

Redefining Lifelong Fitness: A Practical Framework Combining Exercise Snacks and Neuromuscular Fall Prevention Strategies

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Abstract Prolonged sedentary behavior and fall-related injuries represent opposite ends of the age spectrum regarding public health challenges, yet they share a common solution: strategic "exercise snacking" (short bouts of physical activity). This review synthesizes current evidence on two accessible fitness approaches: the Green Tile Workplace Exercise program - a scientifically designed intermittent activity regimen for sedentary office workers - and multicomponent fall-prevention training for older adults. Drawing on recent systematic reviews, meta-analyses, and expert consensus statements, we propose an integrated framework positioning exercise snacking as an effective strategy across the lifespan. We examine the definitions, design characteristics, and health benefits of exercise snacking, highlighting the program as a representative translational model; evaluate the evidence base for multicomponent fall-prevention training among community-dwelling older adults; and explore the potential for cross-population knowledge transfer. Finally, we offer practical recommendations for implementing age-appropriate exercise snacking programs in workplace and community settings and call for future research to focus on integrating balance-specific modules into intermittent activity routines for sedentary populations across all age groups.

Keywords Exercise snacking; Green Tile workplace exercises; fall prevention; multicomponent exercise; workplace health; healthy aging

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1. Introduction

Globally, physical inactivity and sedentary behavior have reached epidemic proportions. Among Chinese adults, the average daily sedentary time is 8.8 hours, and nearly one-third are classified as physically inactive. Meanwhile, population aging has made falls a major public health concern: approximately one-third of older adults aged 65 and above experience at least one fall annually, with nearly half suffering recurrent falls. Falls not only lead to fractures and functional limitations but also trigger anxiety and depression, while imposing a heavy socio-economic burden. Although traditional structured exercise programs are effective, they face significant implementation barriers, including time constraints, issues with facility accessibility, and a lack of motivation. This has sparked keen academic interest in fragmented exercise—often termed "exercise snacks"—defined as multiple bouts of short-duration physical activity performed in non-laboratory settings (each lasting <10 minutes, occurring ≥ 2 times daily, and separated by at least 30 minutes of rest or recovery)[1]. This concept represents a paradigm shift from the "150 minutes per week" model contextualized toward, cumulative physical activity.

This review has two primary objectives. First, we analyze the Green Tile workplace exercise routine—developed by the HP research team at Shanghai University of Sport—as a prototypical example of evidence-based, fragmented exercise for sedentary populations. Second, we synthesize current evidence regarding multicomponent fall-prevention training for older adults. By bridging these two fields, we propose a unified framework that leverages the principles of fragmented exercise to promote fitness across all age groups.

2. Exercise snacks and Green Tile workplace exercise

2.1 Definition of Exercise snacks

"Exercise snacking" refers to performing multiple discrete, short bouts of exercise throughout the day - each lasting one minute or less (or up to a few minutes) and separated by intervals of 1 to 6 hours - requiring minimal equipment and minimal environmental adaptation. Compared to traditional continuous exercise, this fragmented approach offers advantages in terms of time efficiency, scheduling flexibility, enjoyment, and motivation, while delivering health benefits that are comparable or even superior.

A more formal operational definition (adopted in recent systematic reviews) defines exercise snacking as: "performing multiple bouts (≥ 2) of short-duration (≤ 10 minutes) exercise of any type or intensity (including multi-bout interval training) daily in non-laboratory settings, with complete rest or a recovery period of at least 30 minutes between bouts"[1].

2.2 Design and Features

Developed by the HP research team at Shanghai University of Sport, the Green Tile workplace exercise routine represents a practical application that translates research findings on "fragmented exercise" into real-world workplace settings. Named after the university's iconic "Green Tile Building" - where the routine was first implemented - the program aims to promote health and interrupt prolonged sedentary behavior by maximizing feasibility within the office environment[2].

Options for difficulty levels and duration. To accommodate the diverse fitness levels and time constraints of sedentary workers, the routine offers three difficulty levels (beginner, intermediate, and advanced) and three duration options (1 minute, 3 minutes, and 5 minutes). The 1-minute version consists of one warm-up stretch and one exercise movement; the 3-minute version includes two stretches and three movements; and the 5-minute version comprises three stretches and five movements[3].

Warm-up component. The warm-up phase features three stretching exercises - hip flexor stretch, hamstring stretch, and forward bend with arm raise - designed to counteract the musculoskeletal adaptations associated with prolonged sitting, such as the shortening of the hip flexors, hamstrings, pectorals, and latissimus dorsi, as well as the weakening of the upper back musculature.

- Exercise Section. The exercises are arranged in order of increasing difficulty:
- Beginner: Squats, kneeling push-ups, quick-step running in place, jumping jacks
- Intermediate: Squat jumps, standard push-ups, high-knee claps under the leg
- Advanced: Burpees, decline push-ups, high-knee running in place

The warm-up lasts approximately 20-60 seconds; each exercise is performed for about 1 minute, with a 30-60 second rest between exercises depending on the level of fatigue.

2.3 Health benefits of Exercise snacks

Recent evidence supports the efficacy of exercise snacking (short bouts of accumulated exercise) in improving various health outcomes. A consensus statement published in 2025 - synthesizing 27 systematic reviews, 135 original studies, and the insights of 48 experts from 11 countries - systematically documented both the acute and long-term benefits of this approach. Acute benefits included improvements in over 10 biomarkers related to endocrine, cardiovascular, and brain health. Long-term benefits (observed over an average intervention period of 11 weeks) encompassed improvements in more than 20 indicators, such as peak oxygen uptake, resting blood pressure, and metabolic health. Notably, adherence reached 95%, the dropout rate was 12%, and unsupervised adherence stood at 85%[1].

Regarding the older adult population, a systematic review and meta-analysis of remote exercise snacking interventions (comprising 4 publications and 10 studies; n=313) found significant improvements in lower-limbs muscle strength (SMD = 0.29, 95% CI: 0.06 – 0.52, p = 0.01) and endurance (SMD = 0.24, 95% CI: 0.01 – 0.46, p = 0.04), with an overall mean adherence rate of 85%. However, the same review found that exercise snacking had a limited impact on balance in healthy older adults (SMD = 0.04, 95% CI: – 0.14 – 0.23, p = 0.65), suggesting that specific balance-focused modules may need to be explicitly incorporated into such programs[1].

Notably, fragmented exercise also demonstrates unique value in the regulation of glucose metabolism. Drawing on an improved Q-learning algorithm and dynamic physiological modeling, Li and Zeng (2026) systematically investigated personalized aerobic exercise optimization for patients with type 2 diabetes, confirming the positive impact of scientifically designed intermittent exercise on improving insulin sensitivity and glycemic stability[4]. This finding further expands the potential application of fragmented exercise—extending it from general fitness to the management of chronic

metabolic diseases - and suggests that, with appropriate adjustments, workplace-based exercise routines (such as Green Tile Workplace Exercise) could serve as an adjunctive strategy for daily blood glucose control in individuals with prediabetes and type 2 diabetes.

3. Fall prevention training for the elderly

3.1 The Burden of Falls

Falls are the leading cause of injury and death among the elderly. Age-related declines in sensory input, central integration, and motor control impair postural regulation and gait stability, significantly increasing the risk of falling. The economic burden is staggering: in the European Union alone, the annual healthcare costs associated with falls are estimated to reach €25 billion[5].

3.2 Multicomponent Exercise: The Gold Standard

Multicomponent exercise - combining strength, balance, gait, and functional training - has become the evidence-based standard for fall prevention. A recent systematic review and multilevel meta-analysis (41 studies, 36 cohorts, 20,202 participants) demonstrated that multicomponent exercise programs significantly reduce the rate of falls (IRR = 0.776, 95% CI: 0.641 – 0.939), the risk of experiencing at least one fall (IRR=0.914, 95% CI: 0.858 – 0.974), and the incidence of fall-related injuries (IRR = 0.754, 95% CI: 0.663 – 0.858)[6].

The role of adherence. Notably, programs achieving $\geq 75\%$ adherence showed greater reductions in both the rate of falls (IRR = 0.501, 95% CI: 0.336 – 0.747) and the risk of falling (IRR = 0.821, 95% CI: 0.697 – 0.967). Adherence was highest in programs utilizing a combined individual and group instructional format[6].

3.3 Key training content

Evidence-based fall prevention training typically includes the following components[5][7]:

Strength training: Leg muscle strength is crucial for maintaining stability while standing and walking. Recommended low-intensity exercises include wall sits (leaning against a wall with feet shoulder-width apart; hold for 10 – 15 seconds; 3 – 5 sets) and seated leg lifts (slowly lift one leg to a horizontal position; hold for 5 – 10 seconds; 5 – 8 repetitions per side).

Balance training: Recommended exercises include single-leg standing while holding a chair (hold for 10 seconds per side; 3 – 5 repetitions) and heel-to-toe walking (5 – 10 steps). Dynamic balance training (such as center-of-gravity shifting exercises) is also recommended.

Flexibility training: Seated hamstring stretches help prevent the increased fall risk associated with a stiff gait.

International guidelines, including the Vivifrail multicomponent physical training program, have been adopted by over 15,000 healthcare professionals, benefiting more than 500,000 people. The World Health Organization's framework for fall prevention in older adults also emphasizes the necessity of a multicomponent approach[8].

4. Towards an Integrated Framework: A Fragmented Movement Spanning All Ages

4.1 Conceptual Bridge

Despite targeting different populations, both "exercise snacking" and fall-prevention training share core principles: an emphasis on cumulative dosage, contextual integration, and progressive challenge. The success of the Green Tile workplace exercises demonstrates that structured, evidence-based exercise snacking can be effectively implemented in real-world settings. Similarly, strong adherence data for fall-prevention programs - where adherence of $\geq 75\%$ yields the incremental benefit of a 50% reduction in falls - suggest that the "snacking" approach itself may help improve long-term adherence by lowering barriers to participation.

4.2 Applicability across populations

For office workers with sedentary lifestyles. The Green Tile workplace exercise routine offers a ready-made template. However, incorporating specific balance modules - such as single-leg standing or heel-to-toe walking - into the 1-minute or 3-minute versions could extend benefits beyond cardiovascular and musculoskeletal health to include postural control, potentially offering long-term fall-prevention advantages as this population ages[9].

For the elderly population. The principles of the Green Tile routine - progressive difficulty, multiple duration options, and no need for equipment - are directly transferable. "Exercise snacking" protocols tailored for older adults - such as daily sit-to-stand movements, squats, and heel raises (15 repetitions of each per day) - have demonstrated feasibility among pre-frail populations. Remote, home-based exercise snacking is feasible, acceptable, and safe for community-dwelling older adults, yielding meaningful short-term improvements in lower-limbs strength, endurance, and gait speed[10].

"Gentle" intermittent exercise for frail older adults. For older adults with physical limitations or frailty, the focus should be on maintaining joint mobility and muscle strength rather than elevating heart rate. Recommended "gentle" intermittent exercises include seated leg extensions while watching television and wall-supported heel raises[11].

5. Discussion

5.1 Advantages of the Integrated Framework

This framework offers several advantages. First, it bridges the accessibility gap: by lowering time and environmental barriers to physical activity, fragmented approaches can reach populations that traditional programs fail to cover. Second, it supports continuity across the life course: the same underlying principles - short duration, gradual progression, and contextual integration - apply to all age groups, fostering the development of behavioral habits from working age through to old age. Third, it leverages existing infrastructure: workplaces already possess the physical and social structures to support interventions like the Green Tile Workplace Exercise, while community centers can adapt these principles for the elderly population.

Furthermore, the applicability of this framework should not be limited to healthy individuals or specific age groups but should extend to clinical patient populations. In a case report and literature review regarding splenic tuberculosis, Liu, Liu, and Li (2025) noted that - alongside standard anti-tuberculosis pharmacotherapy - moderate, personalized physical activity interventions help improve immune function and physical reserves, thereby reducing the risk of secondary muscle atrophy caused by prolonged bed rest or physical inactivity[12]. This evidence suggests that even for patients suffering from complex infectious diseases, scientifically designed exercise training can serve as a valuable adjunct to rehabilitation rather than being contraindicated. These findings underscore the necessity of extending the concept of "exercise snacking" to clinical settings involving chronic disease management and postoperative rehabilitation, while also providing a theoretical basis for adapting programs like the "Green Tile Workplace Exercise" into "bedside micro-exercises."

5.2 Limitations and Evidence Gaps

In evaluating the theoretical coherence of the proposed integrated framework, several profound methodological limitations and critical empirical gaps within the current literature must be rigorously acknowledged.

First, the foundational evidence base supporting the clinical application of "exercise snacks" (fragmented physical activity) specifically tailored for the geriatric population, though highly encouraging, remains markedly constrained in both scope and statistical power. As underscored by the most contemporary systematic review and meta-analysis, the eligible global literature pool comprises only ten empirical studies investigating this specific modality[1]. This stark scarcity of data induces high clinical heterogeneity, making it mathematically challenging to generalize findings across distinct geriatric strata, such as robust community-dwelling individuals, pre-frail sub-populations, and vulnerable institutionalized older adults with multi-morbidities. Consequently, establishing a precise, standardized dose-response relationship for geriatric exercise snacking remains highly premature.

Second, the distinct neuromuscular and biomechanical efficacy of fragmented balance training - as contrasted with well-documented adaptations in muscular strength or cardiorespiratory endurance - has yet to be adequately characterized. Postural control and dynamic equilibrium are complex physiological processes governed by central nervous system neuroplasticity, multisensory integration, and persistent sensorimotor feedback loops. Conventional fall-prevention paradigms typically dictate sustained, continuous motor learning sessions to effectively surpass the neurological threshold required for systemic adaptation. However, when balance challenges are drastically atomized into episodic bursts of under ten minutes, whether such brief stimuli can sufficiently engage deep core stabilizers or permanently recalibrate dynamic postural reflex chains remains unverified by rigorous laboratory kinesiological or electromyographic data.

Third, the long-term behavioral sustainability and macroeconomic cost-effectiveness of exercise snacking interventions require expansive validation. While short-term clinical trials frequently report exemplary compliance, long-term adherence outside controlled or digitally nudged environments remains behaviorally unpredictable due to the

inherent decay of habituation. Furthermore, robust health-economics evaluations calculating Incremental Cost-Effectiveness Ratios (ICER) or Quality-Adjusted Life Years (QALYs) saved by preventing fall-related hospitalizations via fragmented strategies are noticeably absent from public health datasets.

Fourth, a notable divergence exists between the public health popularization and the empirical validation of the Green Tile Workplace Exercise routine. Currently, this program is predominantly disseminated via mainstream mass media channels, digital video platforms, and institutional administrative promotion[2][3]. Although its practical implementation and widespread visibility within corporate environments are commendable, rigorous empirical evidence validated through the academic peer-review system remains entirely absent. Prospective randomized controlled trials (RCTs) meticulously quantifying its longitudinal effects on cardiovascular biomarkers, metabolic stability, and postural control have not yet been conducted, significantly limiting its generalizability and clinical translation.

5.3 Future research directions

We recommend that future research prioritize the following areas:

Randomized controlled trials of Green Tile Workplace Exercise to evaluate cardiovascular, metabolic, and musculoskeletal outcomes;

Dose-response studies to determine the minimum effective "dose" of fragmented balance training required for fall prevention;

Comparative effectiveness studies to assess the relative merits of fragmented versus continuous exercise modalities among older adults;

Implementation science research to explore the facilitators and barriers to adopting fragmented exercise protocols in workplace and community settings;

Longitudinal cohort studies to track whether fragmented exercise habits established during working age yield fall-prevention benefits in later life;

Translational clinical research to validate the feasibility and efficacy of exercise snacks for patients with diabetes[4] and those recovering from complex infectious diseases[12].

6. Recommendations

6.1 Workplace Health Programs

Adopt the Green Tile workplace exercise routine as a structured, evidence-based program of short-burst physical activity. Offer three duration options (1, 3, and 5 minutes) and three difficulty levels to accommodate varying fitness levels.

Schedule regular reminders every 1–2 hours during sedentary work to incorporate these exercise snacks.

Consider integrating balance modules (such as single-leg standing or heel-to-toe walking) into the existing routine to extend benefits to postural control.

Ensure institutional support by codifying policies that protect time for short-burst exercise and by creating a physical environment conducive to brief, active breaks.

6.2 Programs Targeting the Elderly in the Community

Implement multicomponent exercise programs combining strength, balance, and flexibility training, aiming for an adherence rate of $\geq 75\%$ [6].

Introduce "exercise snacks" for older adults who cannot tolerate or participate in traditional structured programs; remote, home-based video-guided protocols have proven feasible and acceptable[1].

Prioritize "gentle," fragmented exercises - such as seated leg extensions and wall-supported heel raises - for frail or disabled older adults, focusing on maintaining muscle mass and preventing falls.

Adopt a progressive difficulty design modeled after the Green Tile workplace exercise routine, enabling participants to advance as their strength and confidence improve.

6.3 Public Health Policy Measures

Update and Refine National Physical Activity Guidelines: It is recommended that public health policymakers systematically revise existing physical activity recommendations to break away from the singular reliance on traditional, prolonged, and structured exercise regimens. "Exercise snacking" and other fragmented movement modalities should be officially positioned as a core complementary intervention strategy. This paradigm shift must specifically target populations facing significant barriers to participation - such as time-impovertised professionals, individuals lacking dedicated sports facilities, and those with limited physical reserves - thereby substantially lowering the threshold for engaging in health-enhancing physical activity.

Construct a Multidimensional Promotion and Support Network: Leveraging preliminarily validated, evidence-based protocols like the Green Tile workplace exercise routine, policymakers should build a cross-sectoral promotion mechanism. At the corporate level, employers should be encouraged to institutionalize exercise breaks within their comprehensive wellness programs. At the societal level, community health centers should be mobilized for broad health outreach. Technologically, digital platforms - including smart wearables, short-video applications, and health-tracking applets - should be fully utilized to support and solidify the precise delivery and habitualization of fragmented exercise routines.

Establish a Life-Course Approach to Fall Prevention: Public health policies must adopt a preventive medicine philosophy by actively advocating for the integration of fall-prevention training (such as balance and core strength modules) directly into workplace wellness programs. Policymakers must recognize that today's sedentary office workers - who are progressively developing lower-limbs muscle weakness and diminished postural control due to prolonged sitting - are the very older adults who will face exponentially higher fall risks tomorrow. Early intervention is not only vital for current occupational health but also serves as a strategic investment to alleviate the future healthcare burden of an aging society.

Increase Funding for Clinical Translation and Implementation Science: There is an urgent need to establish dedicated public health research grants prioritizing implementation science and interdisciplinary clinical translational research on fragmented exercise. This funding should focus on determining how to standardize and safely scale up exercise-snacking interventions across highly diverse real-world and

clinical settings. Specifically, priority should be given to validating effective strategies for incorporating these micro-interventions into the dynamic daily management of metabolic conditions like diabetes[4], as well as optimizing pathways for clinical rehabilitation in patients recovering from complex infectious diseases[12], thereby providing robust data to formulate precise national exercise prescriptions.

7. Conclusion

The convergence of research on "exercise snacking" (fragmented physical activity) and the science of fall prevention offers a powerful opportunity to reimagine fitness across the lifespan. The Green Tile workplace exercise program demonstrates how evidence-based exercise snacks can be transformed into practical, scalable workplace interventions. Meanwhile, robust evidence regarding multicomponent fall-prevention training indicates that structured, progressive exercise - provided adherence is maintained - can significantly reduce fall risks among older adults. Furthermore, existing evidence suggests that such exercise modalities hold immense potential for managing type 2 diabetes[4] and supporting clinical rehabilitation[12]. By integrating these approaches, we can establish a unified framework that makes fitness accessible, sustainable, and effective for individuals of all ages and health statuses. The challenge ahead lies not in further proving efficacy, but in translating established findings into practice - ensuring that the benefits of fragmented, accessible exercise reach those who need them most.

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