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Original Research

Comparison of Rocker Shoes and Normal Shoes on Reducing the Risk of Falls in the Elderly During the Implementation of an Agility-Based Fall Prevention Protocol

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ABSTRACT

It is possible that using unstable shoes with fall prevention exercise training contributes to better fall-related measures in older adults. We aimed to evaluate the effects of 12-week agility balance training wearing usual (US) or unstable (UnS) shoes on the balance, mobility, strength, and fear of falling in healthy older men. A prospective three arms randomized controlled trial was conducted in a university lab. Fifty-seven male older adults were initially randomized into US, UnS, or a control group, and 53 participants (mean age 67.5±4.1 years) completed the study. Both US and UnS groups received agility balance training wearing usual and unstable shoes, respectively. Group classes were offered three times per week over 12 weeks. The control group did not receive an active intervention. Ankle plantar flexor muscle strength (Calf-Raise Senior test), balance (Fullerton Advanced Balance scale), mobility (Timed Up and Go test), postural stability (force platform), and Fear of falling (Fall Efficacy Scale-International) were measured at baseline, after the 12-week intervention, and one month after the end of the training program. There was a significant improvement in all fall-related measures after the 12-week agility balance training in both UnS (ES= from 1.19 to 2.4) and the US (ES = from 0.63 to 2.5) compared with the control group. The UnS group experienced more mobility gains at the 12-week posttest ($p = 0.03$) compared with the US group. At follow-up, all gains were maintained in the UnS group ($p < 0.05$), but the plantar flexor muscle strength ($p = 0.3$), mobility ($p=0.08$), and postural sway ($p =0.07$) scores returned to baseline values in the US group. At follow-up, significant differences were found between-group for all fall-related measures ($p> 0.05$) in favor of the UnS group. Agility balance training with and without unstable shoes improved fall-related measures. However,

wearing unstable shoes with agility balance training maintains longer-term positive effects on fall-related measures in older men.
Keywords: Shoewear, Balance, Postural control, Fear of falling, Agility balance training

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INTRODUCTION

Falls are a major public health problem that affects almost 33% of older adults who fall once a year, with half of those repeated [1]. Falls lead to enormous direct and indirect costs on medical care, at individual and societal levels [2]. Performance-based measures of mobility, balance, and neuromuscular function have been identified as the strongest intrinsic risk factors for injurious fall events in older adults [3–5].

The majority of static and dynamic employed balance exercises are less similar to situations in which balance is compromised (e.g., balance maintenance following sudden perturbation and rapid production of required articular torques) and cause task-specific training adaptations [6] with marginal transitional effects. Therefore, these programs lack, specificity, and impair their effectiveness to reduce or prevent falls, specifically in older adults.

A more specific form of balance training for fall prevention can be agility-balance training [7], including acceleration, deceleration, stopping and moving patterns, shifting (shear maneuvers), and eccentric loading, in combination with tasks requiring spatial orientation effort, which can be used as an integrative motor competency training approach for older adults [7,8]. A comprehensive agility-balance training regimen can include perceptual and decision-making aspects (such as visual processing, situational awareness, pattern recognition, and prediction), locomotor changes (including motor control reaction, fast and eccentric contraction), and cardiovascular training stimuli (time required to progress through the circuit) as well as balance training drills. The physical and perceptual demands of the training program can be continuously more complex, and the cardiovascular needs can be exacerbated by the choice of additional tasks, circuit length, and the number of circuit reps. However, few studies have tested agility balance training, and its potential effects on fall risk factors, and they are mostly shorter duration (up to 6 weeks) [7,8].

A recent meta-analysis reports around 20% fall rate reduction using balance training, which can be higher when balance training is highly challenging [9]. Studies on traditional balance training, using a wobble board as an unstable condition, show that the balance and physical performance of older adults improves proprioceptive function, leg muscle strength, and ankle strategy [10,11]. In addition, a meta-analysis study showed that strength training on unstable surfaces compared with stable surfaces could be more effective in improving the strength, power, and balance performance of older adults [12]. Another recent study has shown that exercise targeting the core muscles, upper and lower limbs, and moderate-intensity strength exercises using unstable surfaces were extended to functional mobility gains, and reduced concern about falling [13]. Unstable conditions are supposed to have beneficial effects in improving balance and reducing the fall risk in older adults by continually stimulating proprioceptive receptors and increasing muscle activity of lower extremities during closed kinetic chain exercise activities [12,14,15]. However, there is still a gap in evidence examining the effects of innovative sports strategies, including the combined effects of balance training with unstable surfaces, on fall-related measures in older adults.

In recent years, shoes that have unstable soles are being marketed by different companies as unstable shoes. Currently, unstable shoes are used by a broad population, including people with the lumbar, lower limb, and foot problems and patients with knee osteoarthritis [16], healthy athletes, and non-athletes [17]. Due to the unstable nature of these shoe soles, they act similar to wobble boards and can increase posture oscillation and lower extremity muscle activity more than usual shoes and barefoot [14,15] . Some studies have shown positive changes in kinematics and kinetics of gait [17,18], improved posture control and balance [10,19], and increased leg muscle activity [16]. Therefore, it is possible that using unstable shoes with agility-

balance rain may contribute to better mobility, balance, postural control, foot muscle strength, and potential fear of falling.
Therefore, this study aimed to determine the effects of wearing unstable shoes and usual shoes with agility-balance training on balance, postural stability, mobility, plantar flexor muscle strength, and fear of falling in healthy older adults. We hypothesized that both training modes would promote benefits in fall-related measures compared to the control group, but the unstable shoe group would experience more significant gains in balance, postural control, mobility, and plantar flexor muscle strength to reduce the fear of falling when compared to the usual shoe group.

MATERIAL AND METHODS

Participants

This experimental study investigated the effects of a 12-week agility-balance prevention protocol with two shoe conditions (usual (US) and unstable (UnS)) on balance, postural stability, plantar flexor muscle strength, and fear of falling in healthy older adults. Older adults who met the inclusion criteria were enrolled by an independent physician who was not involved in data collection and was blinded to the allocation of participants to experimental conditions. Random allocation sequence using a computer-generated sequence (Random Allocation Software 2.0) was made by an independent, blinded person. Participants were randomly assigned to the US (agility balance + usual shoe), UnS (agility balance + unstable shoe), or control group (block size of 2, 4, 6 allocation ratio 1:1). Group allocations were concealed in sequentially numbered, opaque, sealed envelopes that were opened by a research assistant (SB) after enrolled participants completed all baseline assessments to then allocate the intervention. Both intervention groups completed 12-week agility-balance training. Both types of shoes were provided to participants by investigators to control possible confounders related to footwear design. The outcome assessments were conducted before and after 12 weeks of training and after one month of follow-up. A laboratory specialist, not directly involved in the study and blinded to the interventions, performed the clinical assessments. The data analysts were blinded to group allocation Participants were instructed not to reveal or discuss treatment with the evaluator.
Before the study onset, all participants were fully informed about experimental procedures and provided informed written consent. After the study, written information on the outcomes of both measurement points was offered to participants. This trial was approved by the local ethics committee of (blind) University following the Declaration of Helsinki (blind) and is reported here according to the CONSORT guidelines for randomized clinical trials that were registered at (blind).
Based on a prior study with an effect size of f=0.18, we anticipated that 18 participants in each group were deemed, considering a 2-tailed significance level (α) of 0.05 and desired power (1-β) of 0.85. All volunteers were recruited through flyers posted in public places and healthcare centers (Blind) between February and March 2019. One hundred and thirty community-dwelling older men ≥60 years old were screened using face-to-face interviews, and 57 met the inclusion criteria and were enrolled in the study.
Volunteers were excluded if they reported a metabolic disease, neurological problems, vestibular impairments, severe musculoskeletal disorders and/or a history of lower extremity surgery. Other exclusion criteria were systemic blood pressure greater than 160/100 mm Hg and uncorrected visual impairment or retinal detachment. Also, people who regularly used unstable shoes, who had taken part in balance training programs in the previous three months, or who regularly took part in sports activities (> 3 times per week as questioned subjectively) were also excluded Eligible participants met the inclusion criteria of being aged ≥60 years, a score from 25 to 35 on the FAB scale, able to walk independently for 20 m, a score of > 23 on the mini-mental state examination (MMSE) (20), and a score <6 on the Geriatric Depression Scale (GDS) [21]. Finally, they were eligible to perform the physical activity safely, as assessed by the physical activity readiness questionnaire (PAR-Q) and a physician. The baseline characteristics of participants are displayed in Table 1.

Instruments and Examinations

Ankle plantar flexor muscle strength was measured using a calf-raise senior (CRS) test. This test presented excellent test-retest reliability (intraclass correlation coefficient [ICC] =0.90), and interrater reliability (ICC

=0.93–0.96), as well as a good interrater agreement (ICC =0.79–0.84). The test can be a good indicator of ankle strength (isometric, r=0.87, r2=0.75; isokinetic, r=0.86, r2=0.74) in older adults and proved to discriminate significantly between individuals with improved functionality and levels of physical activity [22]. Participants stand, with their heels on the ground, the knees extended, the spine in the neutral position, and the fingers on the wall to support balance. At the signal of the examiner, the participant raises his/her heels vertically up as high as possible and then lowers into the ground with maximum self-paced velocity. The range of movement was determined using an upper bar supported simultaneously at the top of the participant's head against the wall. The participant's heads should touch the upper bar, and their heels touch the ground at the end of each cycle. The number of correct cycles (repetitions) during 30 seconds was recorded.

Balance was measured using FAB, a well-established, reliable, and valid measure for older adults. It includes ten performance-based activities that measure both static and dynamic balance. Each item is scored on a 5-point ordinal scale from 0 to 4 (0=unable to perform the task as defined and 4=task performed independently within specifications) based on previously validated cut points. A total performance score of 40 is calculated as the sum of the scores in each of the three tests, where higher scores represent better balance.

Mobility was measured using the Timed Up and Go (TUG) test. The TUG measures the total time (seconds) that a participant takes to rise from a chair (approximately 46 cm), walk 3-m at their preferred usual pace, turn around, walk back to the chair, and sit down [23].

Postural stability was measured using a force platform (Kistler type 9284, Kistler Instrumente AG, Winterthur, Switzerland) in three trials, with a short rest break between them. Postural stability was measured while participants stood quietly barefoot, looked straight ahead, arms at their sides, and focused on a visual reference mark at a 2 m distance away. Center of pressure (COP) oscillations data were sampled at 100 Hz for 30 s and then low pass filtered at 10 Hz (Matlab v. 6.0, The MathWorks, Inc, USA) to reduce noise. We calculated the most commonly used COP parameter; 95% confidence ellipsoid COP area (mm2) [24].

Fear of falling was measured using the Falls Efficacy Scale-International (FES-I), a 16-item self-report questionnaire. Participants rate his/her concern about falling when performing a range of activities of daily living, on a four-point Likert scale from 1 (not at all) to 4 (very concerned). The total score ranges from 16 to 64 points; higher values indicate more concerns about falling. The internal reliability of the Persian version of this scale is reported to be 0.98 [25,26].

Interventions

All intervention participants engaged in three 30-45 min agility-balance-based exercise training sessions weekly for 12 weeks. The training protocol in this research was a combination of agility and balance exercises designed as a circuit with seven stations for each session. The series of drills used in this study were selected from the previous study7, 8 and were as follows; Agility drills included cone agility drill (6 cones), hurdle (30 cm) and duck-walking (chest height adjacent for each participant), forward walking on agility ladder (4 m/8 rungs and 6 m/12 rungs), sideways walking on agility ladder, and stairs ascend and descend (5 stairs; each step height 10 cm). Balance activities included Swiss ball sitting (3×45 sec), various balance standing (tandem and single-leg; each 3×45 sec), various wobble cushion standing (Double-leg, tandem, and single-leg stance, each 3×30 s), and balance beam walking (Wooden and foam beams with length: 2 m and widths: 15 cm).

Each session began with a 7 to 10 min warm-up consisting of jogging, dynamic movements, and proper stretch exercises to their tolerance and comfort. After the warm-up, each participant completed a series of 7 drills. A circuit of drills took approximately 15 minutes to complete with a 15-second rest period between each station. The training protocol was repeated two times in the first six weeks and three times in the second 6 weeks.

Three trained sports science specialists, familiar with the research objectives and practice stages, supervised the training sessions with 13 participants in each session. Participants in the control group did not undergo any type of treatment. For this group, we used the basic recommendations for the maintenance of the previous lifestyle behavior. Unstable shoes were not worn after training sessions in daily activities for the period of study. Participants were asked to report any adverse effects that they experienced, such as musculoskeletal discomfort or pain, at each training session. An open-response type format was used for participant responses. All instructors also monitored participants for symptoms of angina, high blood pressure, and shortness of breath during the training classes. Adherence to the exercise training was also assessed based on the percentage of total classes attended.

Statistical Analysis

Descriptive statistics were used to present the demographic characteristics of the two groups. Values are presented as mean ± SD and 95% Confidence intervals (CIs). An independent samples t-test was used to assess group differences at baseline. The Shapiro-Wilk test showed that all data were normally distributed. A 2 (intervention; usual vs. unstable) by 3 (time; pre-test, post-test, and follow-up test) mixed-model ANOVA was used to evaluate the main and interaction effects of all outcomes. When significant group-by-time interactions were found, further post hoc tests with Bonferroni correction to adjust for multiple comparisons were used to determine the simple main effect of intervention within each group. Partial eta squared ($\eta p2$) values of 0.01 to 0.059, 0.06 to 0.139, and ≥ 0.14 represented small, moderate, and large effects, respectively (Cohen, 1973). In addition, Cohen's d effect sizes were calculated to give a measure of the magnitude of the difference. The values of ≤0.2, 0.21-0.49, 0.50 to 0.79, and ≥ 0.80 are interpreted to be trivial, small, moderate, and large effects, respectively (Cohen, 1973). SPSS statistical software (Version 18.0, SPSS Inc., Chicago, IL) was used to perform statistical analyses.

RESULTS

Four participants out of the seventy-five assessed at baseline did not complete the post-test assessment. Two participants withdraw study due to disease or personal matters. However, one participant in the UnS group and one in the US group did not complete the post-test due to ankle and knee pain thought to be related to the intervention. There were no other dropouts or losses at 12 weeks and follow-up measurements. Therefore, data analysis was conducted based on 53 participants. During the intervention period, the compliance rate for the agility balance training program was high for both groups (UnS; 93.8%; range 87.9–100% and the US; 92.7%; range 85.3–100%). Demographic characteristics and baseline assessments for the two groups and the control group are presented in Table 1. There were no significant baseline differences between the three groups for the measured variables.

Table 1. Demographic and health characteristics of participants (Mean± SD)

Variables	UnS (n=18)	US (n=17)	Control (n=18)
Age (yr)	67.6± 4.1	68.1± 4.5	66.9 ± 4.0
Weight (kg)	81.1 ± 6.6	79.8 ± 4.5	81.4 ± 5.5
Height (m)	1.73 ± 0.05	1.72 ± 0.05	1.71 ± 0.04
MMSE (0-30 points)	27.4 ± 1.5	27.2 ± 1.7	26.9 ± 1.1
GDS (0-15 points)	4.7 ± 2.4	5.4 ± 2.0	4.7 ± 1.9
FAB (0-40 points)	28.4 ± 3.4	28.1 ± 2.6	28.9 ± 3.2
TUG (sec)	11.0 ± 1.2	11.5 ± 1.2	11.6 ± 1.0
CRS test (reps)	21.3 ± 6.8	22.7 ± 6.4	21.9 ± 6.9
FoF (16-64 points)	22.9 ± 2.5	23.0 ± 3.2	22.9 ± 2.9
95% conf. ellipse COP area (mm^2)	321.3 ± 111.4	342.2 ± 113.3	346.0 ± 164.3

Abbreviations: US, Usual Shoe; UnS, Unstable Shoe; MMSE, Mini-Mental State Examination; GDS, Geriatric Depression Scale; FAB, Fullerton Advanced Balance; TUG, Timed Up and Go test; CRS, Calf-Raise Senior Test; COP, center of pressure; SD, standard deviation.

Balance

A very large and significant time × group interaction effect ($F_{2, 50} = 23.3$; $p = .001$; $\eta p^2 = 0.48$) was found for the FAB test score. Follow-up comparisons showed that FAB score increases significantly from baseline to post-test in both UnS (t=8.9, p<0.001, Δ=20.4%) and US (t=12.7, p<0.001, Δ=16.6%) groups, significantly higher than for the control group (t=7.3, p<0.001, ES=2.4 and t=7.6, p<0.001, ES=2.5; for UnS and US respectively; Figure 1A). However, there was no significant difference between UnS and US groups at post-test (t=1.3, p=0.19; Figure 1A). There was no significant difference between post-test and follow-up score of FAB for the UnS (t=1.8, p=0.07, Δ=18.2%), indicating maintained improvement at one-month follow-up. However, FAB score decreased significantly from post-test to follow-up in the US group (t=5.2, p< 0.001, Δ=10.7%). At follow-up, the mean of FAB score was also significantly higher in the UnS group than the US group (t=2.3, p=0.03; Figure 1A).

Mobility

A very large and significant time × group interaction effect ($F_{2, 50} = 23.3$; $p = .001$; $\eta p^2 = 0.48$) was found for the FAB test score. Follow-up comparisons showed that FAB score increases significantly from baseline to post-test in both UnS (t=8.9, p<0.001, Δ=20.4%) and US (t=12.7, p<0.001, Δ=16.6%) groups, significantly higher than for the control group (t=7.3, p<0.001, ES=2.4 and t=7.6, p<0.001, ES=2.5; for UnS and US respectively; Figure 1A). However, there was no significant difference between UnS and US groups in the post-test (t=1.3, p=0.19; Figure 1A). There was no significant difference between the post-test and follow-up scores of FAB for the UnS (t=1.8, p=0.07, Δ=18.2%), indicating maintained improvement at a one-month follow-up. However, the FAB score decreased significantly from the post-test to the follow-up in the US group (t=5.2, p< 0.001, Δ=10.7%). At follow-up, the mean of the FAB score was also significantly higher in the UnS group than the US group (t=2.3, p=0.03; Figure 1A).

Plantar flexor muscle strength

A large and significant time × group interaction effects ($F_{2, 50} = 15.2$; $p = .001$; $\eta p^2 = 0.38$) was found for plantar flexor muscle strength. Follow-up comparisons showed that plantar flexor muscle strength increased significantly from baseline to post-test in both UnS (t=2.5, p<0.02, Δ=37.1%) and US (t=5.0, p<0.001, Δ=19.4%) groups, but was only significantly greater in the UnS group than control group (t=2.6, p=0.01, ES=1.19; Figure 1C). There was no significant difference between the US group with control group (t=1.45, p=0.09, ES=0.63; Figure 1C) and UnS group (t=1.3, p=19; Figure 1C) at 12 weeks post-test. There was no significant difference between post-test and follow-up of plantar flexor muscle strength for the UnS group, (t=0.8, p=0.40, Δ=34.2%), indicating maintained improvement at one-month follow-up. However, plantar flexor muscle strength decreased significantly from post-test to follow-up in the US group (t=3.6, p=0.002, Δ=9.3%). At follow-up, the mean of plantar flexor muscle strength score was also significantly higher in UnS group than the US group (t=2.1, p=0.03; Figure 1C).

Postural stability

A large and significant time × group interaction effect ($F_{1, 48} = 11.2$; $p = .001$; $\eta p^2 = 0.31$) was found for the postural stability measure on the force plate. Follow-up comparisons showed that postural stability increases\d significantly from baseline to post-test in both UnS (t=6.4, p<0.001, Δ=42.3%) and US (t=9.6, p<0.001, Δ=30.7%) groups, that was more for both groups than the control group (t=4.5, p<0.001, ES=1.46 and t=2.5, p=0.02, ES=0.84; respectively; Figure 1D). The mean postural stability score was not significantly different between the UnS group and the US group at the post-test (t=1.9, p=0.06; Figure 1D). There was no significant difference between postural stability scores from post-test to follow-up in the UnS group, (t=1.0, p=0.4, Δ=40.1%), indicating maintained improvement at one-month follow-up. However, postural stability decreased significantly from the post-test to the follow-up in the US group (t=3.6, p=0.002, Δ=24.0%). At follow-up, mean postural stability was also significantly higher in the UnS group than the US group (t=2.5, p=0.02; Figure 1D).

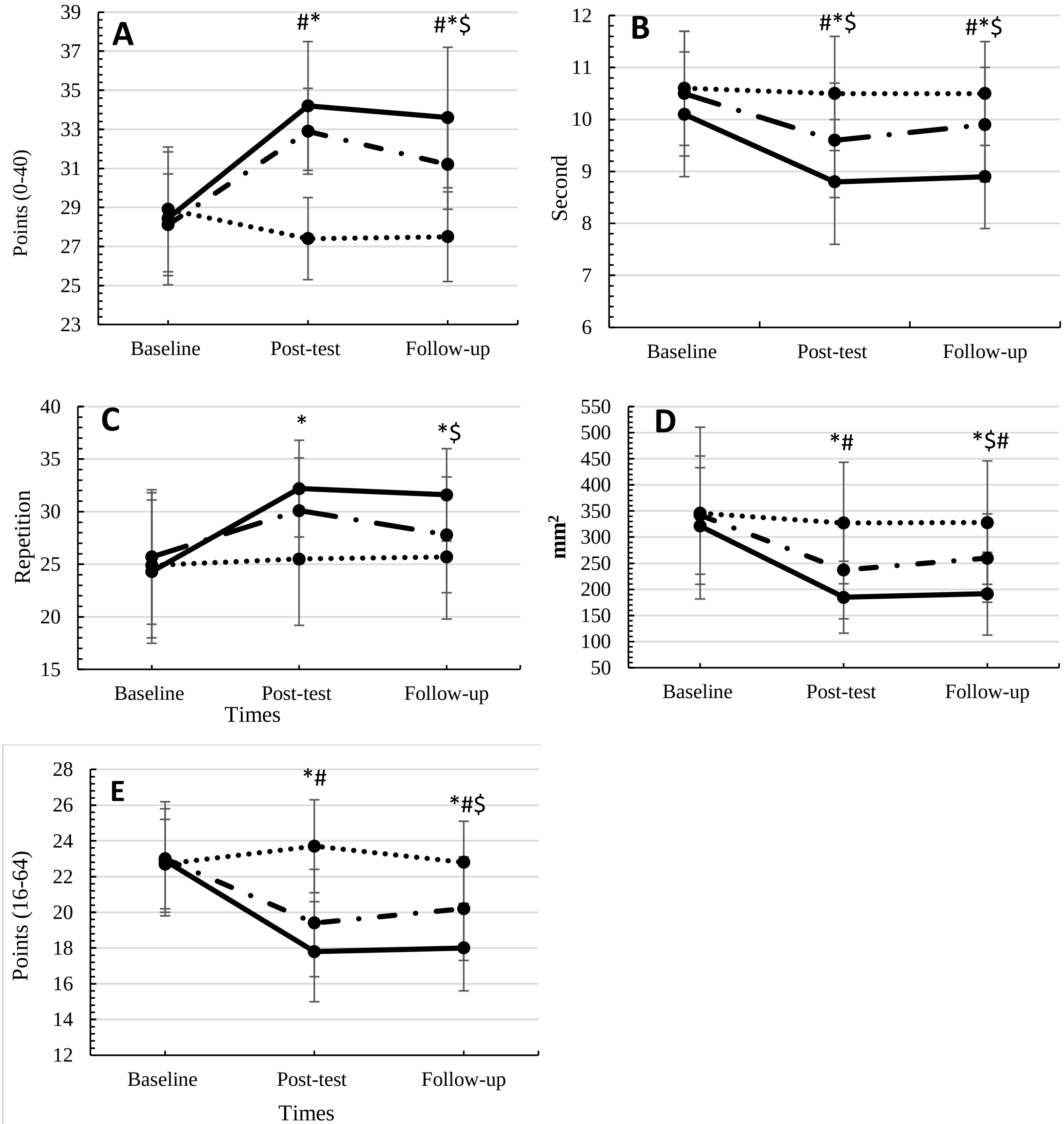

Fig. 1. Changes in **A**) Score of FAB scale, **B**) Time score of TUG test, **C**) Mean of *95%* confidence *ellipsoid* COP area, **D**) Mean of CRS test, and **E**) fear of falling from baseline to post-test, and follow for UnS, US, and Control groups.

Data are presented as the mean ± SD. *; Significant difference between UnS and control groups at $P < .05$, #; significant difference between US and control groups at $P < .05$, and $; Significant difference between UnS and US groups at $P < .05$.

Abbreviations: US, Usual Shoe; UnS, Unstable Shoe; FAB, Fullerton Advanced Balance; TUG, Timed Up and Go test; COP, center of pressure; CRS, calf-raise senior test; and SD, standard deviation.

DISCUSSION

To the best of the authors' knowledge, this is the first study in older adults that investigated the effects of

12-week agility balance-based training using usual versus unstable shoes wearing on some important fall-related measures such as balance, postural control, mobility, plantar flexor muscle strength, and fear of falling in a three-armed randomized controlled trial. There were significant improvements in balance, mobility, plantar flexor muscle strength, postural stability, and reductions in fear of falling irrespective of which shoe type was worn. However, the improvements in balance, mobility, postural control, and plantar flexor muscle strength were maintained only for those wearing unstable shoes at the 1-month follow-up.

In healthy older adults, the probability of falling increased by 8% with each 1-point decrease in the total FAB score 3. Our study results show that the FAB score for those in the unstable shoe group (+5.7; 95% CI, 4.4 to 7.1) and the usual shoe group (+4.8; 95% CI, 4.0 to 5.5) improve equally after 12 weeks of agility-balance training. These results echo the effects of an unstable shoe on balance seen previously (Sobhani, Sinaei, Motealleh, Hooshyar, Kashkooli, and Yoosefinejad 10. Consistent with our study they demonstrated that balance was not influenced by the use of an unstable shoe over a 4-week whole-body vibration training. They found a 3.66 points increase in the usual group and a 4.45 points increase in the unstable shoe group for FAB score and that this gain was only maintained in the unstable group at the 1-month follow-up. In our longer intervention study, the balance score was also maintained better at one follow-up in the UnS (unstable: +5.1; 95% CI, 3.7 to 6.5 and usual: +3.1; 95% CI, 2.5 to 3.7). Considering the older adults showing diminished use of the ankle strategy [27], the persistent effect of unstable shoes in our study might be partly attributable to the enhanced ankle strategy. Repeated use of ankle strategy during our agility balance training can improve ankle strategy and in turn balance and postural control in older adults. However, ankle strategy has not been examined in our study and should be investigated in future studies.

Our results show a reduction in the level of COP sway and thus an improvement in postural stability for both intervention groups, which is higher in those who wear unstable shoes than those with usual shoes at follow-up. (UnS: 40% vs. the US: 25%), revealing better efficiency of the postural control system following prolonged use of unstable shoes. This finding is in line with previous findings reported by Landry, Nigg, and Tecante 14, who showed postural sway decreased after the 6-week accommodation period in healthy young participants. We assume that the unstable shoe can train proprioceptive sense and the extrinsic muscles crossing the ankle joint in older adults, leading to durable and better postural control for participants. However, we did not measure proprioceptive sense, so this needs to be examined in a future study. Improvements seen in the ankle plantar flexor strength are especially important for postural control, mobility, and other motor functions [28,29].

Mobility impairment is a relatively constant fall-related risk factor for older adults that is evaluated in the majority of screening programs using a TUG test. In our study, mobility improved for both unstable (-1.2; 95% CI, -1.1 to -1.4) and usual shoe groups (-0.9; 95% CI, -0.7 to -1.0) compared to baseline and was maintained high in both groups at follow-up. However, between-group comparisons indicated the superiority of unstable over usual shoes in both 12-week post-test (ES=1.45 vs. 0.8; respectively) and follow-up (ES=1.38 vs. 0.56; respectively) measurements. Sobhani, Sinaei, Motealleh, Hooshyar, Kashkooli, and Yoosefinejad 10 showed that 4-weeks of whole-body vibration using unstable and usual shoes induced a moderate to large (ES= from 0.68 to 0.83) improvement in mobility measured by 10-m walk test and that the gains were maintained at follow-up in the unstable group. However, in our study, the gains were maintained for both groups at follow-up. According to a recent report, older adults who take ≥ 12 seconds to complete the TUG are at high risk for falling (CDC govt, 2020). In our study, at baseline, 28% of participants in the unstable shoe group (5/18 participants) and 35% in the usual shoe group (6 participants) were at high risk for falling. However, at follow-up, this had reduced to 5.5% in the unstable shoe group and 17.6% in the usual shoe group. This may be due to plantar flexor muscle strength and balance improving mobility, as a combined effect of them on gait stability [30].

Lower extremity muscle strength is reduced by approximately 35% in older adults compared to younger adults [31] and this can impair balance and gait stability and increase fall risk in older adults [4,29,31]. Our study results show that both unstable and usual shoes improved plantar flexor muscle strength at the 12-

week post-test but there was only a maintenance of improved strength in the unstable shoe group at follow-up. A recent study found a minimal important difference of 3.5 repetitions and a minimal detectable change (MDC) of 4.6 for the CRS test (32). Using these MDC cut-offs, in our study only the unstable shoe group had a clinically meaningful effect on muscle strength at follow-up (unstable: +7.3; 95% CI, 5.3 to 9.2 vs. usual: +2.1; 95% CI, 0.4 to 3.7). Previous EMG studies showed that standing 14 and walking 18 in an unstable shoe effectively activates selected extrinsic foot muscles such as the tibialis anterior and gastrocnemius medialis, leading to the strengthening and conditioning of these muscles. Although we did not measure muscle activity, we did see improved plantar flexor muscle strength.

Fear of falling has been associated with negative consequences, such as reduced activity of daily living, restriction of mobility, reduced quality of life, and increased fall risk in older adults, thus, there is an imperative need for interventions to consider fear of falling following interventions [33]. Structured strength and balance exercise programs do reduce the fear of falling in the short term [34]. In our study, the fear of falling score decreased in both groups after the 12-week intervention, with large ESs of d=2.17 for the unstable group and d=1.46 for the US group, and remained the same in the unstable group at 1-month follow-up. According to established cut-points [35], our participants' concern was moderate [20,27] at baseline, and after 12 weeks of intervention reduced to low (<20) concern for both groups. This result is in accordance with a previous study that considered that showed reductions in the concern about falling in older adults after 12 weeks of strength training on unstable surfaces 13 and another that looked at the combined effects of whole-body vibration and unstable shoes on balance measures in older adults by 10. The imbalance caused by unstable shoes may not only improve balance and mobility but also increase confidence to perform more complex activities in daily life [36]. Therefore, the experience of performing activities safely may lead to greater fall self-efficacy and a realistic view of the risk of falling that needs further study.

While results from the present study indicate the potentially beneficial effects of using unstable shoes on some falls-related measures in healthy older adults, it may be important to define clear prescribing criteria before recommending these shoes. This type of shoe creates an unstable base of support during standing and walking, so recommending it for participants with a higher risk of falling should be with caution unless during supervised exercise. However, previous studies showed that suitably designed unstable shoe has the potential to positively impact trip prevention and may contribute to reduced incident rates of falls [37, 38]. There were two dropouts from the intervention due to joint pain in the knees and hips, one from each of the intervention groups, suggesting that the footwear was not the cause, but instead one or more of the exercises within the circuit session.

We evaluated healthy older men and, therefore, our results cannot be generalized to older women and other people with a higher risk of falling. Additionally, baseline scores of TUG and FES-I indicated that most of the participants performed well and fall risk was comparably moderate and did not necessarily mimic a critically fall-prone population. Further similar well-designed clinical trials on women and other people with a higher risk of falling are warranted, particularly on safety. Another limitation of this study is that we used one type of unstable shoe, which may limit the generalizability of our results. Finally, there was no intervention offered to the control group but this was to reflect a lack of structured exercise as they were asked to maintain usual activity.

CONCLUSION

Three months of agility balance training with and without unstable shoes was effective to improve outcome measures related to falls risk in older men. For those wearing unstable shoes the benefits continued one month beyond the intervention end. The safety and effectiveness of this intervention makes it a potentially suitable candidate for use in older adults but its effect on falls rates is yet to be established.

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REFERENCES

1. Rubenstein LZ. Falls in older people: epidemiology, risk factors and strategies for prevention. Age Ageing. 2006;35(suppl_2):ii37–41.
2. Florence CS, Bergen G, Atherly A, Burns E, Stevens J, Drake C. Medical costs of fatal and nonfatal falls in older adults. J Am Geriatr Soc. 2018;66(4):693–8.
3. Hernandez D, Rose DJ. Predicting which older adults will or will not fall using the Fullerton Advanced Balance scale. Arch Phys Med Rehabil. 2008;89(12):2309–15.
4. Skelton DA, Kennedy J, Rutherford OM. Explosive power and asymmetry in leg muscle function in frequent fallers and non-fallers aged over 65. Age Ageing. 2002;31(2):119–25.
5. Deandrea S, Lucenteforte E, Bravi F, Foschi R, La Vecchia C, Negri E. Risk factors for falls in community-dwelling older people:" a systematic review and meta-analysis". Epidemiology. 2010;658–68.
6. Granacher U, Muehlbaue T, Zahner L, Gollhofer A, Kressig RW. Comparison of traditional and recent approaches in the promotion of balance and strength in older adults. Sport Med. 2011;41:377–400.
7. Donath L, van Dieën J, Faude O. Exercise-based fall prevention in the elderly: what about agility? Sport Med. 2016;46:143–9.
8. Reed-Jones RJ, Dorgo S, Hitchings MK, Bader JO. Vision and agility training in community dwelling older adults: Incorporating visual training into programs for fall prevention. Gait Posture. 2012;35(4):585–9.
9. Ng CACM, Fairhall N, Wallbank G, Tiedemann A, Michaleff ZA, Sherrington C. Exercise for falls prevention in community-dwelling older adults: trial and participant characteristics, interventions and bias in clinical trials from a systematic review. BMJ Open Sport Exerc Med. 2019;5(1):e000663.
10. Sobhani S, Sinaei E, Motealleh A, Hooshyar F, Kashkooli NS, Yoosefinejad AK. Combined effects of whole body vibration and unstable shoes on balance measures

in older adults: A randomized clinical trial. Arch Gerontol Geriatr. 2018;78:30–7.
11. Ogaya S, Ikezoe T, Soda N, Ichihashi N. Effects of balance training using wobble boards in the elderly. J Strength Cond Res. 2011;25(9):2616–22.
12. Behm DG, Muehlbauer T, Kibele A, Granacher U. Effects of strength training using unstable surfaces on strength, power and balance performance across the lifespan: a systematic review and meta-analysis. Sport Med. 2015;45:1645–69.
13. Pirauá ALT, Cavalcante BR, de Oliveira VMA, Beltrão NB, de Amorim Batista G, Pitangui ACR, et al. Effect of 24-week strength training on unstable surfaces on mobility, balance, and concern about falling in older adults. Scand J Med Sci Sports. 2019;29(11):1805–12.
14. Landry SC, Nigg BM, Tecante KE. Standing in an unstable shoe increases postural sway and muscle activity of selected smaller extrinsic foot muscles. Gait Posture. 2010;32(2):215–9.
15. Sousa A, Tavares JMRS, Macedo R, Rodrigues AM, Santos R. Influence of wearing an unstable shoe on thigh and leg muscle activity and venous response in upright standing. Appl Ergon. 2012;43(5):933–9.
16. Nigg BM, Emery C, Hiemstra LA. Unstable shoe construction and reduction of pain in osteoarthritis patients. Med Sci Sport Exerc. 2006;38(10):1701–8.
17. Romkes J, Rudmann C, Brunner R. Changes in gait and EMG when walking with the Masai Barefoot Technique. Clin Biomech. 2006;21(1):75–81.
18. Nigg B, Hintzen S, Ferber R. Effect of an unstable shoe construction on lower extremity gait characteristics. Clin Biomech. 2006;21(1):82–8.
19. Ramstrand N, Thuesen AH, Nielsen DB, Rusaw D. Effects of an unstable shoe construction on balance in women aged over 50 years. Clin Biomech. 2010;25(5):455–60.
20. Ansari NN, Naghdi S, Hasson S, Valizadeh L, Jalaie S. Validation of a Mini-Mental State Examination (MMSE) for the Persian population: a pilot study. Appl Neuropsychol. 2010;17(3):190–5.
21. Yesavage JA, Brink TL, Rose TL, Lum O, Huang V, Adey M, et al. Development and validation of a geriatric depression screening scale: a preliminary report. J Psychiatr Res. 1982;17(1):37–49.
22. Andre H-I, Carnide F, Borja E, Ramalho F, Santos-Rocha R, Veloso AP. Calf-raise senior: a new test for assessment of plantar flexor muscle strength in older adults: protocol, validity, and reliability. Clin Interv Aging. 2016;1661–74.
23. Struble-Fitzsimmons D, Zipp GP, DeLuca D, Zhang N. Exploring the relationship between timed up and go test times and fall history in an inpatient geriatric psychiatry unit: a retrospective case-control study. J Geriatr Phys Ther. 2020;43(3):E25–30.
24. Meshkati Z, Namazizadeh M, Salavati M, Mazaheri M. Reliability of force-platform measures of postural sway and expertise-related differences. J Sport Rehabil. 2011;20(4):442–56.
25. Dewan N, MacDermid JC. Fall efficacy scale-international (FES-I). J Physiother. 2014;60(1):60.
26. Khajavi D. Validation and reliability of Persian version of fall efficacy scale-

international (FES-I) in community-dwelling older adults. Iran J Ageing. 2013;8(2):39–47.
27. Shumway-Cook A, Woollacott MH. Motor control: translating research into clinical practice. Lippincott Williams & Wilkins; 2007.
28. Masani K, Popovic MR, Nakazawa K, Kouzaki M, Nozaki D. Importance of body sway velocity information in controlling ankle extensor activities during quiet stance. J Neurophysiol. 2003;90(6):3774–82.
29. Stenroth L, Sillanpää E, McPhee JS, Narici M V, Gapeyeva H, Pääsuke M, et al. Plantarflexor muscle–tendon properties are associated with mobility in healthy older adults. Journals Gerontol Ser A Biomed Sci Med Sci. 2015;70(8):996–1002.
30. Rantanen T, Guralnik JM, Ferrucci L, Leveille S, Fried LP. Coimpairments: strength and balance as predictors of severe walking disability. Journals Gerontol Ser A Biomed Sci Med Sci. 1999;54(4):M172–6.
31. Mickle KJ, Angin S, Crofts G, Nester CJ. Effects of age on strength and morphology of toe flexor muscles. J Orthop Sport Phys Ther. 2016;46(12):1065–70.
32. André H-I, Moniz-Pereira V, Ramalho F, Santos-Rocha R, Veloso A, Carnide F. Responsiveness of the Calf-Raise Senior test in community-dwelling older adults undergoing an exercise intervention program. PLoS One. 2020;15(4):e0231556.
33. Schoene D, Heller C, Aung YN, Sieber CC, Kemmler W, Freiberger E. A systematic review on the influence of fear of falling on quality of life in older people: is there a role for falls? Clin Interv Aging. 2019;701–19.
34. Kumar A, Delbaere K, Zijlstra GAR, Carpenter H, Iliffe S, Masud T, et al. Exercise for reducing fear of falling in older people living in the community: Cochrane systematic review and meta-analysis. Age Ageing. 2016;45(3):345–52.
35. Delbaere K, Close JCT, Brodaty H, Sachdev P, Lord SR. Determinants of disparities between perceived and physiological risk of falling among elderly people: cohort study. Bmj. 2010;341.
36. Paraschiv-Ionescu A, Büla CJ, Major K, Lenoble-Hoskovec C, Krief H, El-Moufawad C, et al. Concern about falling and complexity of free-living physical activity patterns in well-functioning older adults. Gerontology. 2018;64(6):603–11.
37. Thies SB, Price C, Kenney LPJ, Baker R. Effects of shoe sole geometry on toe clearance and walking stability in older adults. Gait Posture. 2015;42(2):105–9.
38. Jafarnezhadgero AA, sorkhe E, oliveira A. Motion-control shoes help maintaining low loading rate levels during fatiguing running in pronated female runners. Gait & posture. 2019; 73: 65-70.

مقایسه کفش راکر و کفش معمولی بر کاهش خطر سقوط سالمندان حین اجرای پروتکل پیشگیری از سقوط مبتنی بر چابکی

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چکیده:

این امکان وجود دارد که استفاده از کفش های ناپایدار همراه با تمرینات ورزشی پیشگیری از سقوط به اقدامات بهتر مرتبط با سقوط در افراد مسن کمک کند. هدف ما ارزیابی تاثیر ۱۲ هفته تمرین تعادل چابکی با پوشیدن کفش‌های معمولی (US) یا ناپایدار (UnS) بر تعادل، تحرک و قدرت و ترس از افتادن در مردان مسن سالم بود. پنجاه و هفت مرد مسن در ابتدا به‌صورت تصادفی در گروه‌هایUS، UnS یا گروه کنترل قرار گرفتند و ۵۳ شرکت‌کننده (میانگین سنی ۶۷،۵±۴،۱ سال) مطالعه را تکمیل کردند. هر دو گروه US و UnS تمرین تعادل چابکی را با پوشیدن کفش های معمولی و ناپایدار دریافت کردند. کلاس های گروهی سه بار در هفته در طول ۱۲ هفته ارائه شد. گروه کنترل مداخله فعالی دریافت نکرد. قدرت عضلانی خم کننده کف پا مچ پا با آزمون Calf-Raise Senior، تعادل با مقیاس تعادل پیشرفته فولرتون، تحرک پذیری با آزمون Timed Up and Go، ثبات وضعیتی با سکوی نیرو و ترس از افتادن با مقیاس اثربخشی سقوط - بین المللی اندازه گیری شد. در ابتدا، پس از مداخله ۱۲ هفته ای و یک ماه پس از پایان برنامه تمرینی. پس از ۱۲ هفته تمرین تعادل چابکی در گروه UnS حجم اثر از ۱/۹تا۲/۴ در گروهUS از ۰/۶۳ تا ۲/۵ در مقایسه با گروه کنترل، بهبود قابل توجهی در تمام اقدامات مربوط به سقوط مشاهده شد. گروه در ۱۲ هفته پس آزمون (P=۰/۰۳) در مقایسه با گروه US، افزایش تحرک بیشتری را تجربه کرد. در پیگیری، تمام دستاوردها در گروه UnS حفظ شد (P<۰/۰۵) اما نمرات قدرت عضله فلکسور کف پا (P=۰/۵) تحرک پذیری (P=۰/۰۸) و نوسان وضعیتی (P=۰/۰۷) به حالت اولیه بازگشت. ارزش ها در گروه US در پیگیری، تفاوت‌های معنی‌داری بین گروه‌ها برای همه اقدامات مربوط به سقوط به نفع گروه UnS پیدا شد (P<۰/۰۵). تمرین تعادل چابکی با و بدون کفش ناپایدار اقدامات مربوط به سقوط را بهبود بخشید. با این حال، پوشیدن کفش های ناپایدار با تمرین تعادل چابکی، اثرات مثبت بلندمدتی را بر اقدامات مربوط به سقوط در مردان مسن حفظ می کند.

واژه های کلیدی: کفش; تعادل؛ کنترل وضعیتی؛ ترس از افتادن؛ تمرینات تعادل چابکی