EFFECTS OF VARIED MUSIC TEMPOS AND VOLUMES ON VERTICAL IMPACT FORCES PRODUCED IN STEP AEROBICS

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INTRODUCTION

Safety is a concern in step aerobics, since injury can occur as a result of the ground reaction forces (GRFs) created from impact-related activities due to repetitive loading, rate of loading, and magnitude of the load (Hamill & Knutzen, 1995). Step aerobics research literature indicates a relationship between tempo, bench height, and variation of stepping with the GRFs produced. Since instructors are conducting classes in which they employ stepping rates that are faster than previous studies, there is a need to investigate the magnitudes of forces produced by various stepping cadences for injury prevention. As an addition to the existing research, this study was designed to compare vertical GRFs produced in the step down phase by beginning level step aerobics participants as a result of two music tempos and two music volume levels.

METHODS

The 12 subjects selected for this study were female students at Indiana State University. The subjects' mean age was 22.8 ± 2.8 years, the mean height was 164.9 ± 4.9 cm, and the mean weight was 60.8 ± 6.4 kg. The subjects were classified as beginning level steppers, since they had less than 12 months experience in a step aerobics program. All subjects signed an informed consent form before participating. Subjects were required to be in good physical health, which was determined by the results of the Physical Activity Readiness Questionnaire revised by Thomas, Reading, and Shephard in 1992. Prior to individual data collection sessions, all subjects participated in a learning session. All subjects were informed to wear shoes that were customarily used for exercise for both the learning and data collecting sessions. Shoes were visibly inspected for excessive wear, which could influence the resiliency and consequently affect results of impact forces.

Tempos of stepping were set by one music selection at 122 bpm and another at 130 bpm. Both selections were verified for tempo accuracy by comparison with an electronic metronome measure prior to testing. Music decibel levels for two music systems were measured with a Realistic sound level meter prior to testing. Music system 1 was set at the 68 dB (C) level and system 2 was set at a level of 83 dB (C) Both music systems were placed four memters from the subjects and faced them in order to ensure consistency of volume levels. The step bench was 0.15 m high and centered directly in front of the Kistler piezo-electric force plate.

The four treatment combinations used for all subjects throughout the 20 minute step bench routine were a) 122 bpm and 68 dB, (b) 122 bpm and 83 dB, (c) 130 bpm and 68 dB, and (d) 130 bpm and 83 dB. To control the effect that order may have on impact force data, a Latin Square experimental design was used to determine the sequence of the variable combinations. Each of the variable combinations were used as a treatment for five minutes in an assigned sequence for each subject's 20 minute stepping session.

During each five minute application of the tempoldecibel combinations, data was collected for 20 seconds at three different intervals. The first interval began at two minutes, the second at three minutes, and the third at four minutes. The vertical GRFs were collected by an Ariel APAS system using a Kistler force plate at an 500 Hz sampling rate.

Prior to data collection, subjects were weighed on the force platform so that force data could be reported as a percent of body weight. Subjects performed a five minute warm-up of low intensity movements and static stretches for flexibility. During data collection the subjects used the forward and backward stepping sequence which alternated lead legs, (e.g., right, left, right, left, etc.) to allow separate data collection for both feet. Subjects were cued to place the hands on the hips throughout each twenty second data collection period to negate any effect that might occur from an upper body movement pattern. The right foot impact was collected first when each 20 second collection period began. The forceltime graph shows the vertical GRFs for the three phases of the landing footfall pattern from the Ariel Performance Analysis System (see Figure 1). The three phases were (a) step down, consisting of forefoot contact; (b) double support, feet are in contact with the ground; and (c) toe-off, forefoot force created to step up.

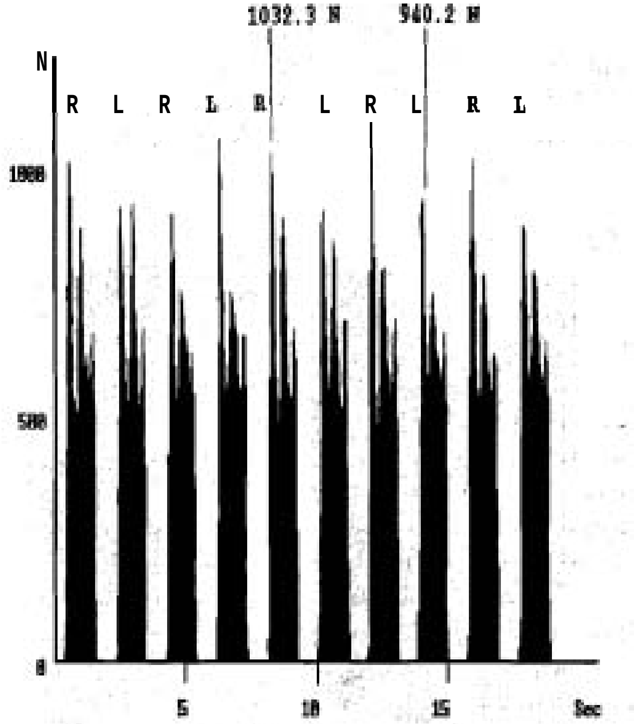

Figure 1. Force/Time Graph for One Data Collection Period.

RESULTS

Three right stride and three left stride peak vertical impact forces were selected from the middle of each 20 second data collection period in the step down phase for analysis. Each of the three data collection periods for all conditions were used; therefore, a total of nine right stride and nine left stride impact forces were used for the analysis of each tempo/decibel condition. An 2 x 2 x 2 x 9 ANOVA (Volume x Tempo x Foot x Trial) with repeated measures on all factors was used to determine the significance of differences in peak vertical impact forces produced by the two treatment conditions.

The subjects' mean age was 22.8 ± 2.8 years, the mean height was 164.9 ± 4.9 cm, and the mean weight was 60.8 ± 6.4 kg. The ANOVA results revealed that there were n significant differences for the factors of trial (p=.733), music volume (p=.424), or stride (p=.217). Significant differences for the varied tempo effects were found to exist at the .09 level when the music tempo was increased from 122 to 130 bpm. The mean peak vertical impact GRFs were 908.2±149.6 N (167%BW), 930.8 ± 147.3 N (171%BW), 921.5 ± 167.0 N (170% BW), and 943.3 ± 187.1 N (174% BW) for the treatment conditions of 68dB/122bpm, 83dB/122bpm, 8dB/130bpm, and 83dB/130bpm, respectively. Average data for the absolute mean GRF, in the step-down phase fro the right and left foot, are shown in Figure 2.

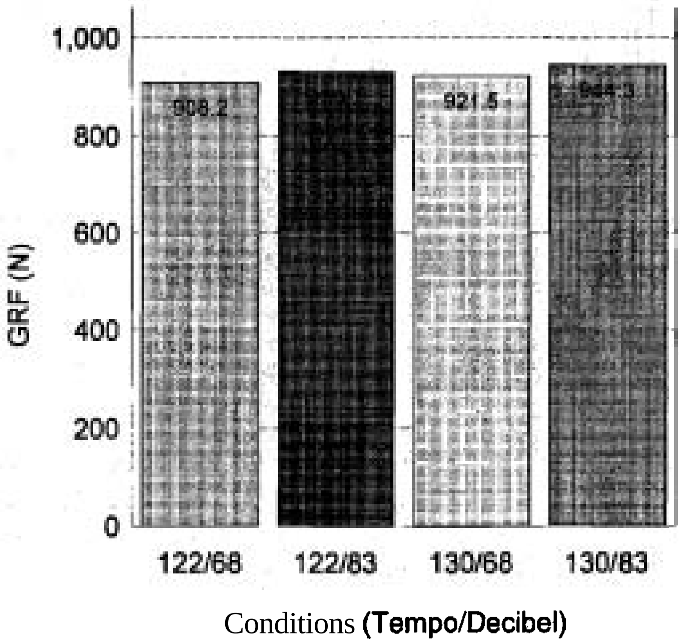

Figure 2. Absolute Mean GRFs in the Step-Down Phase

The GRF mean values and standard deviations for music volume level and tempo were calculated separately for the right and left foot impacts over the nine trials and expressed relative to body weight (see Table 1).

Table 1. Mean GRFs for Music Volume and Tempo Expressed in Newtons and % Body Weight.

	Left Foot		Right Foot	
Volume/Tempo	Mean SD	%BW	Mean SD	%BW
68dB/122bpm	901.7±144.2	166%	914.7±154.9	168%
83dB/122bpm	917.2k146.7	169%	944.3±147.8	174%
68dB/130bpm	913.0±165.5	168%	929.9±168.5	171%
83dB/130bpm	939.9±178.2	173%	948.7k196.0	175%

Note. n = 12 Each mean force value is a nine trial average.
Mean body weight = 543 N (60.85 kg).

Vertical GRFs found in the present study were similar to results from the Francis et al. (1990) study which used the same basic stepping rbutine from a 0.25 m bench at a 120 bpm tempo. Vertical forces were lower in the present study when compared to magnitudes due to a 0.20 m bench height and a 120 bpm tempo throughout a 40 minute stepping routine as reported by Finch and Hecko (1996). It is speculated that the lower forces in the present study were due to the lower bench height of 0.15 m and the absence of arm movements during data collection. Fatigue affected the force results in the Finch and Hecko study as higher forces were reported during the 40 minute stepping session compared to 20 minutes of stepping in the present study. They concluded that the left stride produced an average landing force of 978.2 N representing 186% BW. The right stride resulted in an average of 999.8 N representing 190% BW.

Results of the present study showed an increase in vertical GRFs compared to those reported by Johnson, Rupp, Berry, and Rupp (1992). They used well trained step aerobics instructors performing on a 0.20 m bench at 130 bpm. Results were normalized and reported as 1.41 BW at the five minute interval, 1.51 BW at 20 min, and 1.46 BW at 35 min. The lower forces created by the well trained individuals could be due to more body control, creating efficiency in the capability to absorb forces at landing due to technique. GRFs were lower in the present study when compared to results of the study by Newton and Humphries (1991). They examined the resultant of the GRFs, rather than the vertical forces. The resultant GRFs included the vertical and anterioposterior forces together which were normalized to 2.24 multiples of body weight at the 0.20 m bench height, 2.43 at 0.25 m, and 2.90 at the 0.30 m height. They also found that differences in peak resultant ground reaction forces between the 0.20 and 0.30 m heights indicated that an increase in step height produced a higher force.

CONCLUSION

Findings suggest that the faster loading and unloading rate of the musculature due to faster tempo caused less control of the movement and resulted in a 4% increase in the vertical GRFs. Dufek and Bates (1992) stated that the actual physical tolerance limits of the human lower extremity during landing activities is currently unknown. However, it is safe to express that the use of fast tempos in a beginning level step aerobics class may be a source for elevated risk for potential injury. A higher number of subjects would have increased the power of the study; therefore, it is likely that there would have been a significant difference shown in the tempo effect at the .05 level.

It was hypothesized that the louder music volume would increase the magnitude of forces produced, possibly due to a motivation factor. The findings did not support this theory, although it is still speculated that higher sound volumes may affect the technique.

More investigation in the effects of music volumes on participants' production of GRFs and technique would be an interesting area of study. Further research in step aerobics is necessary in order to identify differences in GRFs created by various conditions. In addition to vertically applied forces, it is likely that anteroposterior or mediolateral shear forces may influence injury; however, vertically applied forces are most often examined because of their high magnitude of 2 to 5 times the body weight,

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