BIOMECHANICAL APPROACH TO BALLET MOVEMENTS: A STUDY OF THE EFFECTS OF BALLET SHOE AND MUSICAL BEAT ON THE VERTICAL REACTION FORCES

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INTRODUCTION

Biomechanical studies have tried to explain the loading characteristics of ballet dancing due to the *pointe shoes* and the extreme positions of the foot while standing *en pointe* [1]. Of great importance to the overall ballet performance is also the influence of musical beat, identified by the time signature of the musical tempo, responsible for the speed aspect and thus the correct dynamic of the dance movements and this aspect should also be considered while studying the ground reaction forces. The purpose of this study was to describe the external loads during a ballet movement, sauté - 1st position, while performed with two different footwears (slippers and *pointe shoes*) and two different time signatures (2/4 and 6/8) in order to identify the relative contribution of these two aspects on the loads measured by a force platform. The ¨*saute*¨ is a vertical leap with both feet from the first position and is considered a basic movement performed in an Allegro tempo.

METHODS

Six female ballet dancers (mean age 17 ± 2,1 years-old, mean mass 52 ± 8,4 kg) with at least six years of training volunteered to this study. All dancers practice at least eight hours per week with slippers and *pointe* shoes and had no musculoskeletal injuries at the time of this experiment. All participants signed an informed consent form before testing. While positioned on the force platform, the dancer performed two trials of eight consecutive sautés from the first ballet position with the slippers and the same trial with the *pointe* shoes.

The time signatures 2/4 and 6/8 are binary tempos and the time unit used in this study was the quarter note. Consequently, in the condition 6/8, the movements were performed in the eighth note. This reveals the speed aspect of the dancer performances during this study. Only the vertical components of the resultant ground reaction forces were studied, because it better reflect the external loads applied to the body during landing from a jump. Ground reaction forces (GRF) were measured by a piezoelectrical force platform (Kistler Instruments), sampled at 1000Hz, low pass filtered with a cut off frequency of 200 Hz. Each sauté were divided into three phases: initial position (*demi-plié* or knees flexion), jump and landing (*demi plié* or knees flexion). For each sauté, the selected variables for descriptive purposes were: peak vertical force during landing (Fy), stance time (ST), vertical force rate of increase (Rfy). The time signature was determined by edited extracts from classical pieces, specially prepared for ballet classes, which were played on a CD-player. The data were tested for normality with a Shapiro Wilks test, and differences among the experimental conditions were tested with an analysis of variance one-way and a post-hoc Scheffe test.

RESULTS AND DISCUSSION

The different footwears did not produce significant differences in the profile of the resultant curves. In accordance with typical curves of each condition, the 6/8 time signature produced two vertical peaks and the 2/4 time signature produced only one peak of vertical force. The mean values for Fy1 and Fy2 as well as for the stance time (ST) and the rate of increase of the vertical force (Rfy) for the four conditions studied are presented in TABLE 1.

TABLE 1: Mean values (± sd) for Fy1, Fy2, ST and Rfy for at least 90 sautes-1st position, with pointe shoes (2/4 and 6/8 beats) and slipers (2/4 and 6/8 beats).

	Fy1 (BW) (mean ± sd)	**Fy2 (BW)** (mean ± sd)	**ST (s)** (mean ± sd)	**Rfy** (mean ± sd)
Pointe 2/4	3,89 (± 0,75)	----	0,37# (± 0,15)	35,14 (± 10,11)
Pointe 6/8	2,89 (± 0,95)	1,67 (± 0,38)	0,57+ (± 0,10)	31,74 (± 12,32)
Slipper 2/4	3,60 (± 0,70)	----	0,35*+ (± 0,09)	33,11 (± 9,57)
Slipper 6/8	2,80 (± 0,82)	1,83 (± 0,34)	0,63*# (± 0,09)	26,98 (± 9,78)

With relation to the footwear type, it was observed that the resultant vertical forces measured were not statisticaly different between slipper and *pointe* shoes conditions. In this way, the results pointed out that the musical beat may be a factor of greater influence on the vertical GRF, compared to the footwear type, determining the different curves observed in this study. Significant differences were only found for the stance time for the different conditions. With respect to the vertical force rate of increase no differences were found for footwear and time signature conditions.

CONCLUSIONS

The *pointe* shoes do not produce greater loads than slipper shoes when measured the GRF. The time signature 6/8 produced greater stance times when compared to 2/4 time signature, thus, it is likely that the musical beat influenced more the mechanical aspects evaluated in this study than the footwear types. There is a clear tendency to the fact that the faster the musical beat, the greater the attention should be payed to the landing technique, mainly that of foot positioning on the ground, independently of the ballet shoe used.

REFERENCE

1. Tuckman, A. S., et al. *Foot and Ankle*, 12:.3, 144-148, 1991.