

# Effects of Integrative Core Stability Training on Balance and Walking Speed in Healthy Elderly People

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## Abstract

The study aims to describe the effects an integrative core stability training on balance and walking speed in healthy elderly people over 65 years old: an adapted training program based on core stability exercises was introduced in the warm up phase. The study was conducted with active adults (n = 84, 38 males, 46 females) randomly divided into 2 groups: adapted core stability group (CSG, n = 40) with age, weight and height (mean ± ds) respectively of 68.2 ± 2.1 years, 69.87 ± 3.2 kg, 166.6 ± 4.8 cm; recreational group (RG, n = 44) with age, weight and height respectively of 68.9 ± 2.2 years, 68.7 ± 3.7 kg, 167 ± 2.8 cm. The sample performed for 10 weeks (3 sessions a week) the two different activities; before and after the training period (T0 and T1), the strength of the core district, static balance ability, dynamic balance and walking speed were evaluated. The results revealed a change in test scores across the two time periods (pre-intervention, post-intervention) for CSG in the McGill sit-up test ( $p < 0.01$ ), in the trunk extension ( $p < 0.01$ ), in the right side plank test ( $p < 0.01$ ), in the left side plank ( $p < 0.01$ ), in the left leg stance ( $p < 0.01$ ) and right ( $p < 0.01$ ), in the 8-foot-up-and-go ( $p < 0.01$ ), in the 3-m backwards walk test ( $p < 0.01$ ), in the tandem walk test ( $p < 0.001$ ), in the single-leg stance test left limb ( $p < 0.001$ ) and right limb ( $p < 0.01$ ). In the RG the only statistically significant difference observed between T0 and T1 was found in the 8-foot-up-and-go test ( $p < 0.05$ ). The comparison between CSG and RG showed significant differences in all T1 tests in the CSG. The introduction of core stability exercises adapted to the over 65 population seems capable of determining advantageous transfers in some motor abilities. The choice of introducing these very static exercises in the warm-up phase allows people over 65 to progressively approach specific motor tasks who do not have particular motivations for controlled and systematic physical exercise.

## Keywords

Warm Up, Core Stability, Balance

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### 1. Introduction

One of the challenges that await the teaching of motor skills is that of involving people over 65 in specific and adapted programs.

Movement education and active lifestyles education are two objectives of motor activities in all age groups.

The elderly population tends to reduce suggested physical activity levels and therefore fails to effectively counteract the aging effects.

These conditions force those over 65 to limit activity daily living (ADL) and favor chronic diseases that characterize advanced adulthood (Kot et al., 2019; Ozsoy et al., 2019; Bordoni, 2019).

In fact the relationship between sedentary lifestyles and related pathologies indicates a potential increase in cardiovascular and metabolic diseases, marked alteration in body composition and individual physical fitness (Dohrn et al., 2020; Jacob et al., 2020; Myers et al., 2019; Wu et al., 2017; de Rezende et al., 2014; Kemi & Wisloff, 2010; Dimkpa, 2009; Bisciotti, 2012; Bisciotti, 2006); this decline becomes more marked, whereas in advanced adulthood, the subject breaks or reduces the motor exercises (Dohrn et al., 2020; Sannicandro, Cofano, & Rosa, 2020; McPhee et al., 2016; Wanigatunga et al., 2019; Bosquet et al., 2013).

The literature provides significant studies that have highlighted how prevention strategies can be implemented through movement (Liguori et al., 2018; McPhee et al., 2016; Bisciotti, 2012); these studies aim to understand which ones can allow more adaptable adaptations with lower risk of overload in subjects over 60 years old (Scurati et al., 2016; Rosa et al., 2016; Sannicandro et al., 2008; Sannicandro, 2013).

These considerations must lead to the identification of preventive as well as rehabilitative interventions (Bordoni, 2019; Granacher et al., 2013; Kahle & Tevald, 2014).

Research is therefore geared towards analyzing the effects of different motor activity protocols for elderly people and to understand which ones can allow more adaptable adaptations with lower overload risks (Conlon et al., 2018; Sannicandro, 2017; Conlon et al., 2016; Cavaggioni et al., 2015; Deruelle et al., 2007).

In recent years, new exercise types are being launched, aimed at reducing the low back pain risk and postural control, including core stability tasks (Kang, 2015; Kahle & Tevald, 2014; Granacher et al., 2013; Granacher et al., 2011; Kang et al., 2012).

Core stability exercises need to be adapted to the characteristics of the elderly population: in fact, many individuals over 65 cannot perform exercises on the ground and core tasks must be organized standing or leaning against the wall.

Core is defined as the coxo-lumbar-pelvic complex formed by the lumbar spine, the pelvis, the hip joint and all the muscles acting, controlling or favoring the trunk movements.

These muscle districts have a significant role in total spine and, in particular, lumbar spine stabilization (Panjabi, 1992; McGill, 2001; Willson et al., 2005; Hodges, 2003; Hodges et al., 2005) for these reasons, some Authors identified a local control system and a global control system on this body district, in relation to their recognized function (Panjabi, 1992; Crisco & Panjabi, 1991; Hodges, 2003; Urquhart & Hodges, 2005).

The core anatomical section is considered to be a cylindrical box composed of abdominal muscles, the gluteus and paraspinal muscles, the diaphragm muscle and the pelvis; it also includes the lower back muscles and coxo-femoral joints (Willson et al., 2005; Hodges, 2003; Hodges et al., 2005; Hibbs et al., 2008).

Therefore, Core training has been considered a useful set of exercises that can be used in sport (Sannicandro, Cofano, & Piccinno, 2020; Sannicandro & Cofano, 2017; Weston et al., 2015; Prieske et al., 2016; Petersen & Nittinger, 2014; Kibler et al., 2006) as well as improving daily living activities (Jacob et al., 2020; Kliziene et al., 2015; Suri et al., 2009).

For ACSM, these types of exercises should systematically be part of the training sessions of all healthy adults (ACSM, 2010; Scurati et al., 2016; Seo et al., 2012; Stephenson & Swank, 2004) to prevent any spinal and lower limbs injuries (Kliziene et al., 2015; Petersen & Nittinger, 2014; Hicks et al., 2005; Petrofsky et al., 2005; Hodges et al., 2005; Willson et al., 2005): ACSM's advices, in practice, support the effectiveness and systematic nature of this type of exercise in order to improve these functional relationships and to extend senior quality life; other Authors view Core stability exercises to prevent falls by increasing the static and dynamic balance ability (ACSM, 2010; Kahle & Tevald, 2014; Granacher et al., 2013; Kang, 2015).

In fact, this ability that requires the complex interaction of the neuromuscular, proprioceptive, vestibular, and visual system is affected by the aging process that is responsible for sensory perception and therefore affects the fall risk in the senior (Sannicandro, 2017; Granacher et al., 2013; Sannicandro, 2013; Bisciotti, 2012).

Core stabilization exercises are able to improve balance control by enhancing deep and superficial trunk muscles such as multifidous, transversus abdominal, longissimus dorsi, inner and outer oblique (Sasaki et al., 2019; Aluko et al., 2013; Sousa et al., 2013; Jemmett, 2003; McGill, 2001).

The programs most frequently recommended and presented to senior students are related predominantly to improve strength, aerobic efficiency or the integration between these two big areas of training (Scurati et al., 2016; Wase-nius et al., 2014; Sannicandro et al., 2008; Sousa et al., 2013; Faina et al., 2008).

In the literature a great attention has been devoted to the rehabilitation effectiveness of core stability exercises (Kot et al., 2019), while an open problem remains to understand how to approach all subjects over 65 to this type of motor task.

In fact, many over 65 prefer recreational activities and rarely adhere to systematic and specific programs.

It must be understood at what moment they can be introduced and with what volumes of exercise.

The adherence to the practice of core stability exercises could be greater if the research can identify in which phase they can be proposed and to what extent.

## **2. Methods**

### **2.1. Objective**

The study therefore aims to describe the effects of a core stability program inserted only in the warm up phase, compared to recreational physical activity only on the balance and walking speed of elderly people over 65 years old.

### **2.2. Participants and Setting**

The study was conducted with active adults ( $n = 84$ , 38 males, 46 females) randomly divided into 2 groups: adapted core stability group (CSG,  $n = 40$ ) with age, weight and height (mean  $\pm$  ds) respectively of  $68.2 \pm 2.1$  years,  $69.87 \pm 3.2$  kg,  $166.6 \pm 4.8$  cm; recreational group (RG,  $n = 44$ ) with age, weight and height respectively of  $68.9 \pm 2.2$  years,  $68.7 \pm 3.7$  kg,  $167 \pm 2.8$  cm.

The subjects included in the study did not exhibit cardiovascular, metabolic or skeletal muscle pathologies, nor did they undergo pharmacological treatment. The study ( $n = 5$ ) was excluded from the study who in the last year had been forced to rest due to functional overload or prolonged trauma. After excluding 5 subjects from the data analysis, the groups were formed as follows: CSG,  $n = 38$ , RG,  $n = 41$ .

### **2.3. Procedure**

All subjects have been informed in advance about the proposed training and potential injury risk. The study was conducted acknowledging the principles presented in the Helsinki Declaration.

The following functional tests were used to evaluate motor capacity:

- McGill Test was used to evaluate trunk strength by the three positions established by the protocol; the subject is encouraged to keep isometrically as long as possible the sit-up, lateral, and trunk extension position. The detector records the time at which the subject manages to hold the assigned positions (McGill, 2001; McGill et al., 2003);
- Single Leg Stance test was presented for static balance evaluation; the subject standing on one foot, with his hands on the chest and with open eyes, is invited to maintain the position assigned taking care not to tilt the bust, abduct the lower limb in suspension or touching the ground. It detects the time at which the subject is able to keep the assigned task. The test was performed on both limbs (Springer et al., 2007);
- Tandem walk test was used to evaluate dynamic balance during a specific

walking task performed on a line (2 m length, 5 cm wide): the subject was instructed to place one foot behind the other, each time making sure that the toe of swing foot was placed directly behind the heel of stance foot. The subject was walk as fast and comfortable as possible without falling down (Robertson & Gregory, 2017; Cohen et al., 2018; Chantanachai et al., 2014);

- 8-foot-up-and-go test was presented to evaluate dynamic balance in a daily task; the assessment involves getting out of a chair, walking 2.44 meters to and around a cone, and returning to the chair in the shortest time possible. The time needed to perform the task measured with 1/10-second accuracy constitutes the test's result (Rikli & Jones, 1999);
- 3-m Backwards Walk test was used to evaluate dynamic balance during walking backwards; the subject, walks backwards for 3 meters and the task were measured with 1/10 second accuracy. The participant performs two trials and the average time was calculated (Carter et al., 2019).

The training period lasted 10 weeks (3 sessions a week) for a total of 30 sessions of about 45 minutes each.

Before and after the training period (T0 and T1), there were established two evaluation sessions on motor skills and anthropometric variables that provided Core stability assessment through the McGill test, the walking speed through 8-foot-up-and-go test and the 3-meters backward test, the static balance assessment by Single Leg Stance Test and Tandem Test (Robertson & Gregory, 2017).

Each training session provided an initial 15 minute warm up phase: in this phase for the CSG were introduced adapted core stability exercises; while the RG performed traditional activation exercises (Table 1, Figure 1 and Figure 2) (joint mobility, walking, flexibility, etc.). All the other activities planned in the session were the same for both groups (physical activity with music, dance, or activities with the use of small tools such as balls, circles, etc.).



**Figure 1.** Adapted plank exercise.



**Figure 2.** Turn and twist with light ball on one-leg stance.

**Table 1.** The different warm up protocol in the CSG and RG at the top of the table; below the activities planned in the central phase for both groups.

	CSG warm up	RG warm up
15 minutes	Free walking: 2 minutes Adapted Core stability exercises: Plank resting with the elbows on the wall: 3 set × 4 rep × 6 sec ( <b>Figure 1</b> ). Free walking: 1 minute Side Plank (with the shoulder against the wall: the body is oblique respect to the wall): 3 set × 6 rep × 6 sec. × side Free walking: 1 minute Climber resting with the elbows on the wall (the elderly alternately detaches the elbow and the contralateral foot): 3 set × 8 rep Free waling: 1 minute Turn and twist with light ball on one-leg stance (controlled movement): 4 set × 8 rep × each side ( <b>Figure 2</b> ) Free walking: 1 minute	Walking: 5 minutes Joint mobility: 5 minutes Flexibility (static and dynamic tasks): 5 minutes
Central phase	physical activity with music, dance, or activities with the use of small tools such as balls, circles, etc.	physical activity with music, dance, or activities with the use of small tools such as balls, circles, etc.

For all the values obtained, the descriptive statistic (mean, standard deviation) was determined, while the comparison of averages was performed by t-test for paired data for comparison of T0 and T1 and T-test for independent data to verify the intergroup differences (CSG vs RG). Statistical significance was set at  $p < 0.05$ . To evaluate the effect size index (Effect Size:  $\leq 0.20$  small, 0.50 mean,  $\geq 0.80$  large, Cohen, 1992), Cohen's D in T1 was calculated.

### 3. Results

The results revealed a change in test scores across the two time periods (pre-intervention, post intervention) for CSG in the McGill sit-up test ( $p < 0.01$ ), in the trunk extension ( $p < 0.01$ ), in the right side plank test ( $p < 0.01$ ), in the left side plank ( $p < 0.01$ ), in the left Leg Stance ( $p < 0.01$ ) and right ( $p < 0.01$ ), in the 8-foot-up-and-go ( $p < 0.01$ ), in the 3-m backwards walk test ( $p < 0.01$ ), in the Tandem walk test ( $p < 0.001$ ), in the Single-leg stance test left limb ( $p < 0.001$ ) and right limb ( $p < 0.01$ ).

In the RG the only statistically significant difference observed between T0 and T1 was found in the 8-foot-up-and-go test ( $p < 0.05$ ).

T-test data for unpaired data did not reveal statistically significant differences between the two groups (CSG vs RG) in the T0.

The unpaired T-test data results yielded statistically significant differences between CSG and RG in T1, always in favor of SCG, in the McGill trunk sit-up test ( $p = 0.04$ , ES: 0.47), in the trunk extension ( $p < 0.01$ , ES: 0.49), in right and left plank side tests ( $p < 0.01$ , ES: respectively 0.66 and 0.68), in the 8-foot-up-and-go ( $p < 0.01$ , ES: 0.67), in the 3-m backwards walk test ( $p < 0.01$ , ES: 0.77), in the tandem walk test ( $p < 0.01$ , ES: 0.68), in the Single Leg Stance test on the right and left limb ( $p < 0.01$ , ES respectively 0.81 and 0.85). The results are summarized in **Table 2**.

### 4. Discussion

The purpose of this study was to verify the effects of integrative core stability program, compared to a traditional recreative activity on balance abilities and walking speed in over 65 years old active adults.

The execution of core stability motor tasks requires a high level of motivation in the over 65 years old: therefore, so that they can also be introduced within recreational activities; the appropriate time and the appropriate dose must be identified.

**Table 2.** Results of CSG and RG in the T0 and in the T1. Legend: CSG: Core Stability Group; RG: Recreational Group;  $p^a$  resulted from paired sample  $t$ -test;  $p^b$  resulted from unpaired sample  $t$ -test; ES: Effect Size,  $*p < 0.05$ ;  $**p < 0.01$ .

Test	CSG			RG				d Cohen (ES)
	T0 m ± ds	T1 m ± ds	$p^a$	T0 m ± ds	T1 m ± ds	$p^a$	$p^b$	
McGill Test—sit-up (sec)	13.9 ± 5.3	16.8 ± 1.9	0.003**	14.1 ± 3.5	14.4 ± 2.2	0.146	0.04*	0.47
McGill Test—extension (sec)	16.1 ± 2.8	21.2 ± 2.5	0.002	17.5 ± 3.2	16.7 ± 5.3	0.160	0.003**	0.49
McGill Test—side plank right (sec)	8.8 ± 2.5	13.9 ± 4.1	0.003**	9.9 ± 1.8	9.5 ± 3.1	0.09	0.003**	0.66
McGill Test—side plank left (sec)	8.4 ± 2.9	13.4 ± 3.6	0.002**	9.1 ± 3.4	9.4 ± 3.1	0.08	0.003**	0.68
8-foot-up-and-go (sec)	7.81 ± 0.68	5.72 ± 0.61	0.002**	7.01 ± 0.94	6.05 ± 2.86	0.04	0.008**	0.67
3-m Backwards walk test (sec)	4.7 ± 1.1	3.2 ± 0.9	0.008**	4.82 ± 1.9	4.61 ± 2.3	0.09	0.003**	0.77
Tandem walk test (sec)	8.68 ± 4.26	6.71 ± 2.41	0.001**	8.16 ± 1.53	7.59 ± 2.37	0.18	0.006**	0.68
Single Leg Stance Test (right)	16.45 ± 3.47	20.47 ± 4.26	0.001**	14.6 ± 7.8	16.7 ± 3.9	0.10	0.004**	0.81
Single Leg Stance Test (left)	14.18 ± 6.04	19.12 ± 4.01	0.002**	15.7 ± 5.5	16.3 ± 4.6	0.11	0.004**	0.85

The studies that followed the guidelines of the ACSM (ACSM, 2010; Scurati et al., 2016; Seo et al., 2012; Stephenson & Swank, 2004) have highlighted the functional relationships between core strength and individual autonomy of people over 65 years old (Sannicandro, 2017; Rosa et al., 2016; Granacher et al., 2013; Kang et al., 2012; Hosseini et al., 2012).

In the present study, at the end of the 10-week activities, from the comparison of the data collected in the T0/T1 assessment, there were differences between the CSG and the RG in all the evaluated abilities.

Observing the values of the two groups at the T1, the CSG in the McGill Test used to verify lumbar stability showed an increase of 17% in sit-up position ( $p < 0.05$ ), in a right plank position of 36.7% ( $p < 0.01$ ), in the left plank position of 37.4% ( $p < 0.01$ ) and in the trunk extension position of 24% ( $p < 0.01$ ), highlighting significant differences over the RG.

The obtained values are consistent with what is present in the literature and obtained with a sample of similar subjects by age and gender, to which core stability exercises have been proposed and superimposed on training studies conducted for periods of time higher than those in this study who have made use of the same evaluation tests (Rosa et al., 2016; Granacher et al., 2013).

The medium ES (from 0.47 to 0.68) indicates the significance of the differences between the average values obtained in the two assessment periods.

The significant increase in almost all of the McGill Test in the CSG suggests that the proposed exercises have proved to be functional to increasing core control, a goal that is considered to be a priority by the ACSM guidelines (ACSM, 2010).

The RG values are also consistent with the literature data as it has been shown that a modest efficacy of muscle strength exercises was observed in core stability in subjects aged between 60 and 68 when not following specific programs (Hosseini et al., 2012; Kasukawa et al., 2010; Nichols et al., 2001).

Conversely, the introduction of Core stability exercises returned a positive transfer in the CSG on left (+37.4%,  $p < 0.01$ ) and right (+36.7%,  $p < 0.01$ ) static balance, suggesting that trunk strength plays a significant role in unilateral stance control.

In this regard, in literature there are numerous evidences that show the relationships between core stability and balance (Kang, 2015; Arnold et al., 2015; Granacher et al., 2013; Kang et al., 2012).

In particular, two studies, always focused on specific trunk stabilization exercises, reported the same increases in static balance capacity obtained in the present study using the same evaluation test; and such functional relationships seem to be maintained and highlighted even for older people up to 80 years old (Kahle & Tevald, 2014; Hosseini et al., 2012).

Significant increases in the SCG Tandem Walk Test (+29.3%,  $p < 0.01$ , ES: 0.68) compared to the modest increase obtained by RG (+7.5%, ns) induces as much as trunk strength influencing balance specific motor tasks: the values are similar to those obtained from other researches that have used this assessment



test (Sannicandro, Cofano, & Rosa, 2020; Chantanachai et al., 2014; Seo et al., 2012).

The advantages obtained in 8-foot-up-and-go (+36.5%  $p < 0.01$ , ES: 0.67) and in 3-m backward test (+46.8%  $p < 0.01$ , ES: 0.77) confirm the transfer between core stability, dynamic balance and walking speed; also the RG shows statistically significant differences in T1 ( $p < 0.04$ ), confirming what is known about the role of active lifestyles on walking speed (Uemura et al., 2018; Layne et al., 2017).

In conclusion, the results obtained confirm what is already described in the literature: the senior also responds to loads targeted at the Core district with positive transfer and adaptation of balance (Rosa et al., 2016; Kang, 2015; Arnold et al., 2015; Kahle & Tevald, 2014; Granacher et al., 2013); and walking speed or step (Sannicandro, 2017; Rosa et al., 2016; Seo et al., 2012; Faina et al., 2008; Katzman et al., 2007).

Comparing the values of this study with other studies in the literature, including those conducted with special people (Youm et al., 2020; Javadian et al., 2015; Sinaki et al., 2005; Hodges et al., 2005; Suri et al., 2009; Kasukawa et al., 2010; Stephenson & Swank, 2004), it is plausible to suppose that these motor tasks can be included in motor activity plans aimed at increasing balance ability, trunk stabilization and, consequently, in senior fall prevention plans (Youm et al., 2020; Sannicandro, Cofano, Rosa, & Colella, 2020; Ozsoy et al., 2019; Arnold et al., 2015; Ko et al., 2014).

This study presents a limit on the size of the sample. It needs to be verified with larger samples.

Further studies are needed to understand whether the introduction of the instability tools can lead to better outcomes in the assessed abilities. The tools that generate instability may be more welcome than adapted core stability exercise in subjects over 65 years old.

## Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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