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Balance Changes in Trained and Untrained Elderly Undergoing a Five-Months Multicomponent Training Program

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A B S T R A C T

Balance is a main focus of elderly activity programs which can be assessed by functional tests or stabilometry platforms. Our study aims to compare balance-changes in trained (TRA) and untrained (UNT) elderly following a 5-month Multi-Component Training Program (MCTP), twice a week, one hour per day. 10 TRA (>2-years) and 9 UNT (first year) performed the Romberg´s test (Open-Eyes 30 seconds/Closed-Eyes 30 seconds ratio) on a stabilometry platform (BT4, Hur Labs). COP displacement (Trace Length: TL) and sway area (C90) were registered twice PRE (1&2), POST (3&4) and 3 months later (Detraining: 5&6) the EFAM-UV© program, a Cognitive MCTP based on gait training and Dual-Task neuromuscular proposals in enriched environments. Regarding Open-Eyes, Bonferroni post-hoc comparisons showed significant group-differences in TL for 1, 2, 5 & 6 sample conditions, and a slight trend toward significance in C90 1&5. TL also showed significant group-differences in Closed-Eyes 1, 5 & 6, while C90 only in 5 & 6 Closed-Eyes. Balance indicators TL and C90 show a different way regarding the training status. A 5-month MCTP reduces differences, but detraining quickly affects UNT. Although effective, short multicomponent interventions could lead to early worsening, so the ratio training-detraining might be considered in untrained elderly population.

Key words: *stabilometry, Romberg test, ratio training-detraining*

Introduction

Falls are a leading cause of injury and death among older adults, and a significant public health issue (Ambrose, Paul, & Hausdorff, 2013). The economic burden caused by these types of injuries is very important for developed countries since approximately 30% of these falls result in an injury that requires medical attention (Martinez-Amat et al., 2013).

On the one hand, aging involves a neuromuscular impairment accompanied by the appearance of sarcopenia, a loss of muscle mass and function which is a central aspect of fragility, as well as the decline of bone mass (Osuna-Pozo et al., 2013). This leads to a severe loss of functional abilities such as Strength and Balance (Granacher, Zahner, & Gollhofer, 2008; Izquierdo, Martínez-Ramírez, Larrión, Irujo-Espinosa, & Gómez, 2008), both straightly related to the problems of falls. Preventing the loss of these functional capabilities becomes, therefore, a crucial target for the elderly population, and physical exercise arises as a cost-effective tool to promote health and well-being. It improves functionality and removes or delays the onset disease and the risk of falls (Warburton, Nicol, & Bredin, 2006). Indeed, physical fitness is nowadays considered an indicator of life expectancy and life quality.

On the other hand, it is well known that fall prevention programs for healthy older adults often combine both, strength and balance (Lacroix et al., 2015). The so called, Multicomponent training programs (MCTP) have shown to be an integrative way to improve them, becoming promising and widely extended (Cadore et al., 2014; Kang, Hwang, Klein, & Hun Kim, 2015; Seco et al., 2013); although despite their proved benefits, the adherence to these programs is still complicated in this population (Farrance, Tsofliu, & Clark, 2016; Garmendia et al., 2013). It is needed to work on their improvement, as well as it is necessary to deepen on what happens after their detraining periods since a few studies point that detraining effects are age-related. Toraman & Ayceman (2005) found a different trend according to the age of the subjects 6 weeks after assessing their balance with the Timed-*Up and Go Test*. Eggenberger (2015) pointed out that positives effects in fall frequencies were fading out during 6-12 months of detraining.

More specifically, the incorporation of Stabilometry Platforms may improve our knowledge regarding balance changes following MCTP, traditionally assessed by means of some functional test like the "Tinetti-Test" (Tinetti, 1986), the "Step-Test" (Jones & Rikkli, 2002), the "Fullerton´s *Functional Fitness Test"* (Rose, 2010), or the "Functional Reach Test" (de Waroquier-Leroy et al., 2014). As an advantage, this group of tests does not need technological materials for the measurements. However, it may exist a subjectivity or error in the data collection, and floor or ceiling effects may occur in any of them. In addition, stabilometry analyses may deep on quantitative and qualitative changes in balance, and may offer a more objective system of assessment.

Our study aims to analyze stabilometry balance changes comparing a group of trained (TRA) and untrained (UNT) elderly following a 5-month cognitive MCTP (the EFAM-UV© program). The first 3 months of detraining were also included in order to analyze Training and Detraining effects looking for group differences. It seems important to extend the balance stabilometry normative values for healthy older adults undergoing functional training. Moreover, understanding the consequences of detraining might help Geriatric Physical Trainers (GPT) to build up better long-term physical conditioning programs for elderly and reduce the risk of falls.

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Methods

Participants

In order to analyze balance changes following the EFAM-UV© program, a cognitive MCTP based on gait training and Dual-Task neuromuscular proposals in enriched environments, 35 healthy older adults participated in this prospective longitudinal study. The final sample comprised those 19 elderly who attended over the 75% of the program and got their full data outcomes. TRA group (1 men and 9 women, 70.77±6.26 years; 68.15±5.87 kg) was training over two years at the EFAM-UV© program, while the UNT group (5 men and 4 women, 72.22±8.73 years; 80.24±16.93 kg) had never participated in the program before. All individuals had signed their written consent to participate in this study approved by the ethic committee of the University of Valencia.

Study protocol

Anthropometric measurements were evaluated before postural stability testing with a Tanita BC 545. Balance was measured at a silent classroom by means of a Balance Trainer 4 platform (BT4, Hur Labs, Tampere). Participants stood quietly, barefoot (with socks) and feet positioned with the heels closed and the toes open 15cm, a 30º angle recommended by the manufacturer. Arms rested at their sides (Smith, Cheng, & Kerr, 2012) while they looked at a black mark on the wall, 3 m away from them, placed at eye level to stabilize the subject´s visual focus during the measurements (Bergamin et al., 2014; Piirainen, Linnamo, Cronin, & Avela, 2013). There was nothing around the platform for security and to avoid supporting help (Bergamin et al., 2014).

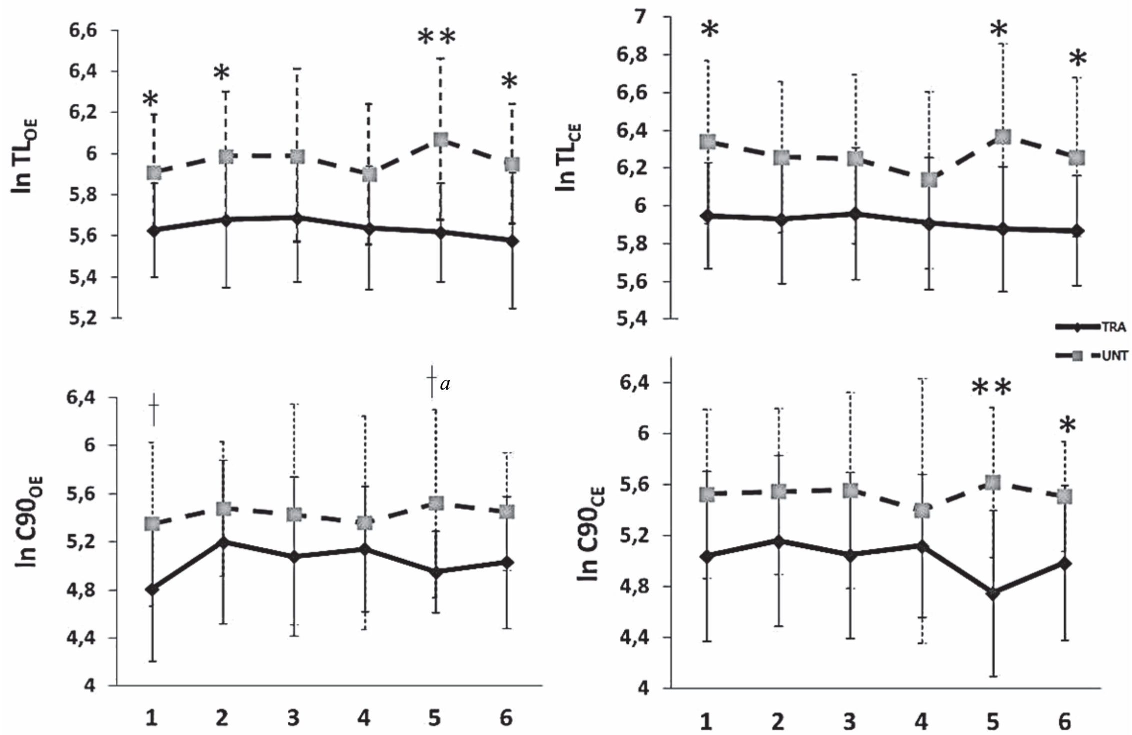
During a Romberg´s test session, the information regarding each subject's sway area (C90) and trace length (TL) was gathered as Centre-of-Pressure (COP) Balance indicators (Smith et al., 2012). Two trials were performed under two visual conditions: Open- Eyes (OE) and Closed-Eyes (CE), where each position was maintained for 35s with the first 5s discarded (Dewhurst, Peacock, & Bampouras, 2015), interspersed with 30s resting within trials. Three sample conditions were considered, resulting in 6 assessments: two at the baseline (PRE: 1&2), two following five months of the EFAM-UV© program (POST: 3&4); and the last two, 3 months later in order to assess detraining effects (DT: 5&6). During detraining, participants were advised not to take part in any balance or functional training activities. Every test was performed at the same hour in the morning, and individuals were asked to avoid changes in their medication, or stimulants consumption; as well as to avoid exercising in the previous 24 hours.

Statistical procedures

Data were analyzed using the Statistical Package for the Social Sciences SPSS, version 22.0 (IBM Inc. Chicago, USA). Distribution tests were conducted by Shapiro-Wilk, and logarithmic transformation was considered when balance indicators were not normally distributed (Nardone, Grasso, & Schieppati, 2006). A Repeated Measures ANOVA was then conducted to analyze changes in the four variables [$C90_{OE}$, $C90_{CE}$, TL_{OE}, & TL_{CE}] comparing training and detraining effects regarding the training status (e.g. between-groups differences). The interaction between training status and sample condition is presented, considering the Bonferroni post-hoc tests, with statistical significance set at the level of $p \leq 0.05$.

Results

Figure 1 shows stabilometry analysis at the PRE (1&2), POST (3&4) and Detraining (5&6) testing conditions. Bonferroni post-hoc tests reveals significant differences between



Legend: the level of * *p<0.05; **p<0.01,* † *a =0.052* and † *p<0.10.*

Figure 1. Stabilometry analysis at the PRE (1&2), POST (3&4) and Detraining (5&6) testing conditions following a 5-months Multicomponent Training Program. Log-transformed mean and standard deviation for the Trace Length (TL) and the Sway Area (C90) under Open Eyes (OE) and Closed Eyes (CE) conditions, are compared for Trained (TRA, N=10) vs Untrained (UNT, N=9) elderly subjects. Bonferroni comparisons regarding the interaction training-status *sample condition.

groups (TRA vs UNT) before the 5-months MCTP for TL_{OE} at PRE1 (285.2±61.8 mm vs 382.15±109.55 mm; p<0.05) and at PRE2 (306.82±90.52 mm vs 420.97±144.74 mm; p<0.05) after log-transformation. This difference is also shown in TL_{CE} at PRE1 (398.2±102.96 mm vs 617.19±276.46 mm; p<0.05). However, none of these variables showed significant group-differences after the MCTP intervention (Post 3&4). Later on, after detraining period, we found again significant differences regarding the training status, with worse (higher) TL_{OE} for UNT at DT5 (284.19±70.35 mm vs 467.37±181.02 mm; p<0.01) and DT6 (277.62±85.3 mm vs 399.77±135.61 mm; p<0.05), and also in TL_{CE} at DT5 (377.72±125.89 mm vs 651.41±320.83 mm; p<0.05) and at DT6 (369.34±99.43 mm vs 565.75±243.16 mm; p<0.05), as it is shown in figure 1.

On the other hand, $C90_{OE}$ showed a slight trend toward significance in PRE1 (141.81±68.6 mm^2 vs 262.10±205.53 mm^2; p=0.08) and at DT5 (148.27±49.15 mm^2 vs 344.25±362.28 mm^2; p=0.05), while $C90_{CE}$ showed significant differences already at DT5 (140.55±100.38 mm^2 vs 318.59±169.38 mm^2; p<0.01) and DT6 (175.43±116.68 mm^2 vs 267.50±108.95 mm^2; p<0.05).

Discussion

The aims of this study were: 1) to extend the balance stabilometry normative values for healthy older adults undergoing functional training, and 2) to determine if the elder's previous training status could influence the balance enhancement due to the 5-months EFAM-UV© program, or the gains retention or worsening after the three months of detraining.

According to previous studies, C90 and TL low values point to be indicators of a better balance (de Oliveira, da Silva, Dascal, & Teixeira, 2014; Dewhurst et al., 2015; Smith et al., 2012; Wuest et al., 2014). Also in our sample, the TRA group had lower values than UNT.

More specifically, TL_{OE} in the TRA group ranged from 277.62±85.3 to 310.2±108.56 mm while the UNT group ranged from 382.15±109.55 mm and 467.37±181.02 mm. In comparison, Han, Lee & Lee (2013) reported TL_{OE} scores of 289.4±86.7 mm at pre-test and 277.3±74.1 mm post-test in a group of young people (25.3±6.2 y) with the same BT4 platform. And both studies described higher scores (worse balance) when performing the test with closed eyes. Han, Lee & Lee (2013) showed pre-post TL_{CE} differences of 368.8±124.9 vs 300.9±80.4 mm for the younger, while TL_{CE} becomes worse in the TRA elderly in our sample (between 369.34±99.43 mm and 408.9±150.71 mm), or even worse in the UNT (between 512.45 ±246.55 mm and 651.41±320.83 mm).

However, regarding C90, Han, Lee & Lee (2013) got lower sway area after the balance intervention in both cases ($C90_{OE}$: 231.1±166.5 to 195.9±114.2 mm^2; $C90_{CE}$: 377.8±241.9 to 252.3±131.1 mm^2), but our TRA elderly obtained similar or even lower scores for both C90 indicators [$C90_{OE}$: 141.81±68.6 mm^2 to 224.59±161.82 mm^2; $C90_{CE}$: 140.55±100.38 mm^2 and 214.45±154.38 mm^2], showing a great capacity to control their COP after more than two years following the EFAM-UV© program.

It's been already described that the aging-induced impairment in vestibular, visual, somatosensory and neuromuscular function results in deteriorated postural control with an increased postural sway during standing balance tasks in the elderly (Donath, Kurz, Roth, Zahner, & Faude, 2015; Gim et al., 2015; Qiu et al., 2011). Furthermore, degeneration on their peripheral sensory receptors detected less information from the environment, leading to higher values in the eyes closed condition (Qiu et al., 2011). However, the EFAM-UV© MCTP seems to be able to help elderly to improve their balance, mostly reflected by the variable C90. These differences in C90 and TL suggest that these indicators may be reflecting different COP control mechanisms.

Regarding COP control under pathology, Gim et al. (2015) analysed the sway area with the BT4 in a group of post-stroke adults (45 to 70 years old) finding $C90_{OE}$ scores between 521.3±397.6 and 602.5±594.1 mm^2; and $C90_{CE}$ between 528.1±497.4 mm^2 and 758.1±635.9 mm^2, which were clearly worse (higher) than our untrained healthy adults [$C90_{OE}$: 259.65±122.23 mm^2 and 346.6±385.03 mm^2; $C90_{CE}$ 267.5±108.95 mm^2 and 421.89±693.73 mm^2]. This confirms a severe neuromuscular dysfunction post stroke assessed by the stabilometry platform BT4 and the need of implementing MCTP in these patients.

On the other hand, significant differences between groups demonstrate that physical fitness and training status is an important parameter to be considered, mostly when talking about the detraining effects. As a main and general finding, COP balance indicators showed some group differences at the beginning of the MCTP program, which disappear after the end of the 5-months of intervention. However, the detraining period lead to the appearance of significant group differences again, mostly in the first time of the assessments (DT5). It is important to note that each indicator had a trend. While LT demonstrated differences in 1, 2, 5 & 6, C90 showed significance only at 5&6 (reducing the baseline or pre-intervention differences to a trend). As already mentioned, after the intervention, the differences were removed in both because the UNT group improved their balance.

Baseline between-group differences at C90 might be reduced due to fear-to-fall, stiffening behaviours and increasing the co-activation so as to augment the control of the posture (Young & Williams, 2014). These strategies are generated frequently under new situations and cause a smaller sway area (Donath et al., 2015; Young & Williams, 2014). Later on, when people already know the situation, they become relaxed and the sway area may become larger. Wuest (2014) also obtained larger area after his intervention, pointing out that C90 could not be a good parameter or balance indicator.

After 3 months of detraining, there were again significant group differences, meaning that there was an excessive detraining period for the UNT group after such a short intervention, and therefore pointing to the need of reviewing the training / detraining ratio, that is, the relation between the length of the MCTP and its holidays' periods. Conversely, trained people were unaffected by detraining. Detraining confirms to be very sensitive to age, gender, physical status (Carvalho, Marques, & Mota, 2007) also regarding Balance training, with differences in the upper and lower extremities behaviour (Toraman & Ayceman, 2005). The design of physical activity programs for elderly people has to consider many different parameters, including the training status. It has to be controlled for the planning of the gains retention, and the effort and the length of the interventions, as well as the detraining periods must be also considered to ensure its long time effects.

However, some limitations need to be addressed. On the one hand, the sample was not big enough for generalizing the results, and there was no control group, therefore decreasing our internal validity. Similarly, some other functional parameters like strength and fitness might had been included to analyze their improvement or worsening in the same sample conditions. On the other hand, we have found some different protocols to evaluate balance with BT4 platforms, and it would be necessary to standardize the time of the registers, as well as the number of trials or the resting times among repetitions. For example, Scoppa, Capra, Gallamini, and Shiffer (2012) propose the use of the mean value among three repetitions and at least 30 seconds resting. Finally, it is important to improve or review the instructions to the people when they come into the platform, since they might be of paramount importance, causing some differences. An instruction like "do not move" may lead the participant to adopt a co-activation strategy and to reduce the sway area, whereas an instruction related to "relax on the platform and do not move", may lead to an increase in the sway are related to a confidence feeling. It is of crucial importance to reproduce the same verbal protocol every time.

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