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.

Keywords | postural balance, dance, dance therapy.

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.

Descritores | equilíbrio postural, dança, terapia pela dança.

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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 execution.

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 tasks. Such control depends on sensory information of the vestibular, visual and somatosensory systems, so that motor actions can be triggered based on experiences and skills. 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 balance. 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 support.

Balance training begins early for dancers, around the age of five, and becomes more complex when they perform en pointe, however, balance is rarely analyzed within the context of dance. 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 activities.

Some studies used stabilometry to quantify the displacement of the center of pressure (CoP) during orthostatic posture, and they demonstrated that visual restriction limits postural control patterns, thus increasing postural oscillations. The common interpretation of the stabilometry suggests that postural tasks with higher values of parameters deriving from stabilometric signals are related to postural instabilities. Another important
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 CoP.

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.

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). 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 studies.

**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.

**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 practice, considered to be of easy execution with good reliability. Therefore, considering specific positions of classic ballet, 27% of the articles assessed the static balance in specific unipodal postures.

Lobo da Costa et al. assessed ballet dancers in several...
### Table 1. Articles distributed considering sample size and characteristics, objective, used tools, results and Oxford classification

<table>
<thead>
<tr>
<th>Study</th>
<th>Sample</th>
<th>Objective</th>
<th>Tools</th>
<th>Results</th>
<th>Oxford</th>
</tr>
</thead>
<tbody>
<tr>
<td>Golomer, Dupui and Monod(^3)</td>
<td>148 adolescents boys and girls ballet dancers, acrobats and non-trained individuals</td>
<td>To assess the influence of gender in dynamic balance tactics</td>
<td>Oscillating platform and accelerometer</td>
<td>Girls presented better balance than boys, and acrobats had better balance in comparison to dancers</td>
<td>B2</td>
</tr>
<tr>
<td>Golomer et al.(^5)</td>
<td>45 male ballet dancers</td>
<td>To assess dynamics balance in association with different visual and position conditions in relation to age</td>
<td>Oscillating platform and accelerometer</td>
<td>Boys aged more than 18 years old presented more visual dependency and better balance</td>
<td>B2</td>
</tr>
<tr>
<td>Golomer et al.(^15)</td>
<td>13 male ballet dancers and 10 non-trained individuals</td>
<td>To assess the level of visual dependency and balance</td>
<td>Oscillating platform and accelerometer</td>
<td>Professional ballet dancers presented better balance and less visual dependency</td>
<td>B3</td>
</tr>
<tr>
<td>Perrin et al.(^11)</td>
<td>31 athletes: 14 fem-ballet, 17 males-judo and 42 non-athlete individuals: 21 fem. and 21 males</td>
<td>To determine if the sensorimotor training of judô and ballet improve postural control</td>
<td>Force platform</td>
<td>With no visual restriction, judô wrestlers and female ballet dancers showed good postural control. With visual restriction, judô wrestlers presented better postural control</td>
<td>B2</td>
</tr>
<tr>
<td>Barcellos and Imbirba(^23)</td>
<td>4 female ballet dancers</td>
<td>To compare postural control and balance between different feet positions used in classic ballet</td>
<td>Force platform and infrared cameras</td>
<td>Better balance in the smaller base position (pointe)</td>
<td>C4</td>
</tr>
<tr>
<td>Schmitt, Kuni and Sabo(^26)</td>
<td>20 athletes: 10 ballet dancers (5 males and 5 fem.) and 10 athleticism athletes (5 males and 5 fem.)</td>
<td>To determine the influence of visual and sensory systems on postural control</td>
<td>Force platform</td>
<td>Ballet dancers have better postural control compared to athleticism athletes</td>
<td>B3</td>
</tr>
<tr>
<td>Cheng-Feng and Fong-Chin(^24)</td>
<td>13 female ballet dancers</td>
<td>To verify ankle kinematics in relevé en pointe of ballet dancers</td>
<td>Infrared cameras and two force platforms</td>
<td>The non-dominant ankle oscillated more when compared to the dominant ankle</td>
<td>B3</td>
</tr>
<tr>
<td>Simmons(^25)</td>
<td>15 female ballet dancers and 16 controls</td>
<td>To analyze the static balance of dancers</td>
<td>force platform and electromyographer</td>
<td>Results indicate a superior postural control mechanism in trained dancers</td>
<td>B3</td>
</tr>
<tr>
<td>Denardi, Ferracioli and Rodrigues(^13)</td>
<td>8 female ballet dancers</td>
<td>To verify the association between the longer duration of the stare before the spin and better balance</td>
<td>Two bidimensional cameras</td>
<td>The unavailability of visual information reduced postural stability</td>
<td>C4</td>
</tr>
<tr>
<td>Guillou, Dupu and Golomer(^21)</td>
<td>10 soccer players, 7 male ballet dancers, 9 acrobats and 10 controls</td>
<td>To assess the balance between different sport modalities</td>
<td>Mobile platform, accelerometer</td>
<td>Better balance for professional than for non-professionals and for male ballet dancers and acrobats</td>
<td>C4</td>
</tr>
<tr>
<td>Gerbino, Griffin and Zurakowski(^27)</td>
<td>32 soccer players and 32 female ballet dancers</td>
<td>To assess balance between different sport modalities</td>
<td>Force platform</td>
<td>Male ballet dancers present less oscillation in relation to soccer players</td>
<td>B2</td>
</tr>
<tr>
<td>Bruyneel et al.(^10)</td>
<td>40 male ballet dancers 20 (8-16 years old) 20 (17-30 years old)</td>
<td>To characterize the balance strategies of male ballet dancers in different positions</td>
<td>Force platform</td>
<td>Young male ballet dancers presented more oscillation than adult male ballet dancers; with visual restriction, there was no difference</td>
<td>B2</td>
</tr>
<tr>
<td>Thiesen e Sumiya(^7)</td>
<td>15 female ballet dancers (9 beginners and 6 intermediates)</td>
<td>To verify balance and the type of plantar arch in classic female ballet dancers</td>
<td>Force platform and plantigram</td>
<td>There was no difference in oscillation speed and in the type of plantar arch and body balance</td>
<td>C4</td>
</tr>
<tr>
<td>Kiefer et al.(^14)</td>
<td>28 professional ballet dancers (10 M and 18 F), 28 without experience with ballet (10 healthy males and 18 females)</td>
<td>To identify differences in postural coordination and balance between ballet dancers and non-trained controls</td>
<td>Electrogoniometer</td>
<td>Ballet dancers presente more stability and coordination, which enables the execution of complex balance tasks</td>
<td>B3</td>
</tr>
</tbody>
</table>

Continue...
Table 1. Continuation

<table>
<thead>
<tr>
<th>Authors</th>
<th>Sample Description</th>
<th>Methodology</th>
<th>Type of Study</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rein et al.</td>
<td>30 male ballet dancers</td>
<td>To compare postural control between professional ballet dancers, amateurs and controls</td>
<td>B2</td>
</tr>
<tr>
<td>Cheng et al.</td>
<td>26 ballet students and 25 active and healthy students</td>
<td>To investigate the effects of dancing exercises on postural stability off male teenagers</td>
<td>B2</td>
</tr>
<tr>
<td>Cheng-Feng Lin et al.</td>
<td>22 ballet students (11 with post-rehabilitation ankle lesions and 11 with no ankle lesions) and 11 healthy individuals</td>
<td>To assess postural stability of ballet dancers in different positions used in the ballet practice</td>
<td>B3</td>
</tr>
<tr>
<td>Lobo da Costa et al.</td>
<td>14 non-professional female ballet dancers</td>
<td>To describe the levels of stability in different positions in demi-pointe with and without ballet slippers</td>
<td>B3</td>
</tr>
</tbody>
</table>

Oxford classification: Recommendation A – Consistent, controlled and homogeneous study and nr. 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 review; 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 research.

Besides, male ballet dancers seem to be more dependent on their vision than female dancers, as they use the use of ballet slippers the cause for more dislocations of the CoP in all of the positions. Bruyneel et al. also found a much smaller dislocation area in similar conditions when the free limb was turned backwards (attitude derrière), in conditions with vision. Barcellos and Imbiriba 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 planter 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. 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), as well as women (>18 years old), because under the same conditions they presented smaller CoP area than the men; 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, 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 men.

Kiefer et al. 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 an electronic goniometer, thus verifying the ankle and hip angular oscillations while the athlete searches for the target. 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 controls.

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. However, 61% of the articles did not control the position of the upper limbs of the athletes, 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, thus pointing out to the major...
visual dependency of ballet dancers to maintain balance. On the other hand, Schmitt, Kuni and Sabo 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., 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 athletes and in relation to other sport modalities, which leads to better body stability, 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.

**REFERENCES**


