BASIC STEP VS. POWER STEP: PEAK VALUES OF VERTICAL GRF ANALYSIS

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INTRODUCTION: The relation between health and fitness has been the object of investigation, it being universally accepted that physical activity positively affects people's health. Step has emerged as a popular form of exercise, being offered in a number of health and fitness centers throughout the world. It has replaced or been combined with traditional aerobics in many fitness programs. Participants follow a routine which involves stepping up and down on steps of varying heights, at varying cadences, in order to achieve an aerobic workout. Originally introduced as a low impact activity, step classes now include propulsive movements that have changed the nature of the activity impact. Regular exposure to moderately high levels of force is desirable because mechanical stress will produce structural changes that toughen important anatomical structures contributing inclusively to the increase of bone density (Panush, 1994) and the capacity of resistance of tendons and ligaments tension (Woo, 1982). However, these same forces can produce undesirable effects. If they are too high, the discomfort is increased and a potential risk of injury arises. This situation is more visible when the forces are too repetitive in a period of time (Nigg *et al.*, 1981), and during a step class there can be 6000 foot impacts.

There are few reported studies on the effects of step aerobics on GRF (ground reaction forces). Francis *et al.* (1992) present data on the vertical GRF that suggest the injury risk involved in step aerobics is relatively low. Tagen (1996) compared the vertical GRF of the basic step with three leap variations: the leap, step leap and run (leap, leap) and found significant differences between all variations. Vertical GRF were 1.03 BW (basic), 1.82 BW (leap), 2.15 BW (step leap) and 2.48 BW (run). Their results indicated that the variations step leap and run produced impact forces similar to those of high impact traditional aerobic dance.

The purpose of this study was to compare the peak vertical GRF of the basic step with the power variations: leap, hop and jump.

METHODS AND PROCEDURES: Sixteen skilled females (mean age of 24.2 ± 5.2 years; mean height of 1.63 ± 0.07 m; and mean weight of 57.7 ± 5.2 Kg) performed 20 trials of each movement with a 120 beats per minute (bpm) tempo, using a 0.15 m Kistler force plate height (mod.9283 UO 14).

The study location and equipment were shown to the subjects, the experimental protocol explained, and an opportunity for questioning given. In order to make the test situation as close as possible to a regular step training class, subjects wore their own step training shoes, which were in good condition, and the step session was taught at a constant rate of 30 cycles per minute, regulated by the use of a specially mixed step aerobic tape at 120 beats per minute.

The step patterns were the same as those defined by Reebok terminology (Reebok, 1994): *Basic step* (up-up-down-down), *Leap* (leap-up-down-down), *Hop* (up-hop-down-down), and *Jump* (jump-hold-down-down).
Vertical GRF was measured directly on the Kistler platform using a sampling rate of 500 Hz. The outputs from the charge amplifiers (mod.9865B) were passed through a 16 bit analog to digital converter board (A/D Biopac MP 100) in a i586 PCI compatible computer using the Acknowledge software.
Peak vertical GRF was expressed relative to each subject's body weight (BW). The value of the 1st peak was determined as the highest value of the first load, i.e., contact of the leading foot on the platform. The value of the 2nd peak was calculated subtracting the lowest value of the depression of the force curve during the transition from the action of the first strike to the second one, as we see in Figure 1. In addition, the parameters: time of each trial (Δ t_t), total time contact (Δ t_c), total time between peaks (Δ t_P), were analyzed as a way to verify the respect of the cadence.

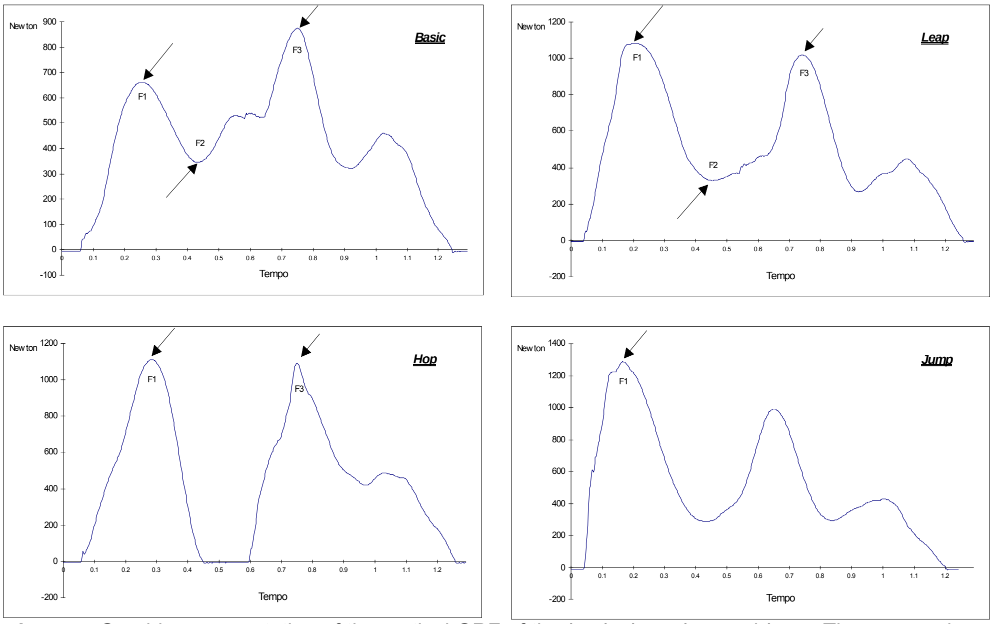

Figure 1*:* Graphic representation of the vertical GRF of the *basic*, *leap*, *hop* and *jump.* The arrows show the reference values of the "1st peak" (F1), "lowest value between peaks" (F2) and "2nd peak" (F3) that allowed us to estimate the highest values of the peak forces. These are referred in Newtons and have no standard value concerning the BW. Time is given in seconds.

The mean, standard deviation and coefficient of relative variation was determined for each variable. The paired T-test were used to compare the different tasks, since the requirements referring to the parametric statistics were fulfilled. The data collection sessions were videotaped to assist in data interpretation.

RESULTS AND DISCUSSION: The paired T-tests (p<0.001) using the mean of each subject's 20 trials showed significant differences between the *basic step* and the power variations for vertical GRF. Summary data for the vertical peak of is provided in Table 1, with means, standard deviations and coefficient of relative variation for each task presented in Figure 2.

Table 1- Summary statistics (mean, *M;* standard deviation, *SD*; and coefficient of relative variation, *CV*) of the 1st and 2nd vertical peak ground reaction force for the *basic* and power variations: *leap, hop* and *jump.*

	BASIC			***LEAP***			***HOP***			***JUMP***		
	M	***SD***	***CV***	***M***	***SD***	***CV***	***M***	***SD***	***CV***	***M***	***SD***	***CV***
peak 1	1.05	0.06	5.38	1.68	0.12	6.87	1.67	0.12	6.88	2.30	0.19	8.9
peak 2	0.68	0.14	20.23	0.79	0.19	24.30	1.88	0.23	12.36			

These mean peak values were 1.05 BW (basic), 1.68 BW (leap), 1.88 BW (hop) and 2.30 BW (jump).
From Table 1 it should be noted that the coefficients of relative variation for vertical peak GRF were greater for the 2nd peak. This may indicate a larger variation in stepping forces possibly due to differences in technique.

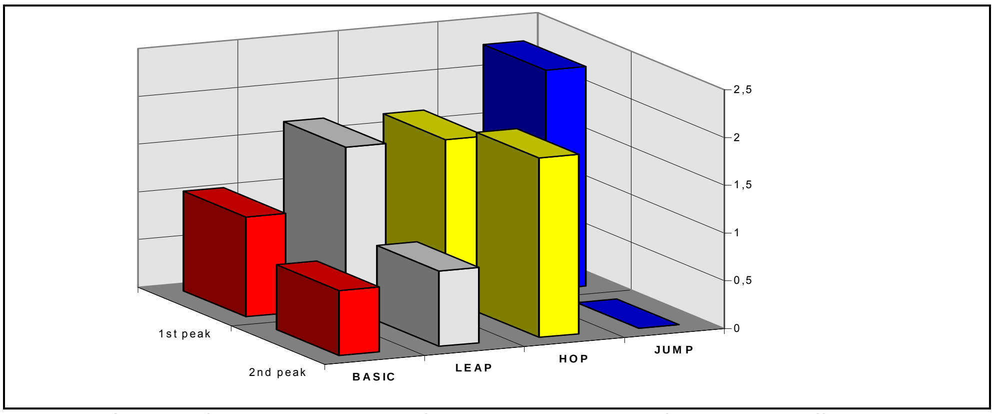

Figure 2: Graphic of the highest values of the 1st and 2nd peak forces in the different tasks. The referred values are expressed relative to BW.

The vertical GRF in this study, for the *basic step*, were closer to the 1.07 BW found by Francis (1992) and 1.03 BW found by Tangen (1996). These values were similar to those reported by Winter (1991) for human gait.
For the power variations *leap, hop* and *jump*, significant increases in mean vertical peak of GRF were found. This seems to agree with the study of Tagen (1996). The values for the *leap*, *hop* and *jump* variations were lower than those found by Tagen (1996) and Francis (1992). This difference may be accounted for by the difference in cadence (126 bpm) and step height (0.20m).

CONCLUSION: The study supports the present recommendation that replacing nonpropulsive steps (basic) with propulsive steps (power) represents an increase in the impact of the activity. The results suggest the need of a broader investigation in this domain. In effect, variables like platform height and music tempo tend to increase the peak values of GRF and should be equated when prescribing step as an exercise program intended to promote health.

REFERENCES:

Nigg, B., Denoth, J., Neukomm, P. (1981). Quantifying the Load on the Human Body: Problems and Some Possible Solutions. In A. Moreki, K. Fidelus, K. Kedzior, S. Wit (Eds.), *Biomechanics VII-B* (pp. 89-99). Champaign, Ill.: Human Kinetics.

Francis, P., Buono, M., Francis, L. (1992). The Science of Step Training. European Educational Conference. Brighton: IDEA.

Panush, R. S. (1994). Physical Activity, Fitness and Osteoarthritis. In C. Bouchard, R. Shephard, T. Stephens (Eds.), *Physical Activity, Fitness and Health - International Proceedings & Consensus Statement* (pp. 712-723). Champaign, Ill.: Human Kinetics Publishers.

Reebok University Press. (1994a). Introduction to Step Reebok. Stoughton: Reebok International.

Reebok University Press. (1994b). Power Step Reebok. Stoughton: Reebok International.

Tagen, I. (1996). Ground Reactions Forces of Three Propulsive Movements in Step Aerobics, Abstract. Eugene: University of Oregon.

Winter, D. (1991). The Biomechanics and Motor Control of Human Gait. 2nd ed. Waterloo, Ontario: University of Waterloo Press.

Woo, S., Gomez, M., Woo, Y., Akeson, W. (1982). Mechanical Properties of Tendons and Ligments. *Biorheology* **19**, 397.