applied sciences

MDPI

Article

Do Grade II Ankle Sprains Have Chronic Effects on the Functional Ability of Ballet Dancers Performing Single-Leg Flat-Foot Stance? An Observational Cross-Sectional Study

Bruno Dino Bodini [1], Giacomo Lucenteforte [2], Pietro Serafin [1], Lorenzo Barone [2], Jacopo A. Vitale [1,*], Antonio Serafin [1], Valerio Sansone [1,3] and Francesco Negrini [1]

1 IRCCS Istituto Ortopedico Galeazzi, Via Riccardo Galeazzi 4, 20161 Milan, Italy; bodinibruno@hotmail.com (B.D.B.); pietro.knw@gmail.com (P.S.); antonio.serafin@grupposandonato.it (A.S.); valerio.sansone@unimi.it (V.S.); francesco.negrini@gmail.com (F.N.)

2 Physical Medicine and Rehabilitation Residency Program, University of Catania, Piazza Università 2, 95124 Catania, Italy; giacomo.lucenteforte@outlook.com (G.L.); lorenzob100887@gmail.com (L.B.)

3 Department of Biomedical Sciences for Health, Università degli Studi di Milano, Via Mangiagalli 31, 20133 Milan, Italy

* Correspondence: jacopo.vitale@grupposandonato.it; Tel.: +39-026-621-4980

Received: 19 November 2019; Accepted: 18 December 2019; Published: 24 December 2019

check for updates

Abstract: Ballet dancers have a higher risk than the general population of ankle sprains. Ankle proprioception is of the utmost importance for executing static and dynamic positions typical of ballet dancing. Ankle sprains can create changes in functional ability that may affect ballet performance. The aim of this cross-sectional observational study is to evaluate if non-professional ballet dancers that were previously injured with a grade II ankle sprain carry a long-term stability deficit in ballet specific positions (passé, arabesque) and in single-leg flat-foot stance, thereby affecting ballet performance. We enrolled 22 amateur female ballet dancers, 11 who previously had a grade II ankle injury and 11 who had no history of ankle injury. Stabilometric data (Center of Pressure Speed and Elipse Area) were assessed with the postural electronic multisensory baropodometer in normal, arabesque, and passè positions with both open and closed eyes. Using an unpaired *t*-test, we compared healthy and pathological feet of the ankle injury group for a standard monopodalic position and two ballet-specific positions. No difference between pathological and healthy feet of non-professional ballet dancers who suffered grade II ankle injury was detected. According to the parameters considered in this study, grade II ankle sprains seem to have a favorable prognosis in the sample that we evaluated.

Keywords: stabilometry; ballet dancers; ankle injury; chronic ankle instability; balance

1. Introduction

During performance, ballet dancers have a great need for stability and balance control [1,2], along with a high level of general "flexibility", which are peculiar characteristics that improve with ballet training [1,3–5]. Ankle control is of the utmost importance for executing static and dynamic positions typical of ballet dancing [6,7]. In 2017, Vassallo et al. reported the epidemiology of dance-related injuries between 2000 and 2013, defining ankle sprains as the most common injury [8]. Later, Smith et al. and Smith et al. collected data about their incidence and prevalence [9,10]. Ankle sprains could cause chronic functional ability changes, as is common in groups of dancers and non-dancers alike [11,12], also increasing the risk of re-injury [13]. In addition, it was seen that people with functional ankle instability had a less refined kinesthesia, in particular for inversion movements [14]. However, a prospective study conducted in 1996 by Leanderson et al., based on stabilometry, demonstrated only short-term consequences after ankle sprain in ballet dancers [15]. Data about chronic ankle instability (CAI) in the general sporting population are, to date, not satisfactory to determine the presence of common aspects of CAI within individual sports [16]. However, an exploratory study conducted by Simon et al. revealed a condition of CAI in 75.9% of university dance majors [17]. Despite new wearable technologies, such as Inertial Measurement Unit IMU [18,19] and wireless electromyography (EMG) [20], having been proposed to investigate balance and postural control, stabilometry remains the most commonly used tool [21]. To date, there is a lack of studies about the chronic effects of an ankle injury in ballet dancers using stabilometry evaluation, but there is an increasing body of literature concerning this method [22,23], including not previously injured ballet dancers [24]. A study performed by Lin et al., using stabilometry to assess dancers with ankle injuries, found that non-acute ankle injuries could worsen postural stability of professional ballet-dancers during ballet-specific postures. However, they did not focus on a specific injury nor on a precise time-frame for the post-injury evaluation [25]. Another relevant aspect in the evaluation of balance control is represented by the visual system's role in proprioception, which has the potential to mask proprioceptive issues in athletes [26]. For this reason, it can be argued that in order to obtain reliable proprioceptive measures, visual occlusion is mandatory [27,28]. As ankle control is crucial for successfully executing ballet specific positions and it could be impaired in ankle sprains, a position specific testing with closed eyes is needed. Moreover, some studies showed that athletic and sport training is task specific and skills acquired in a specific task did not completely translate to the same skills in different tasks [29–31]. Recently, Thalassinos et al. discovered that there were many sport skill-specific bias about sensory inputs for spatial orientation and postural control between experienced soccer athletes, ballet dancers, and nonathletes [32]. Considering the high incidence and prevalence of ankle injuries in professional and non-professional ballet dancers (from 3% to 25.6% of all musculoskeletal ballet injuries [4,8,10,33]), and the primary role of ankle control to perform ballet-specific tasks, the aim of our study was to understand if non-professional ballet dancers, previously injured with a grade II ankle sprain, compared to dancers who did not suffer any ankle injury, carry a long-term stability deficit in ballet specific positions (passé, arabesque), thereby affecting ballet performance.

2. Materials and Methods

This was a cross-sectional observational multi-center study. We enrolled 22 subjects (N = 11 in the pathological group and N = 11 in the control group) from six different schools of classical ballet dance in Italy. The inclusion criteria were: age between 15 and 25 years old; classical ballet dancer; at least 10 years of training (average of 2–3 sessions of training a week); right footed in ballet practice; unilateral ankle injuries; clinical diagnosis of grade II inversion right ankle sprain that occurred at least 6 months before our evaluations made by an orthopedic surgeon [34]; and informed consent signed (parents' consent was collected if subjects were under 18 years old). The exclusion criteria were: professional dancer; another lower extremity injury; history of neurological or motor deficits; and any visual impairment. The control group had the same inclusion and exclusion criteria, except for the history of ankle injury. For grading the severity of the ankle injury, we used the classification proposed by Malliaropoulos et al. [34], and classified grade II ankle injury patients positive to anterior drawer test but negative to talar tilt test. We defined grade II ankle injury as a partial tear of the lateral ligament complex of the ankle without decreased motion and loss of function. All pathological subjects were treated conservatively with soft bandages applied for 2 weeks. No patient underwent a specific rehabilitation protocol. At the moment of inclusion in the study, all patients were symptom free and fully participating in dance at their pre-injury level. Before entering the study, the participants were fully informed about the study's aims and procedures, and written informed consent was obtained before testing. The study protcol was approved by the Ethics Committee of the University of Milan (approved on 12/10/15, Prot. N. 54/15) in accordance with current national and international laws and regulations governing the use of human subjects (Declaration of Helsinki II).

3. Sample Size Calculation

In order to determine the sample size of the study, we carried out an a-priori power analysis on the basis of the scientific literature. Since our main outcome was to determine if there was a difference in monopodalic stance ellipse area between healthy and previously pathological ballet dancers, we used data from the 2017 paper by de Mello et al. [24]. With a reported monopodalic ellipse area in ballet dancers of 155 ± 64 mm^2 and an expected difference of 70 mm^2 (effect size = 1.1), we calculated that we would need a sample of 22 subjects (11 for each group) to detect a significant change with a power of 0.80 and an alpha of 0.05. To calculate the sample size, we used the GPower software (Universitat Dusseldorf-Germany).

4. Tools and Procedures

The internationally approved stabilometric parameters [35] we evaluated in this paper are: (1) Ellipse area (mm^2), contains 90% of the positions sampled of the center of pressure (CoP) and represents the dispersion of the oscillations and the precision of the system; and (2) CoP speed (mm/s), the average speed related to the CoP oscillations. The acquisition of stabilometric data was performed with the postural electronic multisensory baropodometer Diasu®, equipped with Milletrix® interface, which has previously been shown to be a valid and reliable tool [36] This tool features a scanning frequency of 100 frames per second in real time, acquisition surface of 40 cm^2 per module, accuracy of +/−5%, and maximum point pressure of 150 N/cm^2. The evaluations were carried out in six different gyms with a dedicated medical room, characterized by the absence of external perturbations, especially acoustic. Prior to the test, each dancer stretched and warmed up the muscles of the lower limbs via routine self-selected exercises for 5 min. Each dancer wore comfortable and adherent clothes, and a pair of cotton socks.

During the test, an expert podiatrist and a nurse were present in the room. The baropodometer was placed at a distance of two meters from a homogeneous color wall that the subjects faced during the whole time of examination. Each evaluation session was held in the early afternoon and each subject had to be at rest from training in the previous day. The subjects were evaluated with both eyes open and closed. To ensure a reference point to be observed during acquisitions, a mark was positioned on the wall at the same height and equidistant to the patient's eyes, and at a distance of 2 m. We acquired each measurement three times with eyes open and three times with eyes closed. The first try was considered as a demonstration and we did not record it. For each foot we tested, the patients in the following conditions both with eyes opened and closed.

Monopodalic stance with the contralateral limb slightly detached from the ground (5 s length) (Figure 1).

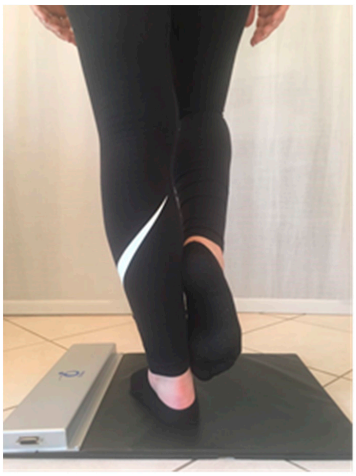

Figure 1. Monopodalic position.

Monopodalic with the limb in contact with the ground in "en dehors" position, and the contralateral in "arabesque" position, defining a 45° angle between them (5 s length) (Figure 2).

Figure 2. Arabesque.

Monopodalic with the limb in contact with the ground in "en dehors" position and the contralateral in "passé" position with a back "retiré" (5 s length) (Figure 3).

Figure 3. Passè.

5. Statistical Analysis

For each subject, parameters were determined by calculating the mean of the trials; subsequently, the grand average and the standard deviation over the subjects in each position were computed. Preliminary tests for normality (Kolmogorov-Smirnov test) and for equality of sample variances (Levene's test) provided the basis for using parametric statistics. All parameters were normally distributed. First, we checked if there were any significant statistical differences between the two groups as far as age, body mass index (BMI), years of dance practice, or age when they started practicing using an unpaired Student's *t*-test. Second, we compared stabilometric parameters, of each position, between the left and right foot in healthy subjects, and between injured and non-injured feet in the post-injury patients by the unpaired Student's *t*-test. Third, the difference between open and closed eyes in each condition, for each foot, was calculated; then, we checked if the differences in stabilometric parameters between closed and open eyes were larger in pathological vs. healthy feet using the unpaired Student's *t*-test. The level of significance was set to $p < 0.05$. Statistical analysis was performed using IBM SPSS 20.

6. Results

Demographical data of the study population are shown in Table 1. We could not find any statistical difference between the two groups for the parameters of age, BMI, years of dance practice, or age when they started practicing.

Table 1. Demographical data of participants.

	Post-Injury (N = 11)	Healthy (N = 11)	*p*-Values
Age (years)	16.36 ± 2.81	17.5 ± 3.37	>0.05
BMI (Kg/m^2)	19.85 ± 2.43	19.37 ± 2.33	>0.05
Years of Practice	11.91 ± 2.11	12.37 ± 4.07	>0.05
Age When They Started Practicing (years)	4.36 ± 1.23	5.18 ± 1.47	>0.05

Data are reported as Mean ± SD. Abbreviation: BMI, body mass index.

First, we analyzed the healthy subjects. We compared stabilometric parameters of the right and left feet for each parameter and no statistical differences for all parameters were detected (Table 2).

Table 2. Comparison between right and left foot in healthy subjects (N = 11) for stabilometric parameters acquired with open eyes.

	Right Foot	Left Foot	*p*-Values
Monopodalic Ellipse Area (mm^2)	105.91 ± 67.87	82.06 ± 47.43	>0.05
Monopodalic CoP Speed (mm/s)	13.84 ± 3.24	13.20 ± 5.34	>0.05
Arabesque Ellipse Area (mm^2)	274.40 ± 255.50	152.23 ± 87.54	>0.05
Arabesque CoP Speed (mm/s)	21.84 ± 8.46	19.65 ± 5.60	>0.05
Passè Ellipse Area (mm^2)	222.49 ± 130.06	133.26 ± 72.00	>0.05
Passè CoP Speed (mm/s)	22.22 ± 4.98	18.17 ± 5.58	>0.05

The pathological group was then analyzed. We compared stabilometric parameters between the injured feet and the healthy feet and no statistically significant differences were observed (Table 3).

Table 3. Comparisons between injured and healthy feet in pathological subjects (N = 11) for stabilometric parameters acquired with open eyes.

	Trauma	No Trauma	*p*-Values
Monopodalic Ellipse Area (mm^2)	128.25 ± 93.83	83.23 ± 49.15	>0.05
Monopodalic CoP Speed (mm/s)	14.23 ± 5.05	13.28 ± 5.55	>0.05
Arabesque Ellipse Area (mm^2)	165.17 ± 127.18	117.16 ± 59.89	>0.05
Arabesque CoP Speed (mm/s)	19.32 ± 4.38	18.54 ± 5.63	>0.05
Passè Ellipse Area (mm^2)	148.15 ± 82.43	119.66 ± 66.75	>0.05
Passè CoP Speed (mm/s)	20.75 ± 6.92	18.58 ± 5.97	>0.05

Data are reported as Mean ± SD. Abbreviation: CoP, Centre of Pressure.

We calculated the differences between open and closed eyes for all the parameters, and with reference to the pathological group, data collected with the feet that suffered a grade II ankle injury were compared with healthy contralateral limbs. As reported in Table 4, no significant differences between the sides were observed.

Lastly, we also compared right foot parameters of healthy and pathological subjects, both with open eyes (Table 5) and the difference between open and closed eyes (Table 6), and no significant differences were detected.

Table 4. Comparison between injured and healthy feet in pathological subjects (N = 11). Mean delta values (difference between open and closed eyes) of stabilometric parameters.

	Trauma	No Trauma	*p*-Values
Monopodalic Ellipse Area (mm^2)	321.47 ± 151.77	358.42 ± 310.67	>0.05
Monopodalic CoP Speed (mm/s)	15.77 ± 3.77	16.88 ±7.81	>0.05
Arabesque Ellipse Area (mm^2)	449.63 ± 203.33	440.82 ±378.02	>0.05
Arabesque CoP Speed (mm/s)	15.28 ± 9.60	15.29 ±9.60	>0.05
Passè Ellipse Area (mm^2)	330.93 ± 294.15	302.69 ± 216.10	>0.05
Passè CoP Speed (mm/s)	16.90 ± 9.22	12.66 ± 7.53	>0.05

Data are reported as Mean ± SD. Abbreviation: CoP, Centre of Pressure.

Table 5. Comparison between right feet of pathological and healthy subjects for stabilometric parameters acquired with open eyes.

	Right Foot Post-Injury (N = 11)	Right Foot Healthy (N = 11)	*p*-Values
Monopodalic Ellipse Area (mm^2)	105.91 ± 67.87	128.25 ± 93.83	>0.05
Monopodalic CoP Speed (mm/s)	13.84 ± 3.24	14.23 ± 5.05	>0.05
Arabesque Ellipse Area (mm^2)	274.40 ± 255.50	165.17 ± 127.18	>0.05
Arabesque CoP Speed (mm/s)	21.84 ± 8.46	19.32 ± 4.38	>0.05
Passè Ellipse Area (mm^2)	222.49 ± 130.06	148.15 ± 82.43	>0.05
Passè CoP Speed (mm/s)	22.22 ± 4.98	20.75 ± 6.92	>0.05

Data are reported as Mean ± SD. Abbreviation: CoP, Centre of Pressure.

Table 6. Comparison between right foot of pathological and healthy subjects. Mean delta values (difference between open and closed eyes) of stabilometric parameters.

	Right Foot POST-Injury (N = 11)	Right Foot Healthy (N = 11)	*p*-Values
Monopodalic Ellipse Area (mm^2)	321.47 ± 151.77	397.47 ± 252.87	>0.05
Monopodalic CoP Speed (mm/s)	15.77 ± 3.77	15.85 ± 5.29	>0.05
Arabesque Ellipse Area (mm^2)	449.63 ± 203.33	307.73 ± 252.13	>0.05
Arabesque CoP Speed (mm/s)	15.28 ± 9.60	14.64 ± 5.04	>0.05
Passè Ellipse Area (mm^2)	330.93 ± 294.15	294.46 ± 85.47	>0.05
Passè CoP Speed (mm/s)	16.90 ± 9.22	15.32 ± 7.14	>0.05

Data are reported as Mean ± SD. Abbreviation: CoP, Centre of Pressure.

7. Discussion

Our study showed that there is no ballet specific long-term balance deficit for grade II ankle injuries in ballet dancers. In order to have this specific conclusion, we checked if our sample of non-professional, but experienced, ballet dancers had any difference in balance while performing ballet specific positions on the dominant or non-dominant foot. We did not find any difference between the two sides. This finding is in contrast with a classic study performed by Leanderson et al. in 1996, where they tested professional athletes and non-athletes in the monopodalic position [15]. However, the study cited is 22 years older, so training techniques and materials such as shoes have changed, and are performed in a different, monocentric, and professional setting. This could very well explain the differences found. Moreover, the verified parameters of validity and reliability of the tools we used [36] and the power set at 80% for the sample size calculation, could be some of the reasons of the differences found between the outcomes of our study and the study published by Leanderson et al. Since the right and left foot were found to have no difference in the healthy group, we compared injured and non-injured side of our pathological group. We found out that, after six months, there was no significant difference in balance between the injured and non-injured sides. The internal (same subject) comparison is of the utmost importance, as any kind of difference in training could be an important bias [37]. In fact, using the contralateral healthy feet as a control, we were able to eliminate biases caused by potential differences in skills, body types, and other physical characteristics between athletes. Recently, a few studies pointed out that a crossover effect of injuries can exist, especially tendinitis, from one side to the other [38,39]. While it is not clear the mechanism of action of this crossover effect (e.g., central nervous system or anticipatory postural adjustments [40]), it still could be a possible confounder of our results as the pathological and healthy side could be similar because of it. Our study arrived to a different conclusion than a similar 2011 study [25]; however, we focused on a more selective group of subjects who had only grade II ankle injury. We supposed that patients with more severe ankle sprains could have long-term impairment in postural control.

One strength of our study was the use of stabilometry in a new way, comparing ballet-specific static positions for determining ankle injury effects. We found just two studies that examined ballet-specific positions; one examined the single-leg retiré position [37] and the other the passé en demi-pointe position [24]. However, neither of the studies focused on post-injury athletes. Another strength of the study was the comparison between healthy and injured feet in the same athletes that eliminate the role of possible differences in skills between different subjects, allowing us to better study the role of the previous ankle injury. Furthermore, we recruited the subjects in six different ballet schools. Different centers have different training strategies, so the results obtained are probably not linked to a peculiar type of training but to the natural history of grade II ankle injuries.

A limitation of our study is the small number of subjects involved; however, we enrolled 22 patients (11 for each group) as resulted with the sample size calculation. Our inclusion criteria were very strict to guarantee the internal validity of our study, and despite screening six different centers, we were able to find 11 patients meeting the required inclusion criteria for the pathological subjects group. Furthermore, because of our study design, we cannot exclude an important role of specific rehabilitation protocol in speeding up the recovery process, as we tested our patients long after their injury.

In the future, it could be important to study in a similar fashion different grades of ankle injuries, classified using imaging support, as well as different types of ankle injuries, such as inversion and eversion. Moreover, it could be interesting to evaluate the parameters used in our study in relevé, another ballet-specific position. One more possible future study could investigate the role of treatment (e.g., immobilization (functional or rigid) vs. no immobilization) and rehabilitation in the time to return to optimal performance as well as potential long-term effects in ankle injuries of higher clinical grading.

Our finding could encourage many dancers all over the world that suffered and will suffer ankle injuries [8]. Dancers with a grade II ankle injury should be reassured by clinicians that their functional ability as ballet dancers performing single-leg flat-foot stance will likely not be hindered in the long term.

8. Conclusions

Our findings show that grade II ankle injury does not compromise the ability of a ballet dancer, even if treated with just soft bandage applied for two weeks, even without a specific rehabilitation protocol.

Author Contributions: B.D.B., G.L., P.S., and F.N. designed the present study, checked the literature, and wrote the manuscript; J.A.V. performed the statistical analysis; L.B., J.A.V., A.S., and V.S. critically revised the manuscript; all authors gave the approval for the final version of the review submitted for publication. All authors have read and agreed to the published version of the manuscript.

Funding: This work was supported by the Italian Ministry of Health (Ricerca Corrente).

Conflicts of Interest: The authors have no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

References

1. Steinberg, N.; Tenenbaum, S.; Stern, M.; Zeev, A.; Siev-Ner, I. The association between menarche, intensity of training and passive joint ROM in young pre-professional female dancers: A longitudinal follow-up study. *Phys. Ther. Sport* **2018**, *32*, 59–66. [CrossRef]
2. Krityakiarana, W.; Jongkamonwiwat, N. Comparison of Balance Performance between Thai Classical Dancers and Non-Dancers. *J. Dance Med. Sci.* **2016**, *20*, 72–78. [CrossRef]
3. Tekin, D.; Agopyan, A.; Baltaci, G. Balance Training in Modern Dancers: Proprioceptive-Neuromuscular Training vs. Kinesio Taping. *Med. Probl. Perform. Art.* **2018**, *33*, 156–165. [CrossRef] [PubMed]
4. Bruyneel, A.V.; Mesure, S.; Paré, J.C.; Bertrand, M. Organization of postural equilibrium in several planes in ballet dancers. *Neurosci. Lett.* **2010**, *485*, 228–232. [CrossRef]
5. Yin, A.X.; Geminiani, E.; Quinn, B.; Owen, M.; Kinney, S.; McCrystal, T.; Stracciolini, A. The Evaluation of Strength, Flexibility, and Functional Performance in the Adolescent Ballet Dancer during Intensive Dance Training. *PM & R* **2019**, *11*, 722–730.
6. Krasnow, D.; Wilmerding, M.V.; Stecyk, S.; Wyon, M.; Koutedakis, Y. Biomechanical research in dance: A literature review. *Med. Probl. Perform. Art.* **2011**, *26*, 3–23. [PubMed]
7. da Silveira Costa, M.S.; de Sá Ferreira, A.; Felicio, L.R. Static and dynamic balance in ballet dancers: A literature review. *Fisioter. Pesqui.* **2013**, *20*, 299–305.
8. Vassallo, A.J.; Hiller, C.; Stamatakis, E.; Pappas, E. Epidemiology of Dance-Related Injuries Presenting to Emergency Departments in the United States, 2000-2013. *Med. Probl. Perform. Art.* **2017**, *32*, 170–175. [CrossRef]
9. Smith, T.O.; Davies, L.; de Medici, A.; Hakim, A.; Haddad, F.; Macgregor, A. Prevalence and profile of musculoskeletal injuries in ballet dancers: A systematic review and meta-analysis. *Phys. Ther. Sport* **2016**, *19*, 50–56. [CrossRef]
10. Smith, P.J.; Gerrie, B.J.; Varner, K.E.; McCulloch, P.C.; Lintner, D.M.; Harris, J.D. Incidence and Prevalence of Musculoskeletal Injury in Ballet: A Systematic Review. *Orthop. J. Sports Med.* **2015**, *3*. [CrossRef]
11. Lin, C.-W.; Su, F.-C.; Lin, C.-F. Influence of ankle injury on muscle activation and postural control during ballet grand plié. *J. Appl. Biomech.* **2014**, *30*, 37–49. [CrossRef] [PubMed]
12. Glencross, D.; Thornton, E. Position sense following joint injury. *J. Sports Med. Phys. Fitness* **1981**, *21*, 23–27. [PubMed]
13. Malliaropoulos, N.; Ntessalen, M.; Papacostas, E.; Longo, U.G.; Maffulli, N. Reinjury after acute lateral ankle sprains in elite track and field athletes. *Am. J. Sports Med.* **2009**, *37*, 1755–1761. [CrossRef] [PubMed]
14. Sousa, A.S.P.; Leite, J.; Costa, B.; Santos, R. Bilateral Proprioceptive Evaluation in Individuals with Unilateral Chronic Ankle Instability. *J. Athl. Train.* **2017**, *52*, 360–367. [CrossRef] [PubMed]
15. Leanderson, J.; Eriksson, E.; Nilsson, C.; Wykman, A. Proprioception in classical ballet dancers. A prospective study of the influence of an ankle sprain on proprioception in the ankle joint. *Am. J. Sports Med.* **1996**, *24*, 370–374. [CrossRef] [PubMed]
16. Attenborough, A.S.; Hiller, C.E.; Smith, R.M.; Stuelcken, M.; Greene, A.; Sinclair, P.J. Chronic ankle instability in sporting populations. *Sports Med. Auckl. NZ* **2014**, *44*, 1545–1556. [CrossRef]
17. Simon, J.; Hall, E.; Docherty, C. Prevalence of chronic ankle instability and associated symptoms in university dance majors: an exploratory study. *J. Dance Med. Sci.* **2014**, *18*, 178–184. [CrossRef]
18. Fusca, M.; Negrini, F.; Perego, P.; Magoni, L.; Molteni, F.; Andreoni, G. Validation of a Wearable IMU System for Gait Analysis: Protocol and Application to a New System. *Appl. Sci.* **2018**, *8*, 1167. [CrossRef]
19. Ghislieri, M.; Gastaldi, L.; Pastorelli, S.; Tadano, S.; Agostini, V. Wearable Inertial Sensors to Assess Standing Balance: A Systematic Review. *Sensors* **2019**, *19*. [CrossRef]
20. Lee, Y.-J.; Liang, J.N.; Wen, Y.-T. Characteristics of Postural Muscle Activity in Response to a Motor-Motor Task in Elderly. *Appl. Sci.* **2019**, *9*, 4319. [CrossRef]
21. McKeon, P.O.; Hertel, J. Systematic review of postural control and lateral ankle instability, part I: Can deficits be detected with instrumented testing. *J. Athl. Train.* **2008**, *43*, 293–304. [CrossRef] [PubMed]
22. Nardone, A.; Godi, M.; Grasso, M.; Guglielmetti, S.; Schieppati, M. Stabilometry is a predictor of gait performance in chronic hemiparetic stroke patients. *Gait Posture* **2009**, *30*, 5–10. [CrossRef] [PubMed]
23. Bruyneel, A.-V.; Humbert, A.; Bertrand, M. Comparison of balance strategies in mountain climbers during real altitude exposure between 1.500m and 3.200m: Effects of age and expertise. *Neurosci. Lett.* **2017**, *657*, 16–21. [CrossRef] [PubMed]

24. de Mello, M.C.; de Sá Ferreira, A.; Ramiro Felicio, L. Postural Control During Different Unipodal Positions in Professional Ballet Dancers. *J. Dance Med. Sci.* **2017**, *21*, 151–155. [CrossRef] [PubMed]
25. Lin, C.-W.; Lin, C.-F.; Hsue, B.-J.; Su, F.-C. A comparison of ballet dancers with different level of experience in performing single-leg stance on retiré position. *Motor Control* **2014**, *18*, 199–212. [CrossRef] [PubMed]
26. Witchalls, J.; Waddington, G.; Adams, R.; Blanch, P. Evaluation of the relative contribution of peripheral and focal vision to proprioceptive differentiation of underfoot inversion angles in young elite athletes. *Percept. Mot. Skills* **2013**, *117*, 923–934. [CrossRef]
27. Han, J.; Anson, J.; Waddington, G.; Adams, R.; Liu, Y. The Role of Ankle Proprioception for Balance Control in relation to Sports Performance and Injury. *BioMed Res. Int.* **2015**, *2015*, 842804. [CrossRef]
28. Marulli, T.A.; Harmon-Matthews, L.E.; Davis-Coen, J.H.; Willigenburg, N.W.; Hewett, T.E. Eyes-Closed Single-Limb Balance is Not Related to Hypermobility Status in Dancers. *J. Dance Med. Sci.* **2017**, *21*, 70–75. [CrossRef]
29. Casabona, A.; Leonardi, G.; Aimola, E.; La Grua, G.; Polizzi, C.M.; Cioni, M.; Valle, M.S. Specificity of foot configuration during bipedal stance in ballet dancers. *Gait Posture* **2016**, *46*, 91–97. [CrossRef]
30. Asseman, F.; Caron, O.; Crémieux, J. Is there a transfer of postural ability from specific to unspecific postures in elite gymnasts? *Neurosci. Lett.* **2004**, *358*, 83–86. [CrossRef]
31. Giboin, L.-S.; Gruber, M.; Kramer, A. Three months of slackline training elicit only task-specific improvements in balance performance. *PLoS ONE* **2018**, *13*, e0207542. [CrossRef] [PubMed]
32. Thalassinos, M.; Fotiadis, G.; Arabatzi, F.; Isableu, B.; Hatzitaki, V. Sport Skill-Specific Expertise Biases Sensory Integration for Spatial Referencing and Postural Control. *J. Mot. Behav.* **2018**, *50*, 426–435. [CrossRef] [PubMed]
33. Biernacki, J.L.; Stracciolini, A.; Fraser, J.; Micheli, L.J.; Sugimoto, D. Risk Factors for Lower-Extremity Injuries in Female Ballet Dancers: A Systematic Review. *Clin. J. Sport Med.* **2018**. [CrossRef] [PubMed]
34. Malliaropoulos, N.; Papacostas, E.; Papalada, A.; Maffulli, N. Acute lateral ankle sprains in track and field athletes: an expanded classification. *Foot Ankle Clin.* **2006**, *11*, 497–507. [CrossRef]
35. Scoppa, F.; Capra, R.; Gallamini, M.; Shiffer, R. Clinical stabilometry standardization: Basic definitions–acquisition interval–sampling frequency. *Gait Posture* **2013**, *37*, 290–292. [CrossRef]
36. Cuccia, A.M. Validity and reliability of spatio-temporal gait parameters in adolescents. *Iran. J. Pediatr.* **2013**, *23*, 610–611.
37. Lin, C.-W.; Chen, S.-J.; Su, F.-C.; Wu, H.-W.; Lin, C.-F. Differences of ballet turns (pirouette) performance between experienced and novice ballet dancers. *Res. Q. Exerc. Sport* **2014**, *85*, 330–340. [CrossRef]
38. Sansone, V.; Maiorano, E.; Applefield, R.C.; Gandola, M.; Negrini, F. Strength Reduction in Unilateral Shoulder Pain: Is the Healthy Side Really Healthy in Rotator Cuff Disease? *Am. J. Phys. Med. Rehabil.* **2019**, *98*, 382–386. [CrossRef]
39. Heales, L.J.; Lim, E.C.W.; Hodges, P.W.; Vicenzino, B. Sensory and motor deficits exist on the non-injured side of patients with unilateral tendon pain and disability–implications for central nervous system involvement: a systematic review with meta-analysis. *Br. J. Sports Med.* **2014**, *48*, 1400–1406. [CrossRef]
40. Cavallari, P.; Bolzoni, F.; Bruttini, C.; Esposti, R. The Organization and Control of Intra-Limb Anticipatory Postural Adjustments and Their Role in Movement Performance. *Front. Hum. Neurosci.* **2016**, *10*, 525. [CrossRef]