



# A Biomechanical Analysis of the *Jeté Dessus* Using Dartfish Motion Analysis Software



## Introduction

Beatrice Turrubiarres was enrolled in the KIN 417 class, Analysis of Movement, and in one of the KIN 417L classes (Analysis of Movement Lab, which is co-requisite with KIN 417) during the Summer II 2009 term. Her term project, A Biomechanical Analysis of the *Jeté Dessus*, was completed in her Analysis of Movement Lab, but it required her to also utilize the knowledge of biomechanical principles which she learned in the Analysis of Movement class. The biomechanical principles, which are discussed in her project, are derived from Newton's Laws of Motion and help us to understand the forces that produce and affect movement. The uniqueness of her project is that she was able to scientifically analyze the performance of the *jeté dessus*, which is a leap in ballet, by using Dartfish Motion Analysis Software, which is the latest and most sophisticated computer video analysis software being used. This software is used by teachers, coaches, physical therapists, occupational therapists, and sports medicine specialists for detecting errors in a person's movements, calculating angles, times, distances, and velocities, and for providing feedback to the performer through the utilization of drawing tools and production of a media book on a DVD. Over 95% of the United States Olympic Teams use the Dartfish Motion Analysis Software for improving movement performances. Stephen F. Austin State University is among an elite group of universities in the United States that has this sophisticated equipment.

## Abstract

During a five-week course in the summer of 2009, Dr. Sandra Cole of the Kinesiology and Health Science Department supervised students in analyzing chosen movements using the latest computer version of Dartfish Motion Analysis Software. In this project, a leap called *jeté dessus* from the ballet genre of dance was analyzed by Beatrice Turrubiarres.

Analysis was performed using a videotape of the step being executed by a dance student. Creation and format requirements of the videotape were very specific in order to be recognizable to the software. The student was instructed to wear a leotard and tights, enabling all joints and body parts to be clearly visible, and to warm up. Meanwhile, the camera, containing a MiniDV cassette tape, was secured to a tripod and set up in a position where it was perpendicular to the plane of movement being videotaped, in the middle of the range of movement while being as far away from the performer as possible, and level in all directions. The student was then instructed to stand in her performing space holding a scaling rod, an object of known length which allows the software to recognize distances, and was recorded for ten seconds. Afterwards, the student was videotaped performing the *jeté dessus*. Four trials were recorded, with five seconds added just before and after the execution of movement.

Once the videotape containing the recording of the scaling rod and four trials of movement execution was properly produced, it was then imported into the computer. The camera was connected to the computer and, after opening the Dartfish program, it was set to VCR. Importing began after the cassette tape was inserted into the camera and advanced to the correct location of the recordings, beginning with the scaling rod. By clicking on the Import Video icon and following subsequent directions, the presenter was able to separately import all five recordings on the cassette tape, which she could then review in the Dartfish program on the computer.

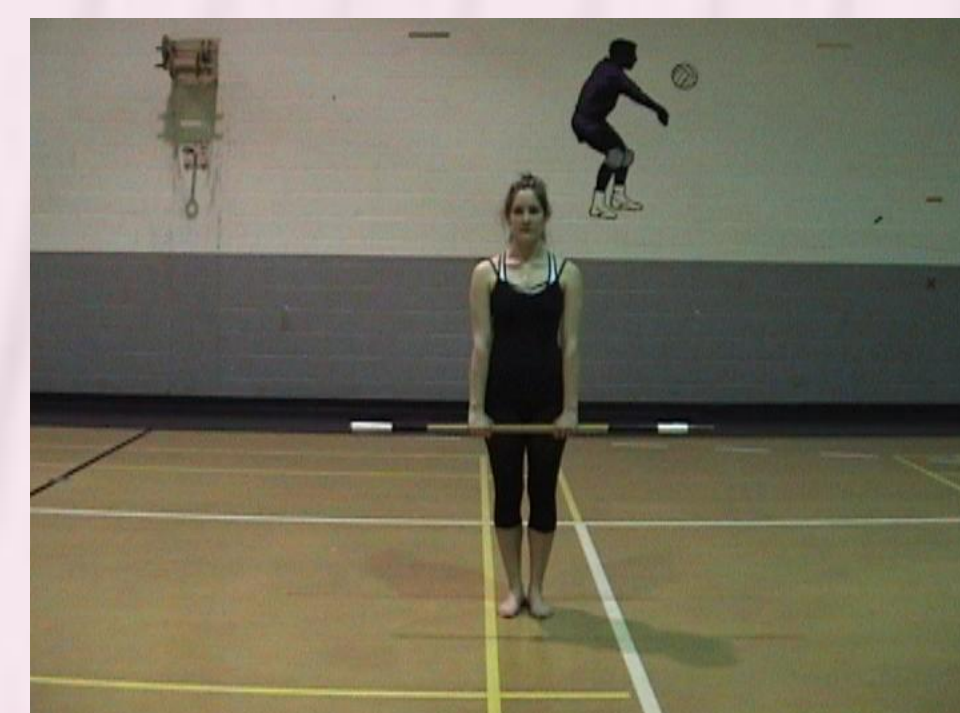
Only one recording of a *jeté dessus* was analyzed; the presenter chose one in which the student performed an average execution. By using the capabilities and tools provided by the Dartfish Motion Analysis Software, she was easily able to distinguish the exact path of motion of the performer. For example, the presenter was able to decelerate the speed of the video, allowing her to clearly see the student's position at the peak of the leap in the air. These means allowed her to discern both strengths and weaknesses of the performance, which she was then able to either praise or correct by providing comments about the performance. Drawing upon the presenter's years of training in ballet and by applying biomechanical concepts of physics to this particular movement, she was able to make suggestions for improvement to the student using sound scientific as well as artistic reasoning.

## Methods

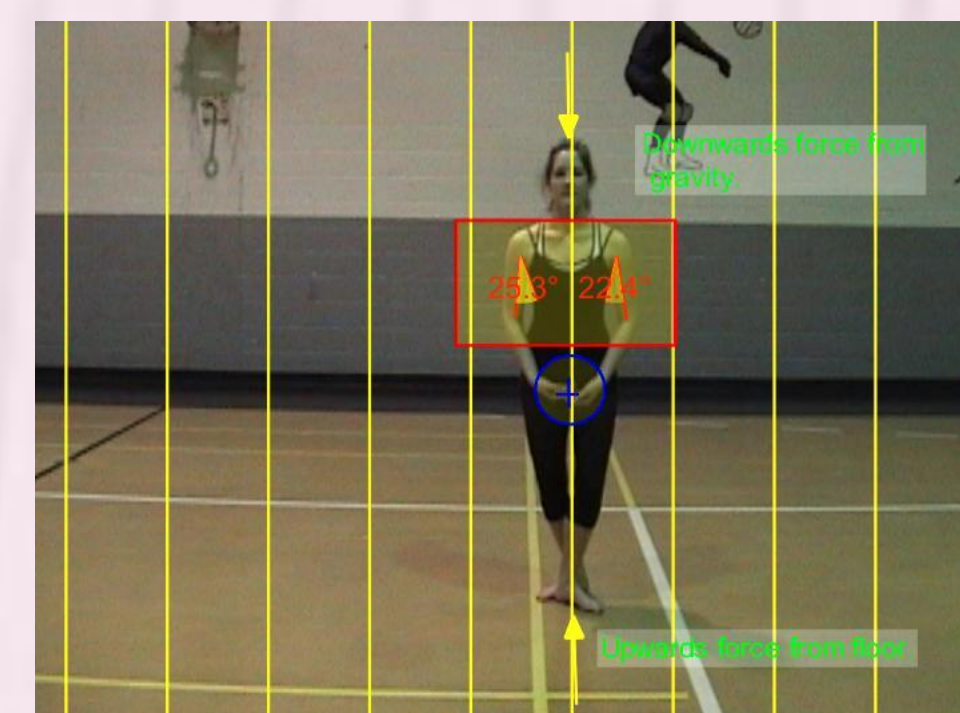
- A videotape of a *jeté dessus* was created requiring strict instructions.
- The videotape was imported, requiring strict instructions, into the Dartfish Motion Analysis computer software.
- The performance was critically analyzed by utilizing the drawing tools (see pictures at right).
- Conclusions were drawn by applying biomechanical principles and personal knowledge of ballet kinesiology (see comments beneath pictures).
- Results were provided to the performer by utilizing the drawing tools to illustrate errors and producing a DVD media book.

## Ballet Terms

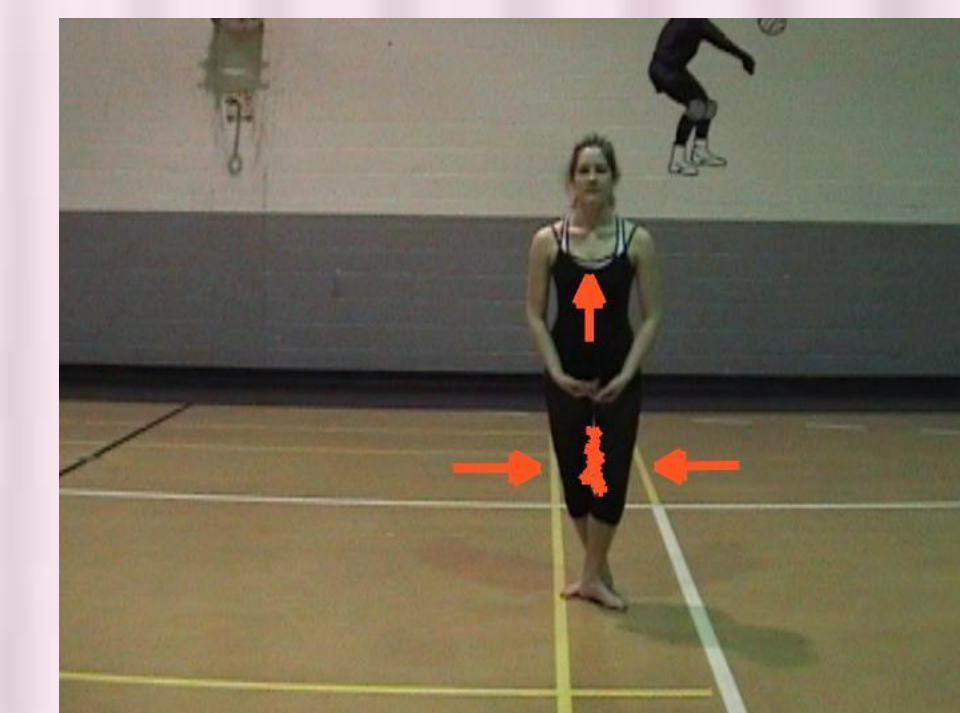
- Leap.** Rising movement in which a dancer leaves the floor from both feet and lands on one foot (differs from a *jump*).
- Turn-out.** Refers to the rotation of the legs and feet outward.
- 5<sup>th</sup> position.** A specific ballet position of the feet.
- Plié.** A bending of both legs at the knees. A *demi-plié* is a half-bend.
- Dégagé.** One foot quickly brushes slightly off the floor.
- Sickle.** Unhealthy action of inverting the foot when pointing.



The performer must be recorded holding a scaling rod as part of the videotaping procedure. This allows the software to accurately calculate life-size distances.



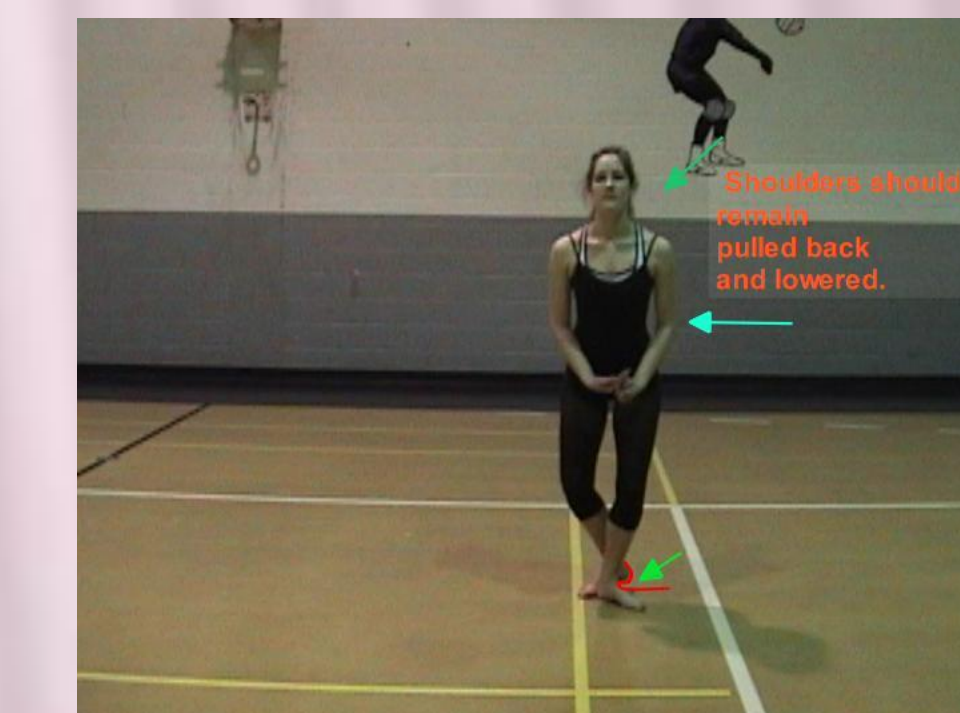
**Beginning position.** This is the correct beginning position for a *jeté dessus*. At this point the only forces acting on the body are the floor (an upwards force) and gravity (a downwards force); there are no horizontal forces. To gain equilibrium and balance, the body's center of gravity must be directly centered on a vertical line by which these forces balance each other. The feet should shift the body's weight accordingly to achieve this balance. However, in this position, the body is not as stable as possible due to the small size of the base and the height of the center of gravity above it. Taller dancers need more strength, then, to perform quick movements like the *jeté dessus*.



**Beginning position.** The performer's feet are in the correct turned-out 5<sup>th</sup> position. Her arms and hands are also in the correct low 5<sup>th</sup> position but the shape of the arms should be more rounded, with the elbows being slightly forward so that there is a greater degree of distance between the upper arms and the side of the torso. The hands should be centered vertically and horizontally and should have 1-2 inches between them. The little fingers of both hands should be about 4 fingers' length away from the thigh.

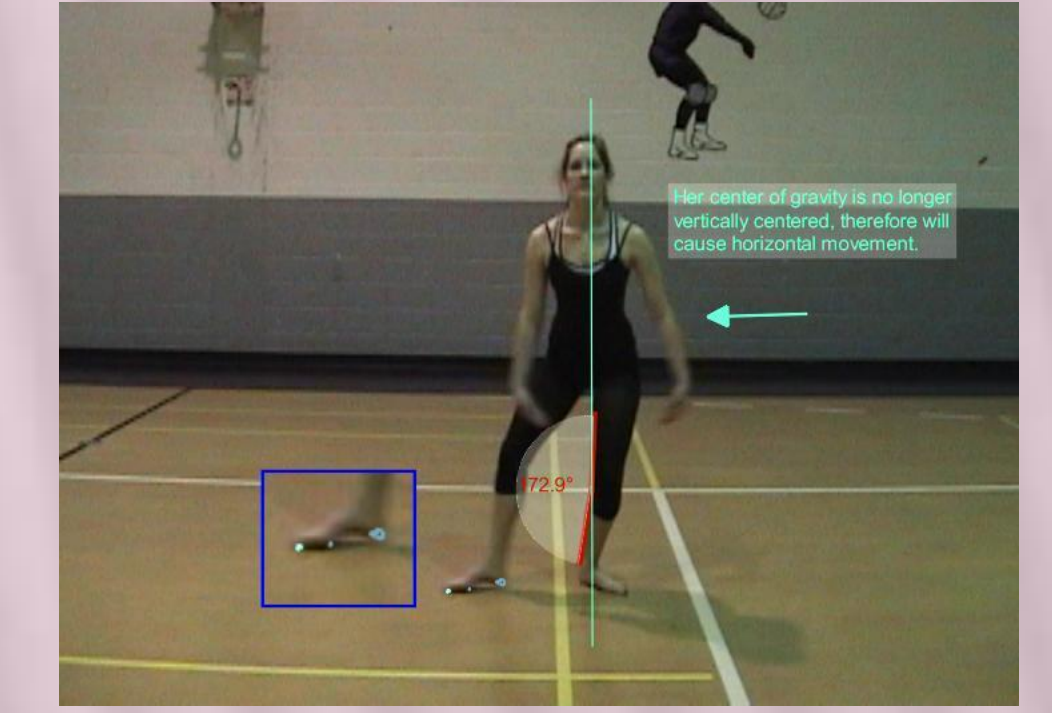
Because it travels vertically, this movement will have drag. Proper dance attire, as shown here, will create smoothness of body and decrease drag, as will maintaining proper alignment.

To achieve proper alignment, the shoulders should be lowered as they appear to be here and the torso should be lifted, thereby pulling the legs together to create a smooth vertical line. This ensures that the center of gravity falls directly vertically in line with the base, creating stability and balance.



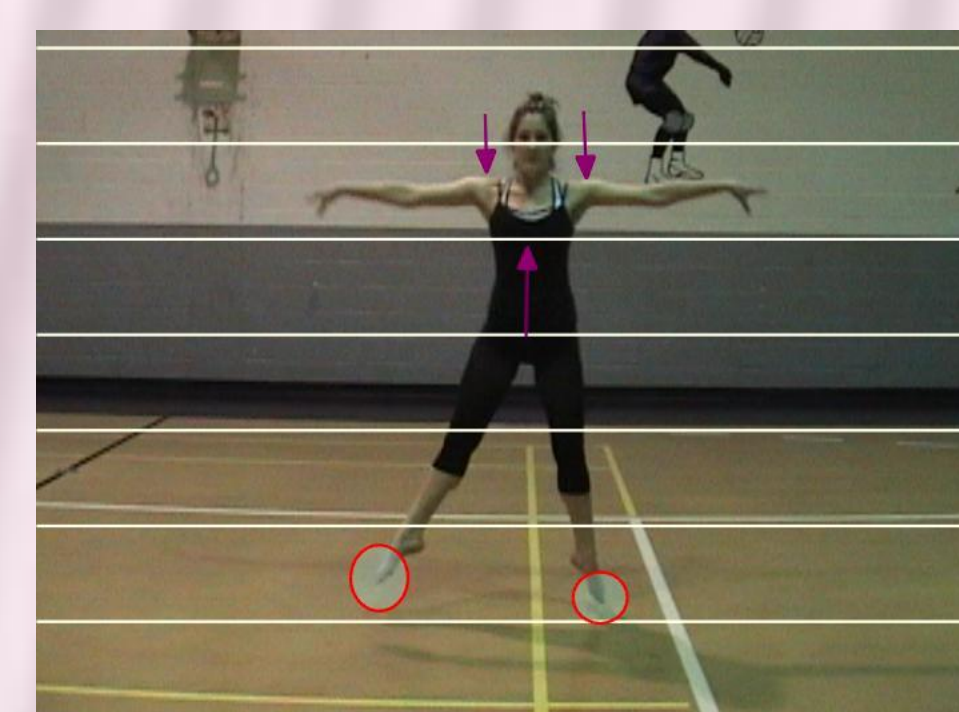
**Demi-plié preparation.** Despite about to lose some stability by removing one foot and decreasing base size, stability will be regained by lowering the center of gravity through knee and dorsal flexion. However, the center of gravity must still remain centered vertically to prevent a force couple, which produces unwanted horizontal forces that cause falling or sideways travel.

Her heel should stay on the ground when beginning the *dégagé* in order to keep the right magnitude of force.



**Demi-plié preparation.** When standing motionless, dancers exert a downward force equal to their weight. To leap, they must exert a force greater than their weight. Therefore, here, a deep *plié* would produce a greater upwards force from the floor and also achieve acceleration for the leap. Due to the force-time relationship, a longer, deeper *plié* results in greater velocity which leads to a higher leap. However, the *plié* should not be too deep or the downwards force exerted is lessened, lowering height of leap.

The performer is correctly lifting her foot from the ground, in the order of the heel of the foot first, then ball of the foot, then toes.

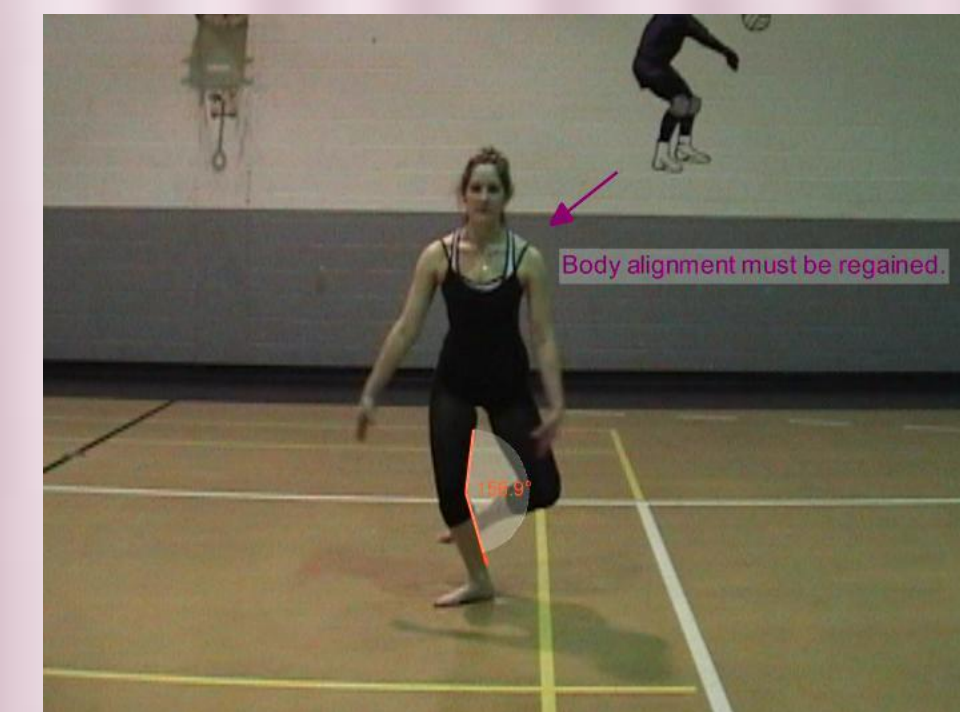


**Spring in air.** In this position, drag is reduced due to the shape of the body; alignment has been regained and the feet are correctly pointed. It is seen that this movement is mostly performed on the frontal plane.



**Spring in air.** We can see that this leap lasted long enough to have sufficient height for her to correctly point both feet. However, if this movement needed to be performed to music in less time, enough height could be decreased that she would not physically be able to do so.

In this demonstration, her height of leap would not seem as grand compared to a shorter dancer's *jeté dessus* performed in the same amount of time. Also, it would require more distance and effort on her part to leap the same amount of height as that of a shorter and lighter dancer.



**Demi-plié landing.** The ending of a *jeté dessus* is important as it could cause injury if not done properly. Because of its motion through air, this movement has kinetic energy. Impact when landing can be lessened by increasing distance; this is done by using the *demi-plié*. A deeper *plié* increases distance and absorbs more energy.

Body alignment must not be lost during the downwards travel. It still reduces drag, stabilizes equilibrium upon landing on one foot, and more efficiently absorbs kinetic energy due to the center of gravity being on a vertical line of balance between forces.

Dancers should always be aware not to sickle the foot and maintain turnout of the legs from the hips.



**Recovery in ending position.** If only performing one *jeté dessus*, the ending position is identical to the beginning position. Here, the performer has regained alignment but should finish her movement by returning to the beginning position with her feet in 5<sup>th</sup> position and her arms in low 5<sup>th</sup> position. All principles of balance and alignment apply. To perform two or more movements, she would continue, applying all principles, to repeat the phrases beginning with the *demi-plié* preparation, and end her motion by recovering into this position.



**Demi-plié landing.** By maintaining the position of the body's center of gravity throughout the movement, she can ensure that she lands just ahead of her lift-off spot on the floor, which is correct for this movement. Here, the light green dot represents her original position and the red dot represents her landing position. The space between them indicates that maintenance was lost during this demonstration, resulting in forces about a horizontal axis that caused her to travel to the side.

## Summary

The Dartish Motion Analysis Software enabled the presenter to better view the performer's movement than with the mere naked eye, allowing her to evaluate the performance using a sound scientific basis and, at the conclusion, offering more detailed advice for improvement to the dancer.

The images presented here were used to publish a DVD media book, which was then given to the dancer as a permanent resource of the instructions and reasoning of performing the *jeté dessus* correctly in a manner that prevents injury.

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