

Static and dynamic balance in ballet dancers: a literature review

Equilíbrio estático e dinâmico em bailarinos: revisão da literatura

Equilibrio estático y dinámico en bailarines: revisión de la literatura

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ABSTRACT | Dance involves integration between movement, postural balance and the multiple aspects involved with postural control. Information regarding the balance of ballet dancers is of great importance, as they are considered models of great postural control. The aim was to review studies about static and dynamic postural balance of ballet dancers, characterizing visual dependency in the postural control of these athletes to maintain balance. A review of literature was performed on PubMed, SciELO, Lilacs, and Science Direct databases considering the period between 1997 and 2013, and using the descriptors balance, postural control, force plates ballet dancers, classical ballet dancers and visual afferences. Eighteen articles were considered able to provide the quantitative and qualitative data to assess the balance among those athletes, and were thus, selected. These papers were classified by Oxford level of evidence. The reviewed literature shows full consensus regarding the effect of removing visual information over postural stability according to the experience of subjects considered highly trained dancers. Studies comparing the balance of ballet dancers to other sporting techniques confirmed that they have a specific postural balance pattern. Nevertheless, in association with visual restriction, ballet dancers show a greater center of pressure dislocation and instability compared to other sports, which suggests that they have higher visual dependence to maintain balance. Ballet dancers have better static balance compared to non-trained subjects and other types of athletes, but greater visual dependence to maintain balance.

RESUMO | A dança envolve integração de movimento, equilíbrio postural e aspectos relacionados ao controle postural. Informações sobre o equilíbrio em bailarinos são de grande importância, pois eles são considerados modelos de controle postural. O objetivo foi revisar estudos sobre equilíbrio postural estático e dinâmico em bailarinos, caracterizando o controle e a dependência visual desses atletas para a manutenção do equilíbrio. Para isso, foi realizada uma revisão nas bases de dados PubMed, SciELO, Lilacs e Science Direct, considerando o período entre 1997 a 2013, utilizando os descritores equilíbrio, controle postural, plataforma de forças, ballet, bailarinos clássicos e aferência visual. Foram selecionados 18 artigos capazes de fornecer dados quantitativos para avaliação do equilíbrio nesses atletas classificados pelo nível de evidência científica Oxford. A literatura revisada mostra completa concordância quanto ao efeito da retirada da informação visual sobre a estabilidade postural de bailarinos considerados como executantes altamente treinados. Estudos mostrando a comparação do equilíbrio de bailarinos com outras técnicas desportivas confirmaram um padrão específico de equilíbrio nesses indivíduos. Entretanto, associando-se à restrição visual, bailarinos apresentaram maior deslocamento do centro de pressão comparado a outras modalidades desportivas, sugerindo maior dependência visual para a manutenção do equilíbrio. Bailarinos apresentam menor oscilação postural em relação a indivíduos não treinados e indivíduos treinados em outras práticas desportivas, com maior dependência visual para manutenção do equilíbrio.

Keywords | postural balance; dance; dance therapy.

Descritores | equilíbrio postural; dança; terapia pela dança.

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RESUMEN | La danza envuelve integración de movimiento, equilibrio postural y aspectos relacionados al control postural. Informaciones sobre el equilibrio en bailarines son de gran importancia, pues ellos son considerados modelos de control postural. El objetivo fue revisar estudios sobre equilibrio postural estático y dinámico en bailarines, caracterizando el control y la dependencia visual de esos atletas para la mantención del equilibrio. Para eso, fue realizada una revisión en las bases de datos PubMed, SciELO, Lilacs y Science Direct, considerando el período entre 1997 y 2013, utilizando los descriptores equilibrio, control postural, plataforma de fuerzas, ballet, bailarines clásicos y aferencia visual. Fueron seleccionados 18 artículos capaces de proveer datos cuantitativos para evaluación del equilibrio en esos atletas clasificados por el nivel de evidencia científica Oxford. La literatura revisada muestra completa concordancia en cuanto al

efecto de la retirada de la información visual sobre la estabilidad postural de bailarines considerados como ejecutantes altamente entrenados. Estudios mostrando la comparación del equilibrio de bailarines con otras técnicas deportivas confirmaron un estándar específico de equilibrio en esos individuos. Entre tanto, asociándose a la restricción visual, bailarines presentaron mayor desplazamiento del centro de presión comparado a otras modalidades deportivas, sugiriendo mayor dependencia visual para la mantención del equilibrio. Bailarines presentan menor oscilación postural en relación a individuos no entrenados e individuos entrenados en otras prácticas deportivas, con mayor dependencia visual para mantención del equilibrio.

Descritores | equilibrio postural; danza; terapia por la danza.

INTRODUCTION

Ballet is a physical activity that requires musculoskeletal conditioning by the use of complex high impact movements, with major joint amplitude, which works on the development of coordination, balance and laterality associated with efficient strength and flexibility in technical execution¹.

Postural control is important to understand the capacity of the human being to perform their activities and maintain body balance, providing stability and orientation during motor tasks². Such control depends on sensory information of the vestibular, visual and somatosensory systems, so that motor actions can be triggered based on experiences and skills³⁻⁵. One determining factor for balance control is the size of the support base, and the movements executed by the ballet dancer are usually performed on a small base, such as the *en pointe* balance⁶ (Figure 1A). This movement involves major weight discharge at the tip of the foot, besides being more unstable and depending on ligaments and muscles for stability and support⁶.

Balance training begins early for dancers, around the age of five, and becomes more complex when they perform *en pointe*⁶, however, balance is rarely analyzed within the context of dance⁷. Training is conducted in the vertical position, with reduced support bases and the use of mirrors, and the direction of the eyes is important to keep control during spins, which implies visual dependency in order to maintain balance when compared to athletes of other sporting activities⁸.

Some studies used stabilometry to quantify the dislocation of the center of pressure (CoP) during orthostatic posture⁹, and they demonstrated that visual restriction

limits postural control patterns, thus increasing postural oscillations^{10,11}. The common interpretation of the stabilometry suggests that postural tasks with higher values of parameters deriving from stabilometric signals are related to postural instabilities¹². Another important



Figure 1. (A) En pointe position. (B) En demi-point position.

aspect in stabilometric tests is the possibility to identify the visual dependency of the individual, characterized by higher values of these parameters when vision is restricted during a motor task, such as more oscillation speed and longer distance crossed by the CoP¹².

The dynamic balance of ballet dancers was assessed by a few authors, and the execution of spins (*pirouette*) was considered as a complex task, involving a strategy of head movement, the “marking the head”, which dissociates the rotation of trunk and head — while the body spins, the eyes stare at an established point, and when the maximal cervical rotation is reached, the head performs a fast rotation towards the same direction of the movement, and then the eyes stare at the same point again; therefore, it is possible to observe the importance of visual information for balance and quality of the motor performance during the spin, correlated to less postural oscillation^{8,13-17}.

Considering that the analysis of static and dynamic balance of ballet dancers, in the main moves, is very important for their performance, besides collaborating with the elaboration of training and rehabilitation programs for these athletes, the objective of this study was to review scientific literature concerning balance in ballet dancers, by observing if specific training would lead to less postural oscillation and to more visual dependency in order to control balance.

METHODOLOGY

A literature review was performed with the following databases: Lilacs, Medline, PubMed, SciELO and Science Direct, with the descriptors: ballet dancers, postural control, balance, force platform, classic ballet and visual afference, combined in groups of three. The pre-selection inclusion criteria of the articles were: date of publication (1997-2013), language (English or Portuguese) and the relation of title and abstract with the subject of interest (ballet and balance). The articles identified in the pre-selection search were assessed according to the following inclusion criteria: (1) population (ballet dancers) and (2) intervention (assessment of static or dynamic balance).

Review was carried out in three stages. In the first one, there was a general selection of publications on the subject, resulting in 57 studies. In the second stage, those which were duplicated and did not belong to the theme were excluded — the 18 remaining articles were included in

the review and grouped together according to the year of publication, being selected based on the abstract. In the third stage, these articles were classified according to the recommendation criteria and evidence-based classification from the Oxford Centre for Evidence-Based Medicine (OCEBM)^{18,19}. Due to the low classification of the selected articles, the level of classification was not used as a selection criterion. The OCEBM levels consider the strength of evidence for therapeutic effect and damage, evidence of prevalence, accuracy of diagnostic tests, prognosis, therapeutic effects, rare damage, common damage, and are used as screening in review studies¹⁸.

RESULTS

The 18 articles selected for this study are presented in Table 1, describing sample, objective, tools used to assess balance, synthesis of results and Oxford classification^{18,19}.

DISCUSSION

The studies included in this review mostly presented (83%) sample size between 8 and 45 dancers, and 11% of the articles ranged from 4 to 8 dancers. With that, it is possible to observe the difficulty to perform studies with larger samples, probably due to the level of expertise and training of these athletes. Because of the number of articles discussing specific movements of professional dancers, especially those related to dynamic balance, these articles were included in this review despite the low sample, level of evidence 3–4 and recommendation B (little satisfactory).

Stabilometry was the most used method to assess static balance (55.5%). However, a major variation was observed as to positions and time of permanence on the force platform for the static balance evaluation according to CoP variables and anterior-posterior and medial-lateral dislocation areas, thus characterizing the balance of dancers by means of these variables.

The difficulty of the balance task increases with unipodal support, and this position is common for the ballet practice²⁰, considered to be of easy execution with good reliability^{21,22}. Therefore, considering specific positions of classic ballet, 27% of the articles assessed the static balance in specific unipodal postures^{6,10,11,20,23-28}. Lobo da Costa et al.²⁹ assessed ballet dancers in several

Table 1. Articles distributed considering sample size and characteristics, objective, used tools, results and Oxford classification¹⁷

Study	Sample	Objective	Tools	Results	Oxford
Golomer, Dupui and Monod ³¹	148 adolescents boys and girls) ballet dancers, acrobats and non-trained individuals	To assess the influence of gender in dynamic balance tactics	Oscillating platform and accelerometer	Girls presented better balance than boys, and acrobats had better balance in comparison to dancers	B2
Golomer et al. ³⁵	45 male ballet dancers	To assess dynamics balance in association with different visual and position conditions in relation to age	Oscillating platform and accelerometer	Boys aged more than 18 years old presented more visual dependency and better balance	B2
Golomer et al. ¹⁵	13 male ballet dancers and 10 non-trained individuals	To assess the level of visual dependency and balance	Oscillating platform and accelerometer	Professional ballet dancers presented better balance and less visual dependency	B3
Perrin et al. ¹¹	31 athletes: 14 fem.-ballet, 17 males -judo and 42 non-athlete individuals: 21 fem. and 21 males	To determine if the sensorimotor training of judô and ballet improve postural control	Force platform	With no visual restriction, judô wrestlers and female ballet dancers showed good postural control. With visual restriction, judô wrestlers presented better postural control	B2
Barcellos and Imbiriba ²³	4 female ballet dancers	To compare postural control and balance between different feet positions used in classic ballet	Force platform and infrared cameras	Better balance in the smaller base position (<i>pointe</i>)	C4
Schmitt, Kuni and Sabo ²⁶	20 athletes: 10 ballet dancers (5 males and 5 fem.) and 10 athleticism athletes (5 males and 5 fem.)	To determine the influence of visual and sensory systems on postural control	Force platform	Ballet dancers have better postural control compared to athleticism athletes	B3
Cheng-Feng and Fong-Chin ²⁴	13 female ballet dancers	To verify ankle kinematics in <i>relevé en pointe</i> of ballet dancers	Infrared câmeras and two force platforms	The non-dominant ankle oscillated more when compared to the dominant ankle	B3
Simmons ²⁵	15 female ballet dancers and 16 controls	To analyze the static balance of dancers	force platform and electromyographer	Results indicate a superior postural control mechanism in trained dancers	B3
Denardi, Ferracioli and Rodrigues ¹³	8 female ballet dancers	To verify the association between the longer duration of the stare before the spin and better balance	Two bidimensional cameras	The unavailability of visual information reduced postural stability	C4
Guillou, Dupu and Golomer ²¹	10 soccer players, 7 male ballet dancers, 9 acrobats and 10 controls	To assess the balance between different sport modalities	Mobile platform, accelerometer	Better balance for professional than for non-professionals and for male ballet dancers and acrobats	C4
Gerbino, Griffin and Zurakowski ²⁷	32 soccer players and 32 female ballet dancers	To assess balance between different sport modalities	Force platform	Male ballet dancers present less oscillation in relation to soccer players	B2
Bruyneel et al. ¹⁰	40 male ballet dancers 20 (8-16 years old) 20 (17-30 years old)	To characterize the balance strategies of male ballet dancers in different positions	Force platform	Young male ballet dancers presented more oscillation than adult male ballet dancers; with visual restriction, there was no difference	B2
Thiesen e Sumiya ¹	15 female ballet dancers (9 beginners and 6 intermediates)	To verify balance and the type of plantar arch in classic female ballet dancers	Force platform and e plantigram	There was no difference in oscillation speed and in the type of plantar arch and body balance	C4
Kiefer et al. ³⁴	28 professional ballet dancers (10 M and 18 F); 28 without experience with ballet (10 healthy males and 18 females)	To identify differences in postural coordination and balance between ballet dancers and non-trained controls	Electrogoniometer	Ballet dancers presente more stability and coordination, which enables the execution of complex balance tasks	B3

Continue...

Table 1. Continuation

Rein et al. ³²	30 male ballet dancers	To compare postural control between professional ballet dancers, amateurs and controls	Force scillating platform	Professional ballet dancers presente better postural control	B2
Cheng et al. ³⁶	26 ballet students and 25 active and healthy students	To investigate the effects of dancing exercises on postural stability off emale teenagers	Force oscillating platform	Ballet students presente better postural stability in relation to non-dancers	B2
Cheng-Feng Lin et al. ⁶	22 ballet students (11 with post-rehabilitation ankle lesions and 11 with no ankle lesions) and 11 healthy individuals	To assess postural stability of ballet dancers in different positions used in the ballet practice	Force platform	During all of the positions, the injured dancers presented more postural oscillation in relation to dancers with no lesions and non-trained individuals	B3
Lobo da Costa et al. ²⁹	14 non-professional female ballet dancers	To describe the levels of stability in different positions in demi-pointe with and without ballet slippers	Force platform	More stability without ballet slippers in all of the positions and with the leg elevated in attitude and a la second presented more balance, while the derrière position presented less balance	B3

Oxford classification: Recommendation A - Consistent, controlled and homogeneous study and; B - Controlled study with less quality; C - lower quality; poor reference pattern and D - Inconsistent or inconclusive. Level: 1 - Clinical, controlled and randomized studies; systematic homogeneous reviews; 2 - systematic review of cohort studies, cohort studies (including a randomized clinical trial with less quality); 3 - systematic review of case-control studies and case-control study; 4 - case report; and 5 - experts' opinion, explicit critical evaluation and translational research⁷

demi-point positions (Figure 1B), wearing ballet slippers and barefoot, being the use of ballet slippers the cause for more dislocations of the CoP in all of the positions. Bruyneel et al.¹⁰ also found a much smaller dislocation area in similar conditions when the free limb was turned backwards (attitude *derrière*), in conditions with vision^{29,30}. Barcellos and Imbiriba²³ verified, by means of kinetics, the angular variations of pelvis, hip, knee and ankle joints, and, together with the mean speed of CoP oscillation, they observed a smaller dislocation area in the *en pointe* position than in a position with total plantar support.

The oscillating platform and the accelerometer (33% of the articles) were used to compare dynamic balance in relation to different visual conditions and different positions, among individuals grouped as to age and sex^{8,15,17,21,31}. It was observed that male professional dancers (>18 years old) with more practice time presented more visual dependency on a bipodal support over a mobile platform in comparison to younger male dancers (<18 years old)¹⁵, as well as women (>18 years old), because under the same conditions they presented smaller CoP area than the men³¹; according to the authors, the relationship between balance and gender would be related to the different movements performed by the dancers during a technical execution, in which men perform rougher and more explosive movements, while women perform more contained and soft moves.

Besides, male ballet dancers seem to be more dependent on their vision than female dancers^{6,15,21,31,32}, due

to differences related to maturity and the development of the vestibular system, which takes place at the age of 9 and 10 years old among women, and 13 and 14 years old among men³³.

Kiefer et al.³⁴ also assessed female ballet dancers during a static task, with the objective of identifying differences in postural coordination between professional dancers and controls, who were not trained during a dynamic visual follow-up task by means of a electrogoniometer, thus verifying the ankle and hip angular oscillations while the athlete searches for the target³⁴. Since dancers are trained to look for reference points during gesture movements, they presented more control, as well as more stable hips and ankles when compared to controls³⁴.

The balance of ballet dancers in comparison to athletes of other sporting activities, such as judo wrestlers, runners, acrobats and soccer players, was discussed in 28% of the selected articles, and the dancers' high balance pattern without visual restriction was consensual, probably related to the specificity of the training for these athletes^{10,11,20,21,26,27,31}. However, 61% of the articles did not control the position of the upper limbs of the athletes^{6,7,10,11,15,17,24,27,29,32,34}; therefore, dancers could have taken the first rank for the upper limb, thus improving balance in the different assessed positions.

However, when assessing balance in association with visual restriction, ballet dancers presented a larger CoP dislocation in comparison to judo wrestlers, acrobats and non-athletes^{11,31}, thus pointing out to the major

visual dependency of ballet dancers to maintain balance. On the other hand, Schmitt, Kuni and Sabo²⁶ indicated that ballet dancers presented less postural oscillation in relation to athleticism. However, they assessed nonhomogeneous groups as to age, time of profession, gender, gestural and analyzed position.

According to Kiefer et al.³⁴, the difficulty to compare dancers with different groups of athletes is due to the fact that there are diversities not only concerning the different types of bodies, but also distinct training.

Despite the increased postural oscillation, other parameters should be taken into account to determine the efficacy of postural control, such as kinematics and kinetics. In relation to dynamic control, no studies comparing the specific activities of ballet with other sport modalities were found, nor those analyzing different types of dancers. Besides, assessing the visual dependency for balance during gestures of other modalities is important to understand the specificity of training for balance.

According to the selected articles, it is possible to observe moderate or unsatisfactory level of recommendation, thus, studies using different control groups, which can monitor the positions of lower limbs, different support bases and different gestural movements, can contribute with the evaluation both of the static and dynamic balance of these athletes.

Based on the used articles, we understand that ballet provides better balance in relation to non-trained groups and in relation to other sport modalities, which leads to better body stability³⁴, however, the visual dependency to maintain balance seems to be more present among dancers. Besides, it is possible to observe a relationship between sports training and postural oscillation, therefore, inserting balance exercises in the training of ballet dancers without emphasizing visual fixation could increase the postural control of these athletes.

Data in this study point out the increased oscillations among ballet dancers with visual deprivation in relation to other populations of athletes. Given the importance of balance for the performance of movement in classic ballet, it is important to explore different situations in dancing gestures, exploring its specificities. When postural control and balance is improved, producing more coordinated and coherent movement patterns, the probabilities of lesions could be reduced due to the presence of strategies of preprogrammed movements.

So, in order to better understand balance, it is important to emphasize aspects of the ballet dancer's gestures, and also work with a more homogeneous sample.

CONCLUSION

In literature, it was consensual that ballet dancers presented better static balance in relation to non-trained individuals and athletes of different sport modalities, however, dancers presented more visual dependency in order to maintain static balance due to the specificity of their training.

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