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Original Article

A Combined Exercise Program in Sedentary Older Adults: A Randomized Control Trial

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ABSTRACT

Background: This study investigated the effectiveness and durability of a combined exercise program on strength, endurance, speed, agility, flexibility, and quality of life in sedentary older adults.

Methods: In this randomized controlled trial, 27 older adults participated, including 13 individuals in the training group (TG; six women and seven men) and 14 in the control group (CG; six women and eight men). Speed, agility, flexibility, lower-limb muscle strength and endurance, and quality of life were assessed at baseline, immediately after the 8-week intervention, and again two months after the post-test. The TG performed combined exercises (strength plus functional training) three times per week for eight weeks.

Results: At the post-test, the TG showed significantly greater improvements than the CG in speed ($p < 0.001$), flexibility ($p = 0.04$), lower-limb muscle strength ($p = 0.002$) and endurance ($p < 0.001$), agility ($p = 0.001$), and quality of life in both the physical ($p < 0.001$) and mental ($p < 0.001$) domains. At follow-up, significant between-group differences persisted in speed ($p < 0.001$), flexibility ($p = 0.03$), strength ($p = 0.001$), endurance ($p < 0.001$), agility ($p < 0.001$), and quality of life in the physical ($p = 0.03$) and mental ($p = 0.04$) components.

Conclusion: The combined exercise program produced durable improvements in functional capacity and quality of life among sedentary older adults. These findings support the use of multimodal exercise interventions to enhance physical and mental health outcomes in this population.

Introduction

Physical fitness refers to an individual's ability to perform daily tasks and recreational activities without experiencing excessive fatigue, and it is particularly crucial for older adults [1, 2]. Aging is associated with numerous musculoskeletal changes, including declines in muscle strength, joint flexibility, postural control, musculoskeletal efficiency, and overall functional ability [3]. Sarcopenia—the age-related loss of muscle mass and strength—is a major contributor to functional limitations and related complications in the elderly population [4]. Reduced agility and mobility are also common consequences of aging and sarcopenia [5].

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Evidence indicates that older adults with greater muscle strength perform better on agility assessments, suggesting improved autonomy and functional performance in daily activities [4]. Physical fitness components are essential for maintaining independence in activities of daily living, such as rising from a seated or lying position, showering, avoiding obstacles, and walking [6]. Functional capacity, defined as the ability to perform routine daily tasks independently, is closely linked to physical fitness and is influenced by both physical and mental factors that interact over time [7].

Older adults living in nursing homes and other institutional facilities often have limited opportunities for physical activity, resulting in markedly reduced physical fitness levels [7]. Given this, improvements in physical fitness variables are closely associated with better health outcomes and may serve as an important preventive factor against functional decline in older adults [1, 2]. Regular exercise has been shown to enhance quality of life and reduce the risk of cardiovascular diseases and mental health disorders in this population [8]. Previous studies have examined the effects of various exercise modalities—including balance, aerobic, and strength training—on maintaining and improving older adults' ability to perform daily activities [9, 10]. Among these modalities, resistance training has been identified as an effective intervention for enhancing physical fitness and mitigating the negative effects of aging on functional capacity [11]. Although some studies have explored the impact of functional exercises on strength, flexibility, and balance improvements [12], relatively few have investigated the effectiveness of combined exercise programs—including components such as strength, functional performance, and flexibility—specifically in nursing home residents [13, 14].

Although the effects of mixed exercise programs on hemodynamic parameters, walking ability, and balance have been demonstrated [15]Their influence on broader physical outcomes—such as overall body strength, endurance, flexibility, agility, speed, and quality of life—remains insufficiently understood in older adults. Moreover, the durability of these interventions has not been adequately investigated, despite their importance for selecting suitable exercise programs for this population. Therefore, the purpose of the present study was to examine the impact and two-month durability of an eight-week combined exercise program on quality of life, speed, agility, flexibility, and muscle strength/endurance in older adults. It was hypothesized that the eight-week combined training program would improve flexibility, speed, agility, strength/endurance, and quality of life in male and female nursing home residents, and that these effects would be maintained after two months.

Methods

Study Design and Participants

This randomized controlled trial included male and female nursing home residents aged 55–75 years. To recruit participants, the researcher visited a nursing home, obtained permission from relevant officials and physicians, distributed a study questionnaire, and invited eligible individuals to participate in accordance with predefined inclusion and exclusion criteria.

The minimum required sample size was calculated using G*Power software for a two-way repeated-measures ANOVA and an independent-samples t-test (effect size = 0.80, $\alpha = 0.05$, power = 0.95) [16]. Among 79 older adults who initially volunteered, 47 met the eligibility criteria. After being informed of the study objectives, six individuals withdrew, and 11 were unable to complete the pretest assessments correctly. Ultimately, 30 participants (16 men and 14 women) completed the pretest.

Participants were then randomly assigned to either the training group (TG) or the control group (CG), with 15 participants in each (7 women and eight men per group). Randomization was performed by assigning numbers to participants and selecting numbers using a random sequence.

During the study, one participant in the TG was excluded for missing more than three training sessions, and another did not attend the post-test. In the CG, one participant was excluded for missing the post-test. Consequently, 27 participants—13 in the TG (6 women, seven men) and 14 in the CG (6 women, eight men)—completed the study (Figure 1).

The inclusion criteria were: absence of acute injuries to the head, spine, pelvis, hip, knees, or ankles, as well as other conditions that could impair physical performance; no history of imbalance-related falls; absence of diabetes mellitus and peripheral neuropathy that could negatively affect posture and balance control; ability to perform all required exercises and tests; a Mini-Mental State Examination (MMSE) score of $\geq$24 to confirm the absence of dementia [17]; and obtaining a full score on the Physical Activity Readiness Questionnaire (PAR-Q) [17].

The exclusion criteria included: unwillingness to continue participation; absence from two consecutive or three non-consecutive training sessions; medical judgment by a physician or researcher indicating that a participant could not safely perform a test or exercise or that participation posed a risk of injury; severe deformities of the spine or limbs; and vision or hearing impairments that could affect balance.

All participants were enrolled after obtaining medical clearance and written informed consent from themselves and their families. The study protocol was approved by the Ethics Committee (IR.SHAHROODUT.REC.1402.030) and registered as a clinical trial (UMIN000053597).

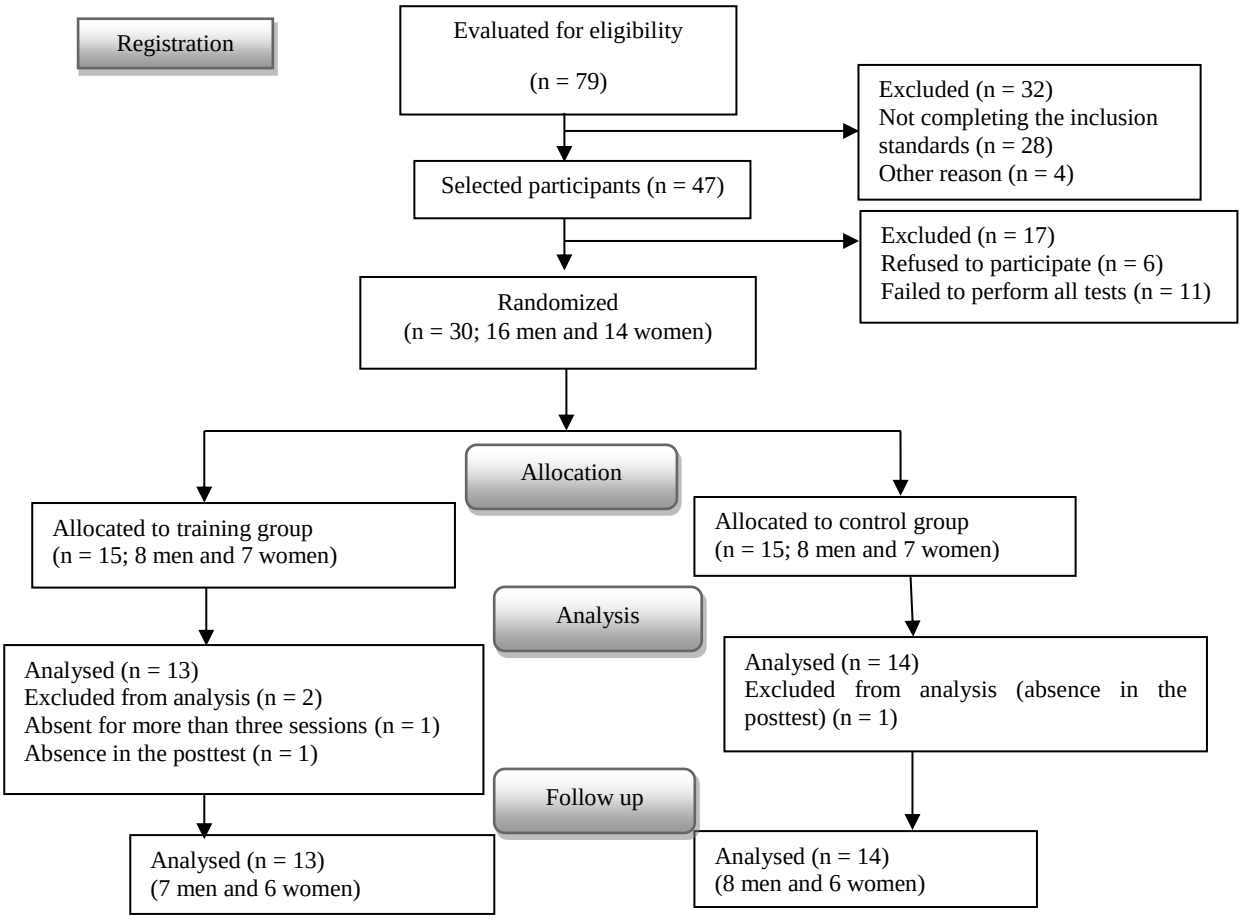

Figure 1: CONSORT participant flow diagram.

Procedure

The study variables were assessed during two sessions at each stage of data collection: pretest, post-test, and follow-up. In the first session, participants completed the questionnaires and performed the agility and flexibility tests. The second session included assessments of lower limb muscle strength, muscle endurance, and gait speed. To minimize fatigue, a 15-minute rest period was provided after each test. All tests were performed three times, and the best performance was recorded.

After completing the pretest assessments, the training group (TG) participated in the combined exercise program for eight weeks. Upon completion of the intervention, the post-test measurements were conducted. A follow-up assessment was performed two months after the post-test to evaluate the durability of the training effects.

Measurement of Study Variables

Health-related quality of life was assessed using the **Short Form Health Survey (SF-8)**, a multipurpose instrument that measures overall quality of life across physical and mental health domains. Higher scores indicate a better perceived quality of life [18].

Flexibility was evaluated using the Chair Sit-and-Reach Test. Participants sat on the edge of a chair with one foot flat on the floor and the knee flexed. The opposite leg was extended forward, with the heel on the ground, the ankle at 90°, and the knee fully extended. Participants placed one hand over the other, exhaled, and leaned forward from the hips—keeping the back straight and the head up—to reach toward the toes. The distance between the fingertips and the tip of the extended foot was measured. A score of 0 indicated fingertip contact with the toes. Distances short of the toes were recorded as negative values, and distances beyond the toes were recorded as positive values [19].

Lower limb muscle strength was assessed using the 10-Second Chair Stand Test. Participants were instructed to cross their arms at the wrists and hold them against the chest, then repeatedly stand up fully and sit down from a standard chair for 10 seconds. The maximum number of completed repetitions within this time was recorded as the strength score [20, 21].

Lower limb muscular endurance was evaluated using the 30-Second Chair Stand Test, following the same movement protocol. The highest number of repetitions completed within 30 seconds was recorded as the participant's endurance score [22].

Agility was assessed using the Supine-to-Stand Test. Participants began in a supine position and were instructed to rise to a stable standing posture as quickly as possible, using their usual preferred movement strategy. Agility performance was recorded as the time required to transition from lying supine to achieving a stable upright standing position [20].

Speed was evaluated using the Walking Around Two Cones Test. Two cones were placed 1.8 m to the right and left sides of the chair and 1.5 m behind it. After rising from the chair, the participant walked to the right, circled the cone, and returned to sit on the chair.

The same movement was then repeated on the left side. Each test trial consisted of two complete circuits, totaling approximately 16.8 meters. The time taken to complete the entire sequence, recorded in seconds, was used as the speed score [20].

Combined Exercise Program

The 8-week combined exercise program was conducted three times per week, with each session lasting 30–40 minutes, including a 10-minute warm-up and cool-down [15]. The control group (CG) received no intervention and continued their usual daily activities. Participants in the training group (TG) were instructed to maintain exercise intensity at 3 (moderate), 4 (moderately intense), or 5 (intense) on the Borg Rating of Perceived Exertion scale [23]. The program was designed following exercise guidelines for older adults recommended by the American Heart Association (AHA) and the American College of Sports Medicine (ACSM) [24]. Sessions were scheduled between 8:00 a.m. and 12:00 p.m., and participants were organized into five subgroups of three to ensure proper supervision (Table 1). All exercises were administered by a certified trainer with five years of experience.

Statistical Analysis

Data normality was assessed using the Shapiro-Wilk test, which indicated that all variables were normally distributed ($p > 0.05$). Levene's test confirmed the homogeneity of variance between the training group (TG) and control group (CG) ($p > 0.05$). Independent t-tests revealed no significant differences in demographic characteristics between groups ($p > 0.05$).

To examine the efficacy and durability of the combined exercise program, a two-way repeated-measures ANOVA with Bonferroni post hoc comparisons was conducted to evaluate within- and between-group differences. Effect sizes (ES) were calculated using partial Eta-squared (η^2), interpreted as small ($\eta^2 = 0.01$), moderate ($\eta^2 = 0.06$), and large ($\eta^2 > 0.14$) [for the group × time interaction]. All analyses were performed using SPSS version 26, with a significance level of $p < 0.05$.

Results

Table 2 presents descriptive data on the participants' demographic characteristics.

Bonferroni post hoc tests were applied following the two-way repeated-measures ANOVA to examine the effects of the combined exercise program and to compare group differences. The results of these analyses are presented in Table 3.

Table 1: Eight-Week Exercise Protocol

Weeks	Volume	Exercises
1 & 2	10 reps×1 sets	**Resistance training:** (1) lower limb strengthening, using a low-resistance band (hip, knee, and ankle motions by means of resistance bands); (2) heel and toe rise; and (3) upper limb strengthening with dumbbells
3 & 4	10 reps×2 sets	
5 & 6	10 reps×3 sets	**Balance training:** (1) single-leg standing; (2) transferring weight laterally from one leg to the other; (3) bending down from the waist; and (4) moving to the sides
7 & 8	12 reps×3 sets	**Functional training:** (1) walking on stairs (five steps with handrails, 30 inches wide by 11 inches deep); and (2) standing from a sitting position

Table 2: Demographic Characteristics of Participants.

Variable	Group	M±SD	T	P
Age (years)	Control	65.71 ± 4.93	0.23	0.82
	Traning	65.23 ± 5.98		
Height (m)	Control	1.66 ± 0.08	0.71	0.48
	Traning	1.63 ± 0.12		
Weight (kg)	Control	66.42 ± 8.77	0.54	0.58
	Traning	64.84 ± 5.84		
BMI (Kg/m^2)	Control	23.86 ± 1.62	-0.59	0.56
	Traning	24.55 ± 3.98		

Table 3: The findings of the research variables' two-way repeated-measures ANOVA.

Variable	Group	M±SD			Within-group differences (MIC)		Between-group differences (P)			Time*group		
		Pretest	Post-test	Follow up	Pre-post	Pre-follow	Pretest	Post-test	Follow up	F	P	η^2
Speed (Sec)	Control	51.65 ± 8.89	51.23 ± 7.75	50.95 ± 7.58	0.81	1.35	0.56	< **0.001**	< **0.001**	85.33	< **0.001**	0.77
	Traning	49.66 ± 8.69	29.07 ± 5.44	27.15 ± 5.49	41.46*	45.32*						
Flexibility (Cm)	Control	-8.50 ± 9.68	-7.64 ± 7.07	-7.50 ± 9.75	10	11.76	0.62	**0.04**	**0.03**	24.82	< **0.001**	1.00
	Traning	-10.61 ± 12.29	-0.69 ± 9.25	-0.15 ± 7.49	93.49*	98.58*						
Lower limb strength	Control	3.42 ± 1.08	3.57 ± 1.28	3.85 ± 1.09	4.38	12.57	0.44	**0.002**	**0.001**	8.75	**0.001**	0.25
	Traning	3.76 ± 1.16	5.15 ± 1.06	5.53 ± 1.33	36.96*	47.07*						

Variable	Group	M±SD			Within-group differences (MIC)		Between-group differences (P)			Time*group		
		Pretest	Post-test	Follow up	Pre-post	Pre-follow	Pretest	Post-test	Follow up	F	P	η^2
Lower limb endurance	Control	8.00 ± 2.07	8.14 ± 1.99	8.28 ± 2.26	1.75	3.5	0.07	< **0.001**	< **0.001**	20.42	< **0.001**	0.45
	Traning	9.38 ± 1.75	13.53 ± 2.98	14.00 ± 3.58	44.24*	49.25*						
Agility (Sec)	Control	19.79 ± 10.06	19.45 ± 9.74	19.11 ± 9.45	1.71	3.43	0.08	**0.001**	< **0.001**	17.01	< **0.001**	0.40
	Traning	13.85 ± 6.56	7.85 ± 5.04	7.30 ± 4.60	43.32*	47.29*						
Quality of life (physical component)	Control	56.16±10.00	56.97 ± 9.49	58.71 ± 13.30	1.44	4.50	0.59	< **0.001**	**0.03**	21.72	< **0.001**	0.46
	Traning	58.65±13.89	82.30 ± 14.85	70.09 ± 13.71	40.32*	19.50*						
Quality of life (mental component)	Control	58.22±16.06	59.20 ± 15.71	59.00 ±14.36	1.68	1.33	0.50	< **0.001**	**0.04**	12.49	< **0.001**	0.33
	Traning	62.01±12.61	80.76 ± 9.36	71.21± 15.85	30.23*	14.83*						

* indicates significant within-group differences, and significant differences between research groups are shown by bold values. (P < 0.05).

The repeated-measures ANOVA revealed significant differences between the training group (TG) and control group (CG) at post-test for speed ($p < 0.001$), flexibility ($p = 0.04$), lower limb muscle strength ($p = 0.002$) and endurance ($p < 0.001$), agility ($p = 0.001$), and quality of life in both physical ($p < 0.001$) and mental ($p < 0.001$) components. Bonferroni post hoc analyses of within-group differences indicated significant improvements in the TG from pretest to post-test for all measured variables: speed ($p < 0.001$), flexibility ($p < 0.001$), lower limb muscle strength ($p < 0.001$) and endurance ($p < 0.001$), agility ($p < 0.001$), and physical ($p < 0.001$) and mental ($p < 0.001$) quality of life. The durability of these effects was confirmed at the two-month follow-up, with significant differences observed compared to pretest values for speed ($p < 0.001$), flexibility ($p < 0.001$), lower limb muscle strength ($p < 0.001$) and endurance ($p < 0.001$), agility ($p < 0.001$), and physical ($p < 0.001$) and mental ($p < 0.001$) quality of life. Between-group comparisons at follow-up also showed significant differences favoring the TG for speed ($p < 0.001$), flexibility ($p = 0.03$), lower limb muscle strength ($p = 0.001$) and endurance ($p < 0.001$), agility ($p < 0.001$), and physical ($p = 0.03$) and mental ($p = 0.04$) quality of life components, indicating that the effects of the combined exercise program were maintained over time.

Discussion

This study aimed to determine the efficacy and durability of a combined exercise program on lower limb muscle strength and endurance, speed, agility, flexibility, and quality of life in older adults. The results demonstrated that the mixed exercise protocol—consisting of strength, balance, and functional training—effectively improved functional ability and quality of life among nursing home residents. Importantly, these improvements were maintained two months after the intervention, indicating the durability of the program's effects.

It is well established that older adults generally exhibit reduced functional capacity compared with physically active or non-sedentary individuals [4]. Therefore, improvements in functional indicators following exercise interventions are both expected and consistent with previous literature. Supporting the present findings, Arietta et al. reported that a combined exercise program significantly enhanced functional capacity in nursing home residents [25]. Additionally, several studies have shown that resistance training contributes to improvements in muscle strength, flexibility, and agility among older adults [26, 27].

As aging is closely associated with sarcopenia, strength training has been widely recommended as a strategy to counteract age-related declines in muscle mass and function [28]. Moreover, neuromuscular dysfunction—an inherent aspect of biological aging—can diminish neurological efficiency and functional capacity in older adults [29]. Muscle power, which is more strongly related to functional performance than muscle strength, tends to decline even more rapidly with advancing age [30]. Notably, some studies have reported no significant improvements in neuromuscular parameters following isolated strength training interventions [31, 32]. Alongside these physiological changes, a marked decline in functional capacity and the ability to perform activities of daily living often occurs, ultimately reducing independence and overall quality of life [4]. These observations underscore the importance of incorporating additional training modalities alongside strength exercises, particularly through multimodal or combined training approaches.

In the present study, improvements in lower limb muscle strength and endurance are likely attributable to the integration of strength, balance, and walking exercises within the combined program. Enhanced posture control may also have contributed to better performance in functional tests that require coordinated neuromuscular engagement [33]. Furthermore, repeated lumbar flexion during certain movements may have facilitated improvements in flexibility. Flexibility exercises are known to increase the range of motion in older adults, with stretching performed two to three

times per week shown to be effective across multiple joints [34]. Flexibility is essential for daily tasks, and reductions in movement efficiency are often used as indicators of muscle weakness or functional decline [30].

The Sit-to-Stand test, which provides valuable insight into functional independence [35] and is often used as an index of slowness or mobility limitation [30], showed significant improvement in this study. The observed gains in lower limb strength and endurance, measured through the 10- and 30-second Chair Stand tests, align with previous findings supporting the effectiveness of combined exercise programs in older adults [35, 36].

Upgrading strength and endurance, along with incorporating walking and lateral-movement exercises, can effectively enhance speed and agility. In this regard, van Abema et al. reported that strength training significantly improves preferred walking speed, particularly when accompanied by balance exercises that promote physical adaptation and greater use of the lower-limb joints [37]. These combined factors have been shown to contribute to improvements in walking speed [3]. Additionally, balance exercises can enhance gait performance by strengthening the flexor and extensor muscles and increasing the hip joint range of motion. Improvements in these variables are associated with an increased percentage of the stance phase during gait. In the present study, gains in these components may have contributed to enhanced agility. Because older adults commonly experience age-related reductions in joint range of motion, targeted exercises can help counteract these declines and improve walking speed [38]. Moreover, gait disturbances in older age are often linked to sarcopenia, muscle atrophy, reduced peripheral sensory function, and impairments in components of the central nervous system [39]. Improvements observed in these contributing factors in the present study likely contributed to increased speed and agility among the older adults.

The higher quality of life observed in the study participants could be attributed to improvements in functional performance. In other words, physical activity is closely associated with better physical and mental health, partly due to the impact that functional limitations have on older adults' behavior and well-being [40, 41]. Maintaining muscle mass in older adults enables them to perform activities of daily living more independently, which, in turn, can enhance their perceived quality of life. Physical activity also contributes to improved physical capability, self-efficacy, and self-confidence, which may enhance interpersonal interactions and social functioning and ultimately support mental health. Consistent with the present findings, Zhang et al. demonstrated that increasing physical activity is an effective strategy for encouraging older adults to engage in exercise and adopt healthier lifestyles [42].

This study, however, had certain limitations. One key limitation was the variation in participants' interests and motivations, which could not be fully controlled. Nevertheless, efforts were made to promote adherence by explaining the benefits of each exercise to participants during the training and assessment sessions. Additionally, while including separate groups performing only strength or only performance-based exercises could have provided clearer insights into the optimal training protocol, this approach was not feasible given the study's limited sample size.

Conclusion

Based on the study findings, the combined exercise program produced desirable improvements in lower limb muscle strength and endurance, speed, agility, flexibility, and both physical and mental components of quality of life in older adults residing in nursing homes. Notably, these improvements were maintained eight weeks after the intervention, indicating the program's continued effectiveness. The results highlight the potential of this combined exercise program to promote health and well-being, particularly by enhancing functional ability and quality of life in older adults. Therefore, physicians, trainers, orthopedic specialists, and geriatric healthcare professionals are encouraged to incorporate this multimodal exercise approach into rehabilitation strategies for elderly populations.

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