STEP EXERCISE PROGRAM FOR ELDERLY WOMEN: SUPPORT LOAD EFFECTS ANALYSIS.

Maria de Lourdes Machado, Hamilton Santos, António Veloso
Universidade Técnica de Lisboa, Lisboa, Portugal

The goal of the step program is the improvement of health and physical condition, within the scope of advisable exercise. The purpose of this study was to assess the safety of the program and identify its possible osteogenic effects on the elderly. Fifteen post-menopause women (mean age 61.66 ± 5.10 years) performed two-step patterns (basic step and knee lift). Vertical GRF were measured when stepping down on a Kistler force plate and a two-dimensional kinematics analysis was done using the APAS system. The amount of BMD was collected by DXA before and six months after the program. Although the conclusions drawn from a restricted population cannot be generalized, the results suggest that the mechanical stress associated with the program seems to constitute a positive osteogenic stimulus and is a safe and healthy activity that may be included in the physical activity programs for the elderly.

KEY WORDS: step, elderly, ground reaction forces, kinematics, osteogenics.

INTRODUCTION: There is promising new progress regarding the prevention and/or the handling of problems commonly associated with aging. Beyond the age of 50 years there are progressive declines in exercise performance and muscle strength that may compromise activities of daily living and bring individuals close to, or beyond, the threshold of dependency. Since it is universally accepted that physical activity positively affects people's health, intervention to increase muscle strength in the elderly would be potentially very useful. This premise has originated some physical activity programs, among which is the step program. Step has emerged as a popular form of low impact exercise, being currently offered in a number of health and fitness centers throughout the world. It has replaced or combined with traditional aerobics in many fitness programs. Participants follow a routine, which involves stepping up and down on platforms of varying heights, at varying cadences, in order to achieve an aerobic workout. Regular exposure to moderately high levels of force is desirable since mechanical stress will produce structural changes that toughen important anatomical structures, contributing to the increase of bone density (Baptista, 2000; Nigg *et al*, 1995). 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 forces are too repetitive during a period of time (Nigg, 1986), and in a step class there can be up to 6,000-foot strikes (Machado & Abrantes, 1998). The assessment of function in elderly people is of particular importance. The attainment of image records and subsequent analysis constitutes the ideal means of measuring the movement of the body segments as well as the locomotor system as a whole (Veloso, 2000). There are few reported studies on the effects of step aerobics, none of which concerning the effects on elderly people, therefore, the main purpose of this study was to assess the safety of the step program on elderly people and to identify its possible osteogenic effects. These effects were evaluated by measuring the amount of external mechanical load applied to the body during the performance of the most common step patterns. Considering that the subject's technical skills and experience could have a substantial influence on the mechanical load, the planar joint angular kinematic parameters were measured and related to the mechanical load values.

METHODS: Fifteen elderly women participating in the Oeiras community program "*Mexa-se Mais*" (mean age of 61.66 ± 5.10 years; mean height of 1.54 ± 0.06 m; and mean weight of 65.96 ± 6.01 kg) performed 2 step patterns (basic step, BS, and knee lift, KL) at a 0.15 m Step Reebok Platform® height using a 120-bpm tempo. The study location and equipment where shown to the subjects, the experimental protocol explained and the 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 shoes (same model for all participants), which were in good condition, and the step session was taught at a constant rate, 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) and knee lift (up-knee-down-down). Vertical Ground Reaction Forces (GRF) were measured when stepping down, directly on the Kistler force plate (mod. 928 UO 14) using a sampling rate of 1000 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 PCI compatible computer using the Acknowledge software. Peak vertical GRF were expressed relative to each subject's body weight (BW). The value of the peak was determined as the highest value of the load when the leading foot contacts the floor (Kistler device). A two-dimensional kinematic analysis of the motor task was done, by recording it with a camera (Redlake PC/1000 with a fixed lens Cosmicar 6 mm, operating at 125 Hz) from a transversal plane. The camera was fixed at 1.14 m height and 3.50 m away from the subjects. Digitizing and analysis of the images were done using the APAS system, in order to determine the full kinematic characteristics. A digital filter with a cut-off frequency of 5 Hz was used to smoothen the kinematic data (Winter, 1990). A complete cycle of the two patterns was digitized. Six markers were fixed on the joint axes of the left side: two on the foot (at the level of the projection of the 5^{th} head metatarsal bone and at calcaneal); one on the ankle (external mallealus); one on the knee (in the inter-joint line); one at the hip (trocantherion); and another one in the anterior face of the shoulder. Joint net moments from hip, knee and ankle were calculated using an inverse dynamic method. After time normalization, force, position angle and the percentage of muscle length signals were averaged for each test condition. Anthropometric measurements were taken following standard procedures. The amount of mineralized bone (BMD) was collected by Dual-energy x-ray absorptiometry (DXA, QDR-1500 Hologic) synchronized at 70 and 140 kV, before the beginning of the program and after six months. All data expressed as mean $\pm$ S.D. were analyzed using SPSS 10.0. Paired Sample T-Test with a level of confidence of 0.05 was used to compare the mean values of the different kinematic and dynamic parameter. In the lack of normal distribution, the Wilcoxon Mann-Whitney ($p<0.05$) was used. We also verified some linear regressions.

RESULTS AND DISCUSSION: The load values attained in the two task patterns did not show statistical differences and surprisingly the KL values (1.62 BW) were slightly smaller than the ones attained in the BS (1.71 BW). One of the possible explanations is the care put in the performance of the movement. These values are greater than the ones found in previous studies (Tagen, 1996; Machado, 1998; Santos-Rocha *et al.*, 2001, 2001a). Other studies present similar values, but attained because of the increase of the musical *tempo* and platform height. Another explanation may concern the body mass index (27.46 $\pm$ 2.87 kg/m^2) of the sample subjects. According to Liu and Nigg (2000), a variation in the mass of the trunk can affect the load attenuation mechanisms. Tables 1 and 2 summarize the results of the analyzed parameters in the two task conditions from a kinematic point of view. From the data, we could conclude that the maximum force value attained for the vertical component F_z is found within the breaking period of the gravity center (GC), becoming an indicator of the mechanical control of the performance of the task. The maximum load values registered coincided with the impulsion phase and no impacts (passive load) were observed. The linear regressions allowed to verify the relation between some independent variables namely with the Δt or BW. The angular displacement of the joints (ankle, knee and hip) is highly related with Δt ($R^2=0.67$) specially the ankle ($p=0.002$) in the KL. These findings agree with MacFadyen and Winter (1988) that, during stairs step-down, verified a main action of ankle in force absorption. In the BS the amplitude variation of the three main joints is highly related with BW ($R^2=0.66$) specially the knee ($p=0.015$) and hip ($p=0.001$). The ankle and the hip joints seem to attenuate the weight of the motor task. These findings agree with the strategies that Wollacot and Cook (1996) consider typical in elderly. Also in relation with BS, initial vertical velocity of CG and initial vertical velocity of ankle during landing are related with BW ($R^2=0.41$) specially the initial vertical velocity of CG ($p=0.024$). Regarding the BMD, we found statistically significant differences between the values registered before and six months after the exercise, in the trocantherionm($p<0,001$), intertrocantherion ($p<0.05$) and femur neck ($p<0.001$) areas. However, the observed differences are within the range of possible measuring errors of the device (Baptista, 2000). Further research is needed in this regard.

Table 1. Kinematic data concerning both tasks.

Kinematic Parameters	***Basic Step***	***Knee Lift***	***p***
$t_0 - t_1$ (s)	0.14 ± 17.14	0.15 ± 15.91	<0.05
Δt total F_1 (s)	0.38 ± 1.75E-02	0.39 ± 1.75E-02	<0.05
Ankle vertical vel. at touch down ($m.s^{-1}$)	- 0.74 ± 0.16	- 0.79 ± 0.17	NS
Max. downward ankle vertical vel during landing ($m.s^{-1}$)	- 1.27± 0.13	- 1.62 ± 0.28	<0.001
Time of ankle Max.vertical vel (s)	0.18 ±3.22E-02	0.11 ± 6.96E-03	<0.01
Breaking instant v.CG=0 (s)	0.39 ±2.54E-02	0.41 ± 2.35E-03	<0.051
CG vertical velocity at touch down ($m.s^{-1}$)	- 0.70 ± 0.11	- 0.67 ± 0.10	NS

NS: not significant

Table 2. Kinematic data concerning the angular position of the three main joints involved at touch down.

Kinematic Parameters	***Basic Step***	***Knee Lift***	***p***
Ankle angular position (°)	94.71 ± 4.76	97.33 ± 4.10	<0.05
Knee angular position (°)	150.57± 6.85	151.49 ± 6.71	NS
Hip angular position (°)	170.59 ± 5.40	173.45 ± 6.16	<0.05

NS: not significant

CONCLUSION: In the scope and limitations of the present study, results have shown that there were no significant differences between the loads in BS (1.71 BW) and KL (1.22 BW), due to the kinematic changes in the performance of the technical gestures from the sample subjects. However, it seems that the participation of the ankle joint has a predominant action in the breaking of the movement. The kinematic data stress the importance of the hip and the ankle joints as the acting mechanisms responsible for the reduction of the loads concerning the motor tasks, according to Wallacot & Cook (1996). No passive loads were found, the peak values occur after 0.140 seconds in the BS and 0.150 seconds in the KL, allowing the subjects the active control in the task. Thus, it seems that there is an adaptive neuromuscular response (Nigg, 1986; Abrantes, 1993). The mechanical stress associated with the program, according to Baptista (2000) and Heinonen *et al.,* (1999) seems to constitute positive osteogenic stimuli in the specific bone areas where exercise has a preponderant role. Although the conclusions drawn from a restricted population cannot be generalized, the results of the study suggest that the Step program is a safe and healthy activity that may be included in the physical activity programs for the elderly. Further studies should include investigation to understand the load values required to achieve a positive osteogenic effect.

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