Comparative study of the force-velocity profile with different starting positions of the vertical jump in dance

Estudio comparativo del perfil fuerza-velocidad con diferentes posiciones de partida del salto vertical en danza

***Adriana Vieiro Pérez*[1]**

***Salvador Romero-Arenas*[1]**

[1]Facultad de Deporte, Universidad Católica de Murcia, Murcia, Spain

Correspondence:
Salvador Romero-Arenas
sromero@ucam.edu

Short title:
Force-velocity profile in dance

How to cite this article:
Vieiro, A. & Romero-Arenas, S. (2023). Comparative study of the force-velocity profile with different starting positions of the vertical jump in dance. *Cultura, ciencia y deporte*, *18*(56), 35-50. https://doi.org/10.12800/ccd.v18i56.1811

Received: 27 September 2021 / ***Accepted:*** 30 September 2022

Abstract

The purpose of this study was to compare the mechanical variables of the force-velocity profile during the jump starting from the en dehors position versus the parallel position in students of the university degree in Dance. The sample consisted of 22 dancers with 10.7±5.96 years of experience. A vertical jump test was performed in which each participant performed eight jumps with progressive increases in load, alternating the positions of feet in dehors and in parallel. All the jumps were recorded with an iPad at 240 Hz, and later analyzed with the application for iOS MyJump2. The following variables were analyzed: jump height, maximum theoretical force, maximum theoretical velocity, maximum power, and force-velocity profile. The results showed a difference between the jump height starting from the en dehors position versus the parallel position (en dehors: 18.8±3.44 vs parallel: 20.3±3.57 cm; p=0.002). The analysis of the force-velocity profile showed a force deficit in both situations, being more accentuated when the jump was executed from a starting position en dehors (en dehors: 43.0±46.24 vs parallel: 70.9±21.21%; p=0.022). The individualization of training programs focused on reducing the imbalance of each dancer and in each position, could help dancers to improve the height of the jump and therefore the performance of the dance.

Key words: en dehors, ballet, performance, profile force-velocity.

Resumen

El objetivo del presente trabajo fue comparar las variables mecánicas del perfil fuerza-velocidad durante el salto partiendo de una posición en dehors frente a una posición en paralelo en estudiantes del grado universitario en Danza. La muestra estuvo compuesta por 22 bailarinas con 10,7±5,96 años de experiencia. Se realizó un test de salto vertical en el que cada participante ejecutó ocho saltos con incrementos progresivos de carga, alternando las posiciones de pies en dehors y en paralelo. Todos los saltos fueron grabados con un iPad a 240 Hz, y posteriormente analizados con la aplicación para iOS MyJump2. Se analizaron las variables: altura del salto, fuerza teórica máxima, velocidad teórica máxima, potencia máxima, perfil fuera-velocidad. Los resultados mostraron una diferencia entre la altura del salto partiendo de la posición en dehors frente a la posición de paralelo (en dehors: 18,8±3,44 vs paralelo: 20,3±3,57 cm; p=0,002). El análisis del perfil fuerza-velocidad mostró un déficit fuerza en ambas situaciones, siendo más acentuado cuando el salto se ejecutada desde una posición de partida en dehors (en dehors: 43,0±46,24 % vs paralelo: 70,9±21,21%; p=0,022). La individualización de los programas de entrenamiento centrados en reducir el desequilibrio de cada bailarina y en cada posición, podría ayudar a las bailarinas a mejorar la altura del salto y, por tanto, el rendimiento de la danza.

Palabras clave: en dehors, ballet, rendimiento, perfil fuerza-velocidad.

This work is licensed under a Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International License.

Introduction

The *en dehors* or "turn out" is the basic technical foundation of classical dance. It consists of the external rotation of the coxo-femoral joint, with the involvement of the rest of the leg: external rotation of the knee, external torsion of the tibial, and abduction of the plantar footprint in the metatarsal joint (Bueno Aranzabal, 2016; Kushner et al., 1990). The aim is to rotate each leg 90º, thus forming an angle of 180º with both feet (Gómez-Lozano & Vargas-Macías, 2010; Massó Ortigosa, 2012). Although its origin is not clear, this position may have arisen with an aesthetic purpose, to show the heels of the dancers to the public or also to offer the viewer the vision of the body of the dancer in front in its maximum silhouette (Abad Carlés & Burell, 2012; Alemany Lázaro, 2009). However, Carlo Blasis already justifies the use of *en dehors* in the nineteenth century for practical-anatomical reasons, above the aesthetic importance prevailing until that time (Abad Carlés & Burell, 2012). But this external rotation could be a limitation to an element widely used in dance, such as jumping. (Bazán et al., 2016; Kushner et al., 1990). In classical dance, jumps are of great importance and reaffirm the philosophy of weightlessness. (Angioi et al., 2009; Bazán et al., 2016; Brown et al., 2007; Harley et al., 2002). The search for elevation requires an upright body position, playing a fundamental role in the external rotation of the hip. The *en dehors favors* verticality and balance, and provides a greater range of abduction, but can limit the execution of jumps (Bazán et al., 2016). On the other hand, in contemporary dance, jumps are used as a dramatic resource, with freer and more natural movements. (Angioi et al., 2009).

Most ballet sessions involve complex, controlled, and precise movements followed by ballistic actions such as jumps. Jumping ability has been identified as one of the best predictors of performance in dance; those dancers who are able to jump higher will be able to implement a greater variety of skills to perform the aesthetic components of the choreography. (Harley et al., 2002). This height of the jump is influenced by biomechanical and physiological factors of each dancer and determined by the take-off speed which in turn depends on the force produced by the lower extremities during the thrust. (Jarvis & Kulig, 2016; Jiménez-Reyes et al., 2017b). This relationship, force-velocity (F-V), informs us of the physical abilities of the dancer, evaluates neuromuscular performance, and tells us if the power developed in the jump is mainly due to the force or velocity with which it is executed. (Samozino et al., 2014). Samozino et al. (2010) concluded that variations of 10% in maximum force, maximum velocity, or power entail changes in the height of the jump of approximately 10-15%, 6-11%, and 4-8%, respectively. The information obtained by working with different loads in the field studies allows to determine the real F-V profile of the dancer and compare it with the optimal F-V profile to develop the necessary power and reach the maximum height (Escobar et al., 2020b). The differences between the two profiles indicate the imbalance between mechanical capabilities and determine a deficit in strength or velocity. This allows adapting the appropriate training guidelines to compensate for the deficits detected and improve the vertical jump capacity (Jiménez-Reyes et al., 2017a).

Studies of the F-V profile in dancers are scarce. Recientemente, Escobar et al. (2020b) evaluated 87 professional ballet dancers (age: 18.9±1.3 years; height: 164.4±8.2 cm; and body mass: 56.3±5.8 kg). The authors reported that all participants were velocity-oriented, evidencing a deficit in strength values. An imbalance in the high or low F-V profile can adversely affect the ability to jump (Morin & Samozino, 2016). To correct these deficits, it is suggested to prescribe training plans that address the F-V imbalance for each dancer individually (Escobar et al., 2020a).

Up to now, there is little literature assessing the F-V profile in jumping in female dancers. (Escobar et. al., 2020a, Escobar et. al., 2020b); and we have not found any work in which the requirements of different starting positions are compared. Therefore, the need arises to analyze the execution of the jumps and the strength-speed profile of dancers, comparing the execution of the jumps from a classical position of *en dehors*, compared to a contemporary position of parallel feet. The previous hypothesis raised is that the dancers have a deficit of strength starting from both positions and that the position *in dehors* presents a greater deficit of strength for the execution of the vertical jumps since the muscular effort required in the maintenance of the position hinders the activation of the musculature involved in the jump.

Method

Design

This study was carried out with a cross-sectional design, in which mechanical variables of the vertical jump (such as the height reached, the maximum theoretical force, the maximum theoretical velocity, and the maximum power) and the F-V profile were measured, starting from the positions in parallel and in first position (*sauté*) *in dehors*. Each participant performed eight vertical jumps with different load conditions calculated in relation to the percentage of body mass (0%, 5%, 10%, and 15%), alternating the position of the feet in parallel and *en dehors*.

Participants

Twenty-two dancers, students of Dance Degree at the Catholic University of Murcia, took part in this study. The descriptive characteristics of the study sample can be seen in table 1. The dancers were selected through convenience sampling. Participants interested in taking part in the study voluntarily responded to the researchers' call.

Table 1. Mean and standard deviation (SD) for the descriptive variables of the participants (n = 22)

Variable	Mean ± SD	Minimum	Maximum
Age (years)	21.8±2.59	19	28
Height (m)	1.63± 0.07	1,50	1,75
Body mass (kg)	58.1± 7.83	45,7	72,0
% body mass (%)	23.8± 6.79	13,5	35,7
Free fat mass (kg)	41.5±2.47	37,3	48,2
Body mass index	21.9±2.83	18,5	29,4
External rotation *en dehors* (°)	127.7±13.25	105	150
Experience (years)			
Ballet	10.7±5.96	1	20
Contemporary dance	4.7±4.37	1	19
Other dances	6.7±5.53	1	17

All participants were invited to the university facilities where they were informed of the activities to be carried out, the characteristics of the protocols, contraindications of the tests, benefits, and possible injuries. After the explanation, an informed consent form was completed and signed by all participants before the tests began. It detailed that the study was conducted in accordance with the Declaration of Helsinki and that all the ethical aspects required by the University's Ethics Committee had been considered.

Procedure

The participants went to the laboratory in pairs. After signing the informed consent form, a survey was administered to find out about their background and experience in classical ballet and contemporary dance. Body parameters such as body mass, height (cm) and lower limb measurements needed to obtain the push distance were then recorded. (Samozino et al., 2014). Body mass was measured with a scale Tanita BC-543 (Tanita Corporation, Tokyo, Japón), fat-free mass and fat mass percentage were estimated by bioimpedance with the same scale (Tanita BC-543, Tanita Corporation, Tokyo, Japón). The height was estimated with a stadiometer Seca 713 (Seca Hamburgo, Alemania), the length of the lower limb and the initial height of both positions were measured using a tape measure. To measure the opening of e*n dehors* the dancers were standing on a goniometer, without manual help of hip stabilization and taking as a reference the second toe of each foot because it is the one that must be aligned with the patella.

A standard warm-up was performed, consisting of five minutes of continuous running, joint mobility, dynamic stretching, and a total of six jumps with progressive intensity (i.e., 40%, 60% y 100% of the maximum perceived effort), alternating the position of feet in parallel and *en dehors*. After the warm-up, the participants were instructed to jump as high as possible each jump. The order of performance of the jumps was random, following the protocol indicated in table 2, with two minutes of rest between each jump, to avoid fatigue. The execution of the jumps was supervised by the researchers with the aim of ensuring the correct execution of the jumps, starting from a static standing position, and keeping the legs straight during the flight phase of the jump. The landing was made with complete dorsiflexion of the ankle. Jumps in which the position of the feet was lost on landing, and in which the participant was propelled with her arms (the hands had to be fixed on the hips) were not considered valid. All the jumps were performed without shoes.

Jump height and F-V profile were measured using a *MyJump2* app for iOS 14.0 on an iPad device (iPad Air, Apple inc. EEUU) which used a sampling frequency of 240 *Hz* (Balsalobre-Fernández et al., 2015). To record the jumps with *MyJump2*, a researcher lay face down on the ground with the iPad on a vertical stand in front of the participant (in the front plane), at ~1.5 m. They were selected with *MyJump2*, the first frame in which the feet ceased to be in contact with the ground (moment of takeoff) and, subsequently, the first frame in which at least one foot was in contact with the ground (moment of landing).

To determine the F-V profile *MyJump2* used the dancer's body mass, the height of the jump, and the thrust distance, obtained by the difference between the length of the lower limb in a fully extended position and the initial height at 90° for each starting position. The application provided information on the magnitude and orientation of the F-V imbalance for each dancer ($F\text{-}V_{IMB}$), theoretical maximum force (F_0), theoretical maximum velocity (V_0), and theoretical maximum power (P_{max}), according to Samozino's method. (Samozino et al., 2010).

Statistical analysis

The data was recorded and stored with the Excel for Microsoft 365 worksheet (v2205, Microsoft corp., Redmond, WA, EEUU). To carry out the statistical analysis, the SPSS v24.0 statistical package was used (IBM corp., New York, EEUU). Initially, a descriptive analysis of the variables was performed, and the values were expressed as mean and standard deviation. The differences between the results of the mechanical abilities obtained in the positions in parallel and *in dehors* were evaluated by means of the *t-Student* test, with a level of statistical significance set at $p \leq 0.05$. However, even if the effects were statistically significant, they might be irrelevant, so the magnitude of the effect was considered. To do this, Cohen's d was used, in which values below 0.2 were considered to indicate a small effect, between 0.5-0.7 indicate a mean effect, and values >0.8 indicate a high effect. (Ledesma et al., 2008).

Table 2. Distribution of jumps and loads

FIRST DANCER **Jump**	SECOND DANCER **Jump**	Load
en dehors	Parallel	Body weight
Parallel	*en dehors*	
Parallel	*en dehors*	+ 5%
en dehors	Parallel	
en dehors	Parallel	+ 10%
Parallel	*en dehors*	
Parallel	*en dehors*	+ 15%
en dehors	Parallel	

Results

Figure 1 shows the comparison between the height reached with the starting position in parallel and *in dehors*, in the sequence of jumps made with progressive loads. It is evident that there are statistically significant differences ($p<0.05$) in all situations between both starting positions of the vertical jump.

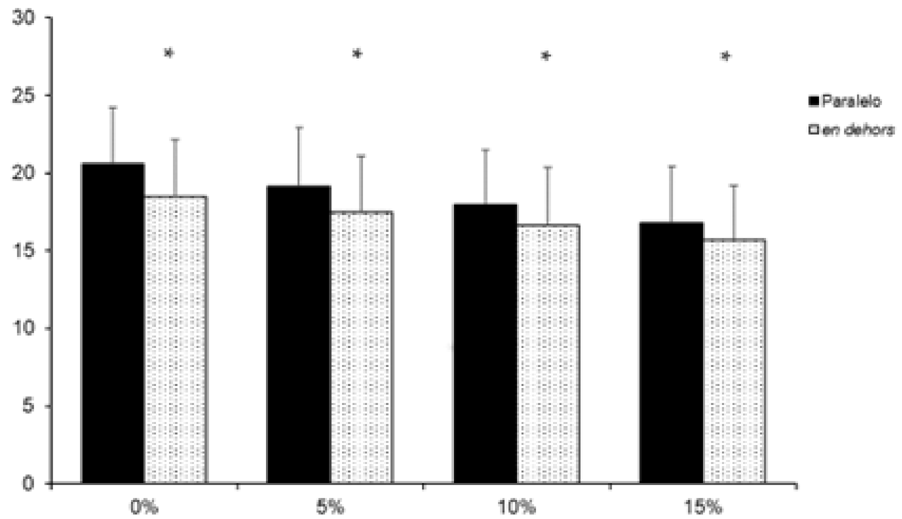

Figure 1. Jump height in parallel and en dehors
*: statistically significant differences, p<0,05

Table 3 shows the results of the mechanical variables and the heights reached in the jumps made by the participants. The results refer to both the jump starting from the parallel position and *en dehors*, with the aim of comparing the jump performance in both positions. Statistically significant differences in the height of the no-load jump were reported between the two positions and medium-high effect size. In both positions a deficit of strength is observed in the dancers, this deficit being higher when the jump is executed from a starting position *en dehors.*

Table 3. Mean and standard deviation (SD) for mechanical and performance variables in the participants' jump (n = 22)

Variable	Parallel	*en dehors*	*p*-value	ES (Cohen's *d*)	Confidence interval (95%) for *Cohen's d*	
					Lower	Upper
Jump height (cm)	20,3 ± 3,66	18,8 ± 3,51	**0,003**	0,722	0,244	1,186
$F\text{-}V_{IMB}$ (%)	70,9 ± 21,21	43,0 ± 46,24	**0,022**	0,776	0,163	1,384
F_0 (N / kg)	30,2 ± 9,42	29,1 ± 9,82	0,532	0,271	-0,568	1,110
V_0 (m / s)	2,47 ± 1,04	2,66 ± 1,25	0,539	0,266	-0,573	1,106
$P_{máx}$ (W / kg)	17,1 ± 3,59	17,35 ± 3,95	0,838	0,044	-0,462	0,374

F_0: maximum theoretical force; $F\text{-}V_{IMB}$: force-speed profile; P_{max}: maximum power; TE: effect size; V_0: maximum theoretical velocity.

All the dancers who took part in the study had a force deficit. When the movement was carried out from parallel, 18.2% of the participants presented a force deficit <10%, 50% of the participants presented a force deficit between 10-40%, and 31.8% of the participants presented a force deficit >40%. When the movement was carried out starting e*n dehors*, 9.1% of the participants presented a force deficit <10%, 36.4% of the participants presented a force deficit between 10-40%, and 54.5% of the participants presented a force deficit >40%.

Discussion

The skill of jumping is a very present resource in a large part of performative performance, as the basis for a multitude of artistic gestures. Dancers with a higher jump height can perform a wider range of skills during their flight time and implement more specific technical skills related to the aesthetic components of a dance choreography (Harley et al., 2002). Therefore, the objective of this study was to analyze the efficiency in the execution of the jumps and the F-V profile of the dancers, comparing the execution of the jumps from a classical position of *en dehors*, compared to a contemporary position of parallel feet.

The position *en dehors* seems functionally less efficient for the execution of a vertical jump, although it can provide advantages in jumps in which a large opening of the legs is sought because the external rotation of the hip allows a greater range of motion (Clippinger, 2011). The *en dehors* is the external rotation of the coxofemoral joint. This rotation depends on three factors: the bony shape of the hip joint, the ligaments in front of the hip (ileofemoral and pubofemoral) and the deep external rotator muscles (Bueno Aranzabal, 2016). The ileofemoral ligament is in front of the coxofemoral joint and tightens during external rotation so it acts as a movement limiter; greater extensibility of this ligament will allow a greater opening (Clippinger, 2011). Deep external rotators (piriform, upper, and lower geminus, internal and external obturator, femoral square) are a group of six small muscles that are located deep in the gluteus maximus in the buttocks. Its fibers extend mainly horizontally and are especially important for their external rotation action of the hip. Their ability to generate external hip rotation without other accessory movements makes them the key to generating and maintaining the *en dehors* (Clippinger, 2011). However, a position divided *into dehors*, in the jumps, has anatomical requirements of the musculature involved in the rotation gesture that can interfere with the development of strength in the muscles of the lower extremity involved in the jump, because when the dancers work with a large external hip rotation, the traction line of the muscle's changes. (Clippinger, 2011).

La posición *en dehors* desde un punto de vista mecánico, supone una desventaja en el desarrollo de la fuerza como en el salto y, por tanto, también en la altura alcanzada. Traditionally, in ballet classes, it can be observed how the work of external rotation is done through static exercises, looking for improvements in range of motion, but there are studies that question this type of stretching in relation to strength gains (Ikeda & Ryushi, 2021), because they cause laxity, so that muscle strength is lost, which also means a loss of velocity. Ikeda & Ryushi (2021) also detected that this passive training, although it improves the range of motion, does not manage to increase strength and, therefore, performance in the vertical jump. The search for greater joint mobility as the basis of training pursues aesthetic perfection but involves a lower functional capacity and lower muscle strength (Scheper et al., 2013). Therefore, the programming of strength exercises to improve jumping *en dehors* should not work separately rotation and jumping, but seek an external rotation in which not only is the extension of the ligaments of the anterior face of the hip important, but it is necessary to improve the musculature associated with the position by strengthening the deep external rotators, but also the rest of the muscle groups involved in vertical jumping (Wyon et al., 2006).

When we analyze the results obtained in the F-V profile, we observe that the dancers have a velocity orientation evidencing a deficit in the force values. This deficit is more marked when the starting position is e*n dehors*. Similar results reported Escobar et al. (2020b), when evaluating 87 professional dancers in a parallel jump execution the participants showed force deficits. This can be justified to the extent that ballet jumps are usually related to the term *allegro*, i.e., movements performed quickly, in which the dancer's velocity and agility are emphasized (Bazán et al., 2016). According to the results of the present study, the F-V imbalance is an important parameter to consider in the evaluation of the jumping capacity of the dancers. These results are in line with the movements required by the interpretation of the dance, which involves both athletic and aesthetic elements. This way dance training alone may not be enough to improve jumping ability. The fact that all of our participants showed strength deficits may lead to the conclusion that dance training predominantly develops speed capabilities and training plans should be designed around the magnitude and direction of F-$V_{IMB.}$ The analysis of the F-V profile and power allows for the description of the functional characteristics of the neuromuscular system and, thus, determines possible imbalances in the F-V ratio of the lower limbs during the vertical jump (Morin & Samozino, 2016). The development of training programs focused on reducing this imbalance in the F-V ratio, with specific lower extremity strength sessions (even using additional loads for the execution of gestures) could help dancers improve jump height and thus the performance. (Brown et al., 2007; Dowse et al., 2020; Rafferty, 2010).

Conclusions

The standards of classical dance consider the ideal of external rotation immovable, but from a functional point of view the *en dehors* is inefficient in jumping. Efforts to improve position are focused on the development of muscle flexibility by performing exercises that do not provide improvements in force and velocity. In addition, the neuromuscular and anatomical requirements required to reach 90° of external rotation of each leg, involve changes in muscle alignments and limit the performance of other muscles during the execution of the jump. The results of the present work show the differences in the height reached starting from the position *en dehors* compared to the parallel position, with worse results in the executions with external rotation of legs. The analysis of the F-V profile detected force deficits in all the dancers, being more pronounced in the starting position e*n dehors*. The dancers are velocity-oriented in terms of the F-V profile during the performance of the jump, so it shows the need to propose individualized training programs, focused on reducing the imbalance of each dancer and in each position. This could help dancers improve the height of the jump and, therefore, the performance of the dance.

Acknowledgments

The authors of this paper would like to thank the dancers who participated in the study in a disinterested manner. Also, Ms. María Dolores Molina, Ms. Catalina Castro and Mr. Sebastián Gómez.

Bibliography

Abad Carlés, A., & Burrell, V. M. (2012). *Historia del ballet y de la danza moderna* (2ªed.). Madrid: Alianza Editorial.

Alemany Lázaro, M. (2009). *Historia de la danza I. Recorrido por la evolución de la danza desde los orígenes hasta el siglo XIX.* Madrid: PILES Editorial de la Música.

Angioi, M., Metsios, G., Twitchett, E., Koutedakis, Y., & Wyon, M. (2009). Association between selected physical fitness parameters and aesthetic competence in contemporary dancers. *Journal of Dance Medicine & Science, 13*(4), 115–123. https://doi.org/10.1055/s-0031-1279718

Balsalobre-Fernández, C., Glaister, M., & Lockey, R. (2015). The validity and reliability of an iPhone app for measuring vertical jump performance. *Journal of Sports Sciences, 33*(15), 1574–1579. https://doi.org/10.1080/02640414.2014.996184

Bazán, N. E., Bruzzese, M. F., Laiño, F. A., Ghioldi, M., & Santa María, C. (2016). Evaluación de la capacidad de salto y estado ponderal en estudiantes de danza clásica de la escuela del Teatro Colón en Buenos Aires. *Apunts Medicina de l'Esport, 51*(190), 56–62. http://dx.doi.org/10.1016/j.apunts.2015.07.001

Brown, A., Wells, T., Schade, M., Smith, D., & Fehling, P. (2007). Effects of plyometric training versus traditional weight training on strength, power, and aesthetic jumping ability in female collegiate dancers. *Journal of dance medicine & science: official publication of the International Association for Dance Medicine & Science, 11*(2), 38–44. https://www.thefreelibrary.com/Effects+of+plyometric+training+versus+traditional+weight+training+on...-a0190052937

Bueno Aranzabal, M. (2016). Consecuencias de una técnica incorrecta en dehors en danza clásica: análisis y prevención de lesiones. Universidad Pública de Navarra. Tudela. Recuperado a partir de: https://academica-e.unavarra.es/xmlui/handle/2454/21496

Clippinger, K. S. (2011). *Anatomía y cinesiología de la danza* (1ª ed.). Barcelona: Paidotribo.

Dowse, R., McGuigan, M., & Harrison, C. (2020). Effects of a resistance training intervention on strength, power, and performance in adolescent dancers. *Journal of Strength and Conditioning Research, 34*(12), 3446–3453. https://doi.org/10.1519/jsc.0000000000002288

Escobar Álvarez, J. A., Fuentes García, J. P., Da Conceição, F. A., & Jiménez-Reyes, P. (2020a). Individualized training based on force-velocity profiling during jumping in ballet dancers*. International journal of sports physiology and performance, 15*(6), 788–794. http://dx.doi.org/10.1123/ijspp.2019-0492

Escobar Álvarez, J. A., Reyes, P. J., Pérez Sousa, M. Á., Conceição, F., & Fuentes García, J. P. (2020b). Analysis of the force-velocity profile in female ballet dancers. *Journal of dance medicine & science: official publication of the International Association for Dance Medicine & Science, 24*(2), 59–65. https://doi.org/10.12678/1089-313X.24.2.59

Gómez-Lozano, S., & Vargas-Macías, A. (2010). El en Dehors en la danza clásica: mecanismos de producción de lesiones. *Revista Del Centro de Investigación Flamenco Telethusa, 3*(3), 4–8. https://doi.org/10.23754/telethusa.030301.2010

Harley, Y., Gibson, A., Harley, E., Lambert, M., Vaughan, C., & Noakes, T. (2002). Quadriceps strength and jumping efficiency in dancers. *Journal of dance medicine & science: official publication of the International Association for Dance Medicine & Science, 6*(3), 87–94.

Ikeda, N., & Ryushi, T. (2021). Effects of 6-week static stretching of knee extensors on flexibility, muscle strength, jump performance, and muscle endurance. *Journal of strength and conditioning research, 35*(3), 715–723. https://doi.org/10.1519/jsc.0000000000002819

Jarvis, D. N., & Kulig, K. (2016). Lower extremity biomechanical demands during saut de chat leaps. *Medical problems of performing artists, 31*(4), 211–217. https://doi.org/10.21091/mppa.2016.4039

Jiménez-Reyes, P., Samozino, P., Brughelli, M., & Morin, J. B. (2017a). Effectiveness of an Individualized Training Based on Force-Velocity Profiling during Jumping. *Frontiers in physiology*, *7*, 677. https://doi.org/10.3389/fphys.2016.00677

Jiménez-Reyes, P., Samozino, P., Pareja-Blanco, F., Conceiçao, F., Cuadrado-Peñafiel, V., González-Badillo, J., & Morin, J. (2017b). Validity of a simple method for measuring Force-Velocity-Power profile in countermovement jump. *International Journal of Sports Physiology and Performance, 12*(1), 36–43. https://doi.org/10.1123/ijspp.2015-0484

Kushner, S., Saboe, L., Reid, D., Penrose, T., & Grace, M. (1990). Relationship of turnout to hip abduction in professional ballet dancers. *The American Journal of Sports Medicine, 18*(3), 286–291. https://doi.org/10.1177/036354659001800312

Ledesma, R., Macbeth, G., & Cortada de Kohan, N. (2008). Tamaño del efecto: revisión teórica y aplicaciones con el sistema estadístico Vista. *Revista Latinoamericana de Psicología, 40*(3), 425–440. https://www.redalyc.org/pdf/805/80511493002.pdf

Massó Ortigosa, N. (2012). *El cuerpo en la danza: postura, movimiento y patología* (1ª ed.). Barcelona: Paidotribo.

Morin, J., & Samozino, P. (2016). Interpreting power-force-velocity profiles for individualized and specific training. *International Journal of Sports Physiology and Performance, 11*(2), 267–272. https://doi.org/10.1123/ijspp.2015-0638

Rafferty, S. (2010). Considerations for integrating fitness into dance training. *Journal of dance medicine & science: official publication of the International Association for Dance Medicine & Science, 14*(2), 45–49. https://www.ingentaconnect.com/content/jmrp/jdms/2010/00000014/00000002/art00002;jsessionid=3rmhnjsbwn5qf.x-ic-live-01

Samozino, P., Edouard, P., Sangnier, S., Brughelli, M., Gimenez, P., & Morin, J. (2014). Force-velocity profile: imbalance determination and effect on lower limb ballistic performance. *International Journal of Sports Medicine, 35*(6), 505–510. https://doi.org/10.1055/s-0033-1354382

Samozino, P., Morin, J., Hintzy, F., & Belli, A. (2010). Jumping ability: A theoretical integrative approach. *Journal of Theoretical Biology, 264*(1), 11–18. https://doi.org/10.1016/j.jbiomech.2008.07.028

Scheper, M., de Vries, J., de Vos, R., Verbunt, J., Nollet, F., & Engelbert, R. (2013). Generalized joint hypermobility in professional dancers: a sign of talent or vulnerability? *Rheumatology, 52*(4), 651–658. https://doi.org/10.1093/rheumatology/kes220

Tsanaka, A., Manou, V., & Kellis, S. (2017). Effects of a modified ballet class on strength and jumping ability in college ballet dancers. Journal of dance medicine & science: official publication of the *International Association for Dance Medicine & Science, 21*(3), 97–101. https://doi.org/10.12678/1089-313X.21.3.97

Wyon, M., Allen, N., Angioi, M., Nevill, A., & Twitchett, E. (2006). Anthropometric factors affecting vertical jump height in ballet dancers. *Journal of dance medicine & science: official publication of the International Association for Dance Medicine & Science, 10*(3), 106–110. https://core.ac.uk/download/pdf/1931753.pdf