physical condition and the psychological factors may have contributed to the increase in injuries to students.

Ankle sprain occurring during repetitive landing damages the peroneus longus muscle, which maintains ankle eversion, and the tibialis anterior muscle, which maintains ankle dorsiflexion. In other words, strengthening the peroneus longus and tibialis anterior muscles increases ankle stability during hyper plantarflexion with open pack position. Therefore, strength training for these two muscles (Figure 5), which were antagonist to ankle sprain direction, is necessary to prevent ankle sprains (Lee, Lee, & Jung, 2017; Lee, & Ahn, 2017; Lee, Lee, & Han, 2001).

Unlike sports, ballet is a dance genre in which performers cannot wear protective gear or clothing. Ballet dancers must wear costumes that are as light as possible because they are required to exhibit the line of the body as it is and to make it look as beautiful as possible. Therefore, dancers need additional training to prevent injuries, and to prevent foot and ankle injuries,

balance training program is necessary(Spilken, 1990). Of course, dancers are better at balancing than ordinary people and sports players(Gerbino, Griffin, & Zurakowski, 2007). In other words, their proprioception ability is better; however, this adjudication is relative. The present study posits that dancers must be accorded the means to prevent injuries through additional strength training to improve their basic fitness along with much more difficult neurological training.

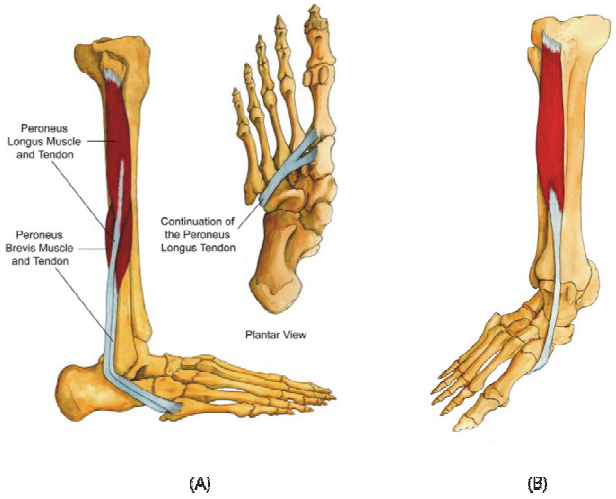

Figure 5. (A) Peroneus Longus Muscle, (B) Tibialis Anterior Muscle(Dubin, 2011)

When analyzing the causes of injury in ballet students in this study, following issues were identified: suboptimal (n = 56), insufficient warm-up (n = 19), and lack of physical strength (n = 19), which ranked the highest after excessive exercise. These causes can be mitigated through small changes, thereby reducing the incidence and severity of injuries. Insufficient warm-ups could be also ameliorated by donning thicker uniforms before classes or showering with warm water before practice sessions to elevate body temperature. Insufficient warm-ups also imply a lack of preparatory exercise. Schools must implement mandatory warm-up programs to reduce student injuries(Ekstrand, 1982). Taking a similar approach to this study, Allen & Nevilll(2012) surveyed professional ballet dancers and found that most injuries occurred during classes. In basic classes, students often begin immediately without doing a proper warm-up. Thus, the stress or concentration levels of students may be lower in class sessions than during rehearsals for performances, and such psychological factors could lead to injuries.

While overall injuries were more likely to occur when dancers did not wear pointe shoes (n = 177) than when they wore their pointe shoes (n = 105), lower limb injuries, including Achilles' tendon and ankle, showed higher incidences with pointe shoes. The plantar flexion is a very similar form to the pointe position (Figure 6). The plantarflexed position increases when dancers are dancing with pointe shoes. In ballet, the lisfranc injuries, ankle sprains, posterior ankle impingements, and flexor hallucis longus tendonitis are caused by plantar flexion, which is increased by the wearing of pointe shoes(Kadel, 2006; Wright, Neptune, van den Bogert, & Nigg,

2000). In the case of the lower leg and Achilles tendon injuries, the feet of dancers become hyper-plantarflexed by the wearing pointe shoes. These factors can also cause ankle injuries(Milan, 1994). Increased plantarflexed position at touchdown increases the chances of sprains. In addition, in the plantar flexion position, the usual mechanisms of ankle sprain injuries include improper jump landings and the rolling over of the lateral part of the foot while on demi-pointe(Kadel, 2006). Therefore, prevention strategies for ankle sprain may be applied to prevent injuries caused by jump landing and pointe shoes work that require excessive plantar flexion.

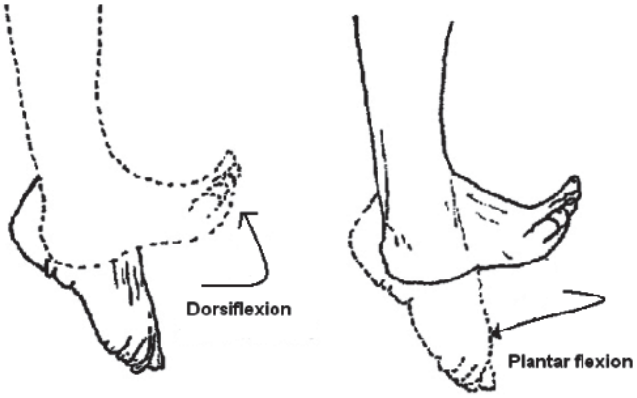

Figure 6. Ankle Plantarflexed Position(Kanthi, 2013)

In this study, we followed 170 subjects over 1 year and investigated various injury characteristics. The limitation of this study was that students from various universities were not recruited at the same rate. In addition, not only the data were collected by the dancers but also were not collected in real time. Thus, there may have been recall bias or faulty recollection. Considering this, future studies are necessary to collect injury data on a shorter term or in real time. In addition, to analyzing the mechanism of injury more accurately, consideration should have been done to recording their practice or class so that video analysis could be performed later. Future studies should continue to study the extant safety-related research on pointe shoes and to implement an ISS to prevent injuries and improve the performance of dancers.

V. Conclusion

This study investigated the injury characteristics of preprofessional ballet dancers through a continuous follow-up study for one year. As a result, the major findings of this study may be summarized as follows: 1) ankle sprain during landing was the most common injury and mechanism for ballet dancers and 2) overall, more injuries were sustained by students who danced without pointe shoes, but more injuries to lower leg sites occurred when students danced with pointe shoes.

The ultimate goal of this study is to investigate the various characteristics of ballet injuries in order to reduce the injuries suffered by ballet dancers, and to present important basic data for developing training methods or equipment to prevent injuries based on the results. Based on these data, students, dancers, teachers, trainers, and medical staff can develop effective preventive measures to prevent such injuries.

The reasons dancers get injured are very complex. Internal factors may be the amount of exercise, physical limitations, wrong technique, or even psychological problems. It can also be an external factors, such as the weather, dress condition, and practice room environment. Therefore, there is a need to conduct epidemiological studies to identify more diverse factors in future studies. The epidemiological studies will benefit the population suffering from ballet injuries not only in Korea but also around the world. Through continuous epidemiological studies, the risk factors of injury should be identified and analyzed to prevent injury, thereby creating an environment where dancers can live a healthier and longer life.

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초록

Preprofessional 발레 무용수의 부상: 병역학 연구

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발레 무용수는 운동선수만큼이나 높은 신체 활동을 요구하고, 따라서 이들에게 부상은 매우 빈번한 일이다. 부상에 대한 정보를 파악하여 상해 예방 전략 개발에 적용하기 위해서 역학 연구는 부상의 빈도, 메커니즘, 부위 등을 심도있게 파악하는 방식으로 수행되어야 한다. 본 연구는 1년 동안 세 차례에 걸쳐 웹기반 시스템을 통해 170명의 preprofessional 발레 무용수의 다양한 부상 특징을 수집하였다. 부상 발생률 / 1,000 시간, 급성 및 만성, 재발, 부상 위치, 유형 및 메커니즘 등이 분석되었고, 통계 프로그램은 Statistical Package for the Social Sciences 버전 23.0 (IBM Corp., Armonk, NY, USA) 및 Microsoft Excel (Microsoft Corp., Redmond, WA, USA)이 사용되었다. 170명의 무용수에게서 재발을 포함하여 282개의 부상이 나타났고 노출 시간은 96,717시간으로, incidence rate(IR)은 2.92/1,000 h (95% confidence interval, 2.59-3.27)으로 나타났다. 만성 및 급성 부상은 각각 40.4%와 37.4%였고, 1차 및 2차 재발은 각각 19.5%와 2.8%였다. 발목, 발/발가락, 무릎이 가장 많이 부상을 입은 신체 부위였고, 가장 흔한 부상 유형은 염좌, 연골 손상 및 건병증으로 확인되었다. 가장 흔한 부상 메커니즘은 점프 후 착지, 도약 시 및 엉덩관절 사용이었고, preprofessional 발레 무용수의 전체 부상 중 하지 부상의 비율은 포인트 슈즈를 작용했을 때 더욱 높게 차지하였다.

키워드 : 병역학, 부상 감시 시스템, 발레 무용수, 부상

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