applied sciences

MDPI

Review

From Fall Prevention to Injury Prevention: The Role of Martial Arts-Derived Training in Older Adults—A Narrative Review

Artur Kruszewski [1,*], Bartłomiej Gąsienica Walczak [2], Dariusz Boguszewski [1], Agata Aleksandra Pałka [1] and Rafał Tabęcki [1]

[1] Faculty of Physical Education, Józef Piłsudski University of Physical Education in Warsaw, 01-813 Warsaw, Poland; dariusz.boguszewski@awf.edu.pl (D.B.); agata.palka@awf.edu.pl (A.A.P.); rafal.tabecki@awf.edu.pl (R.T.)

[2] Health Institute, Podhale State College of Applied Sciences in Nowy Targ, 34-400 Nowy Targ, Poland; bgw01@interia.pl

* Correspondence: artur.kruszewski@awf.edu.pl

Abstract

Falls are among the leading causes of injury, hospitalization, disability, and loss of independence in older adults. Traditional fall-prevention programs primarily focus on reducing fall risk through improvements in balance, muscle strength, and functional performance, while less attention is paid to mitigating the consequences of unavoidable falls. This narrative review aimed to evaluate the potential of martial arts-derived exercise and safe-fall training as complementary approaches to fall and injury prevention in older adults. Publications published between January 2000 and March 2026 were identified using combinations of keywords and Medical Subject Headings (MeSH) related to safe falling, fall prevention, injury prevention, older adults, martial arts, balance training, and physical activity. Evidence from interventions incorporating elements of boxing, judo, aikido, tai chi, and self-defence training was analysed, with particular attention to balance, postural control, mobility, dual-task performance, protective responses, and fall preparedness. Current evidence suggests that appropriately adapted martial arts-based interventions may improve several factors associated with fall risk and injury mitigation, including postural stability, functional capacity, coordination, reaction time, and cognitive-motor performance. Emerging evidence also indicates potential benefits of safe-fall training in developing protective movement strategies during loss-of-balance situations. The INNOAGON (Innovative Agonology) model is discussed as a framework integrating motor, cognitive, and behavioural components across multiple levels of prevention. However, most available studies have evaluated functional, behavioural, and biomechanical outcomes rather than clinically meaningful endpoints. Consequently, direct evidence demonstrating reductions in fall incidence, fractures, fall-related injuries, hospitalizations, or long-term disability remains limited. Martial arts-derived exercise may therefore be considered a promising complementary component of multifactorial healthy ageing and fall-prevention programmes. Further large-scale prospective studies and randomized controlled trials are needed to determine whether observed improvements in functional outcomes translate into meaningful clinical benefits in real-world settings.

Keywords: healthy ageing; fall prevention; safe-fall training; martial arts; combat sports; older adults; balance training; dual-task performance; INNOAGON; injury prevention

Academic Editors: Antonios E. Koutelidakis and Mark King

Received: 11 September 2026
Revised: 27 October 2026
Accepted: 30 October 2026
Published: 2 November 2026

Copyright: © 2026 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license.

1. Introduction

The ongoing ageing of the population means that preventing falls among older adults is becoming one of the most important challenges facing contemporary gerontology, public health and physical education. Falls are among the most common adverse events in the elderly population and are the leading cause of injury, loss of functional independence, hospitalisation and premature mortality in this age group [1–3]. It is estimated that at least one third of people over the age of 65 experience at least one fall per year, and the incidence of this phenomenon increases with age and the level of functional dependence [2,4].

The consequences of falls extend far beyond the immediate physical effects. In addition to fractures, head injuries and soft tissue damage, which incur significant costs for treatment and rehabilitation, falls lead to the development of what is known as 'post-fall syndrome', comprising a fear of falling again, reduced physical activity, social isolation and a decline in quality of life [5–7]. Paradoxically, the avoidance of physical activity caused by the fear of falling contributes to a further decline in muscle strength, balance and mobility, which in turn further increases the risk of subsequent incidents [7].

In accordance with the injury prevention framework proposed by Van Mechelen and colleagues [8], effective prevention strategies should be based on identification of injury incidence, underlying mechanisms, implementation of preventive measures, and evaluation of their effectiveness.

Contemporary prevention strategies indicate that one of the most effective methods of reducing the risk of falls is systematic and appropriately tailored physical activity [9,10]. Research shows that exercise programmes improve muscle strength, postural control, motor coordination and gait quality, leading to a significant reduction in the number of falls amongst older adults [11–13]. Interventions focusing on balance and functional exercises, which simultaneously engage the cognitive processes responsible for planning, controlling and modifying movement, are particularly effective [10,14].

In recent years, exercises inspired by sports and martial arts have attracted increasing interest from researchers; due to their multidimensional nature, they may serve as a valuable tool for the prevention of falls. Unlike traditional training programmes, which focus mainly on building strength or endurance, exercises derived from martial arts integrate motor, sensory and cognitive components. These include control of the centre of gravity, multi-planar body movement, responses to balance disturbances, spatial orientation and the rapid adaptation of movement strategies to changing environmental conditions [14–16].

A particularly valuable feature of exercises inspired by hand-to-hand combat systems is their ability to develop motor and cognitive functions simultaneously. A growing body of evidence suggests that deficits observed during dual-task performance, which requires simultaneous cognitive and motor control, are among the most significant risk factors for falls in both older adults and patients with neurological conditions [17–20]. Training incorporating elements characteristic of combat sports, such as changes in direction of movement, postural transitions, reactions to external stimuli or movement sequences requiring rapid decision-making, can effectively support the mechanisms responsible for maintaining postural stability and adapting to sudden destabilising situations [14,21].

At the same time, it should be emphasised that most modern fall prevention programmes focus on preventing the fall itself, whilst overlooking the issue of minimising its consequences. However, it is impossible to completely eliminate falls, particularly amongst the elderly. Consequently, increasing attention is being paid to the need to incorporate the art of falling safely into prevention programmes, a discipline whose roots lie mainly in martial arts and selected self-defence systems [22–24]. Research conducted within the framework of the 'susceptibility to bodily injuries during a fall' (SFI) suggests

that appropriately developed movement patterns can significantly reduce the risk of head, upper limb and hip injuries upon contact with the ground [25,26].

From a public health perspective, exercises inspired by combat sports may therefore represent a particularly valuable form of physical activity for older adults. Their potential effectiveness stems not only from improved physical fitness, but also from the development of adaptive abilities, increased body awareness, improved postural control and the development of safe responses in situations where balance is lost [27–29]. This approach is consistent with the modern model of primary, secondary and tertiary prevention, aimed at both reducing the incidence of falls and minimising their adverse health consequences.

However, analyses to date have focused primarily on reducing the incidence of falls, while the potential role of martial arts-derived exercises in simultaneously reducing fall risk and mitigating the consequences of unavoidable falls has received much less attention.

The aim of this paper is to present ways of preventing falls among older adults through the use of physical exercises modelled on martial arts, with particular emphasis on their impact on balance, functional fitness, cognitive-motor abilities and learning how to fall safely as part of a comprehensive gerontological prevention programme.

2. Materials and Methods

Search Strategy

A narrative literature review was conducted to identify studies investigating safe-fall training, fall-response education, and fall-related injury prevention in older adults. Electronic searches were performed in the PubMed, Scopus, Web of Science, and Google Scholar databases. The search covered publications released between January 2000 and March 2026. Search terms included combinations of the following keywords and Medical Subject Headings (MeSH): “safe fall”, “safe falling”, “fall training”, “fall techniques”, “fall preparedness”, “fall prevention”, “injury prevention”, “protective responses”, “older adults”, “elderly”, “ageing”, “aging”, “martial arts”, “judo”, “balance training”, and “physical activity”. Boolean operators (AND, OR) were used to combine search terms. Additionally, a manual screening of reference lists from eligible articles was performed to identify further relevant studies. The final search was completed on 31 March 2026.

Inclusion Criteria

Studies were considered eligible if they involved older adults or populations relevant to the mechanisms underlying safe-fall training and injury prevention; examined safe-fall training, fall-response education, fall-preparation programmes, martial arts-based fall education, or related interventions; reported outcomes related to balance, mobility, fall-related skills, protective responses during falls, fear of falling, self-efficacy, injury risk, or other fall-related outcomes; used experimental, quasi-experimental, cohort, pilot, or randomized controlled trial designs; were published in peer-reviewed journals; were available in English.

Exclusion criteria

Studies were excluded if they focused exclusively on conventional balance, strength, or fitness training without a safe-falling or injury-mitigation component; were review articles, conference abstracts, editorials, commentaries, letters, or academic theses; did not report outcomes relevant to fall prevention, injury prevention, or protective motor responses during falls; represented duplicate publications; were unavailable in full-text format.

Definition of Older Adults

For the purposes of this review, older adults were defined as individuals aged 60 years and older, consistent with definitions frequently used in gerontological and public health research.

Study selection

The study selection process was conducted independently by two reviewers. After removing duplicates, titles and abstracts were screened based on predefined eligibility criteria. Subsequently, the full texts of potentially relevant articles were independently assessed by both reviewers. Any discrepancies regarding study eligibility were resolved through discussion and consensus. Following the independent evaluations, the reviewers jointly determined the final set of studies included in the review.

A total of 163 records were identified through database searching. After the removal of 46 duplicates, 117 records underwent title and abstract screening. Twenty-five full-text articles were assessed for eligibility, and 11 studies met all inclusion criteria and were included in the final descriptive review. Two publications were included in the group Direct evidence from martial arts-derived interventions in older adults; two in the Contextual Evidence on Fear of Falling group; and seven in the Mechanistic and indirect evidence supporting safe-fall training and injury prevention group.

Although the review primarily focused on older adults, a limited number of studies involving younger populations, children, or long-term martial arts and combat sports practitioners were also considered during the evidence synthesis when they provided important mechanistic insights into safe-fall training and injury prevention. Such studies were not used as direct evidence of effectiveness in older adults but were included to support the understanding of biomechanical principles, protective motor responses, injury-mitigation strategies, and the acquisition of safe-falling skills that form the theoretical foundation of safe-fall education programmes. This approach was considered particularly important because of the relatively small number of studies specifically examining safe-fall training in older populations.

Given the limited number of studies specifically addressing safe-fall training in older adults, a narrative synthesis was conducted. The primary aim was to summarize current scientific evidence regarding functional, biomechanical, and behavioural outcomes, rather than to perform a quantitative meta-analysis.

3. Results and Discussion

3.1. Martial Arts-Derived Exercise and Functional Outcomes

Physical activity is widely recognized as one of the most important determinants of healthy aging and the preservation of functional independence. Among the diverse forms of exercise available to older adults, programs incorporating selected elements of martial arts and combat sports have attracted growing attention due to their ability to simultaneously stimulate physical, cognitive and postural functions. When appropriately adapted, these activities can be safely implemented in older populations and provide a multidimensional training stimulus that supports mobility, balance and everyday functional performance [16,21].

Although martial arts and combat sports differ in their cultural backgrounds and competitive objectives, they share a number of fundamental movement characteristics. These include continuous control of the centre of gravity, balance maintenance, rapid changes in movement direction, postural transitions and coordinated whole-body actions. From a health promotion perspective, particular value lies in non-contact training elements that develop motor and cognitive abilities without the physical demands associated with competitive participation [27,28].

Regular participation in martial arts-derived exercise programs has been associated with improvements in muscle strength, coordination, reaction speed and postural control. Unlike conventional exercise programs that often target isolated physical capacities, these activities involve functional movements performed across multiple planes and under constantly changing conditions (Table 1). Therefore, they more closely reflect the motor

demands encountered during daily living and may better prepare older adults for real-world challenges [14,21].

Table 1. Potential contributions of selected martial arts and combat sport disciplines to fall and injury prevention in older adults.

Discipline	Evidence Level	Key Training Components	Functional and Cognitive Benefits	Potential Contribution to Fall and Injury Prevention
Boxing (non-contact forms)	Direct evidence in older adults	Footwork, reaction drills, hand–eye coordination, multidirectional movement, stimulus–response exercises	Improved reaction time, gait adaptability, executive function, dual-task performance, coordination	Enhanced mobility and obstacle avoidance; improved ability to respond rapidly to balance disturbances and environmental hazards
Judo	Direct evidence in older adults	Ukemi (safe-falling techniques), postural transitions, rolling, getting up from the floor, dynamic balance exercises	Improved body awareness, functional strength, movement control, confidence in mobility	Development of protective responses potentially associated with lower injury susceptibility through development of protective responses and impact-distribution strategies
Wrestling	Indirect/mechanistic evidence	Body positioning, centre-of-gravity control, functional strength, dynamic stability exercises	Enhanced neuromuscular coordination, core stability, postural control	Better recovery after perturbations and improved maintenance of stability during daily activities
Aikido	Indirect/mechanistic evidence	Balance redirection, controlled body movements, rotational techniques, spatial awareness	Improved proprioception, coordination, movement fluidity and postural adjustment	Enhanced ability to regain balance and adapt to unexpected destabilising situations
Tai Chi	Direct evidence in older adults	Slow controlled movements, weight shifting, postural alignment, breathing control	Improved balance, lower-limb strength, concentration and motor control	Potential reduction in factors associated with fall risk through enhanced postural stability and gait control
Self-defence-based exercise programmes	Theoretical rationale/indirect evidence	Situational awareness, defensive movement patterns, rapid decision-making, multidirectional locomotion	Improved cognitive-motor integration, attention, adaptability and confidence	Better management of unexpected environmental challenges and reduction in fall risk in everyday situations

A particularly important characteristic of martial arts-derived exercise is the integration of cognitive and motor demands. Participants are frequently required to memorize movement sequences, process sensory information, respond to external stimuli and adapt their movements to changing situations. Such skills are directly relevant to fall prevention because many falls occur while individuals simultaneously perform motor and cognitive tasks. Accordingly, improved dual-task performance is increasingly recognized as an important protective factor against balance loss and falls [18,20,29].

In practice, programs designed for older adults typically utilize selected elements from boxing, judo, aikido, tai chi and self-defense training. Common exercises include multidirectional stepping, balance-challenging footwork, controlled shifts in body weight, postural transitions, exercises for rising from the floor and movement tasks requiring rapid adaptation. These activities can be tailored to individual fitness levels while promoting the development of skills necessary for maintaining stability and responding effectively to unexpected perturbations [30,31].

From a gerontological and public health perspective, martial arts-derived exercise may represent a valuable component of preventive strategies for older adults. By targeting balance, mobility, functional strength, coordination, and cognitive performance, these programmes address multiple factors associated with functional decline and fall risk. However, current evidence is based primarily on functional outcomes rather than clinically meaningful endpoints [27–29].

Martial arts-derived exercise programmes provide a multidimensional training stimulus and may improve several factors associated with healthy ageing and fall prevention.

Nevertheless, further prospective studies are needed to determine whether these benefits translate into reductions in falls, injuries, and loss of independence in real-world settings.

3.2. Evidence from Specific Martial Arts-Derived Interventions

Falls are among the leading causes of disability and loss of independence in older adults. Their occurrence is influenced by multiple factors, including impaired balance, reduced muscle strength, slowed reaction times, cognitive decline and diminished adaptability to environmental challenges [2,4]. Effective preventive interventions should address these interacting mechanisms rather than focusing on a single component of physical function.

Martial arts-derived programs are of particular interest because they combine physical, cognitive, and behavioural training within a single intervention framework (Table 2). These programs expose participants to movement situations requiring dynamic balance control, continuous regulation of the centre of gravity, and rapid adaptation to changing sensory information. Such characteristics resemble challenges encountered during everyday mobility and may contribute to the development of functional capacities associated with fall prevention [14–16]. However, improvements in balance control, mobility, or movement adaptability should be interpreted as surrogate indicators of reduced fall risk rather than direct evidence of a decrease in real-world falls or fall-related injuries.

Growing evidence suggests that deficits in dual-task performance contribute to fall risk, particularly among older adults and individuals with neurological disorders. Combat sport-inspired activities often incorporate coordinated movements, stimulus-response tasks, and movement sequences requiring simultaneous cognitive processing and motor execution. Such training may enhance attentional allocation, sensory integration, and cognitive-motor coordination, which are considered relevant to safe mobility. Nevertheless, the extent to which improvements observed in standardized dual-task assessments translate to real-world fall prevention remains uncertain.

In a study involving individuals with Parkinson's disease, Shearin et al. [18] reported improvements in gait performance and cognitive-motor task execution following a boxing-based intervention. In contrast, Staniszewski et al. [20] observed no significant changes in postural stability after participation in a Rock Steady Boxing program. These findings indicate that the effects of such interventions may depend on program characteristics, participant profiles, and outcome measures. Importantly, the reported benefits primarily concern surrogate outcomes related to fall risk, whereas direct evidence demonstrating reductions in fall incidence, fall-related injuries, or fractures remains limited.

Exercises inspired by judo and other grappling-based disciplines provide additional opportunities to develop functional movement skills. These interventions commonly include postural transitions, rolling activities, balance recovery exercises, and floor-to-standing movements. Such activities improve functional strength, body awareness and movement control while promoting strategies that may help individuals recover safely from instability episodes [22,32].

Table 2. Key evidence on the role of martial arts-derived training in fall and injury prevention among older adults.

Study	Sample Size and Duration of Intervention	Study Design	Group Allocation/Comparison	Population/Years	Intervention	Main Outcomes	Implications for Fall/Injury Prevention
Direct evidence from martial arts-derived interventions in older adults							
Li et al. (2018) [16]	670 adults; 24 weeks, 2 × 60 min/week	Randomized controlled trial (RCT)	Random allocation to 3 parallel groups; tai chi quan, multimodal exercise, stretching control	Older adults at risk of falls; >70 years	Long-term tai chi participation	study of fall frequency	Effectiveness of tai chi balance exercises among older people at high risk of falls
Zanotto et al. (2025) [24]	24 older adults; 4 weeks, 2 × 30 min/week	Prospective, single-anonymized, pilot RCT with 2 parallel arms	Random allocation (1:1) after baseline assessment to FAST or active control (modified Otago Exercise Program)	Older adults at risk of falls; >65 years	Falling Safely Training Study	Improved safe-fall strategies	Confirmation of the rationale for teaching safe-falling strategies
Contextual Evidence on Fear of Falling							
Yardley, Smith (2002) [7]	166 adults; 6 months	Observational study/prospective survey study	No interventional and no group allocation; participants were observed/reported their physical activity and fall-related behaviour	Older adults at risk of falls; >75 years	survey research	avoidance of physical activity	The relationship between physical performance and falling
Pauelsen et al. (2018) [30]	153 adults	Cross-selection observational study	No interventional and no experimental allocation	Older adults at risk of falls; >70 years	survey research; years	fear of falling, morale, and physical fitness.	the relationship between physical performance and falling
Mechanistic and indirect evidence supporting safe-fall training and injury prevention							
Shearin et al. (2021) [18]	26 individuals; 12 weeks, 2 × 60 min/week	Prospective interventional pre-post study	Single intervention group; no randomization or control group; all participants completed the multimodal boxing programme	Individuals with PD	Multimodal boxing exercise programme	Improved gait performance and cognitive-motor task execution	Enhanced dual-task performance may reduce fall risk
Staniszewski et al. (2025) [20]	18 Individuals; 4 weeks, 2 × 60 min/week	Interventional experimental study with repeated measures	No random allocation; PD participants constituted the intervention group and underwent repeated pre/post-session assessment. A separated age-similar non-PD control group was used for baseline comparison only	Individuals with PD; >70 years	Rock Steady Boxing programme	No significant changes in postural stability	No clear improvement in postural stability
Domingos et al. (2019) [14]	26 individuals and 10 instructors; 18 months	Prospective observational/interventional study	Single boxing training cohort; no randomization; participants were exposed to a community-based boxing programme and assessment over time	PD patients	Community-based boxing training	Improved functional mobility and balance	Enhanced safe mobility in daily activities

Groen et al. (2010) [23]	6 judo athletes, qualitative study	Experimental biomechanical laboratory study	No randomized intervention allocation; experienced judo practitioners performed standardized falling techniques, with biomechanical responses compared across fall conditions	Adults trained in judo techniques; 24.22 ± 3.8 years	Safe-fall (ukemi) techniques	Reduced impact forces at the hip during falls	Potential biomechanical mechanisms associated with reduced injury risk
Klimczak et al. (2024) [19]	4 old men; Susceptibility to Fall Injury (SFI)	Small experimental/interventional pilot study / case-series design	Single intervention group; no randomization and no conventional control group; nursing-home residents underwent an intervention based on SFI/INNOAGON principles	Nursing home residents; 62–81 years	Cognitive–behavioural intervention based on SFI/INNOAGON principles	Improved motor responses during falls and reduced injury susceptibility	Supports tertiary prevention through improvement of movement responses associated with injury mitigation
Kalina et al. (2022) [25]	191 children 2–6 years old; Susceptibility to Fall Injury (SFI)	Observational/experimental diagnostic study	No randomized group allocation; participants were assessed under standardized movement/fall conditions to examine the SFI phenomenon	Children (methodological study); 2–6 years	Safe-fall education and injury susceptibility assessment	Improved diagnosis and modification of injury-related movement patterns	Supports development of safe-fall educational models
Boguszewski et al. (2024) [33]	107 practitioners of combat sports; 66 comprised physically active persons; Susceptibility to Fall Injury (SFI)	Comparative observational study	No randomized comparison between combat-sport practitioner and physically active/non-combat participants	Combat sports practitioners; 21–25 years	Long-term martial arts/combat sports participation	Lower susceptibility to selected fall-related injuries	Suggests protective adaptation through long-term training

Not all studies were conducted in older adults; selected studies were included due to their relevance to mechanisms associated with fall and injury prevention.

Among all martial arts-derived approaches, Tai Chi currently provides the strongest evidence base for fall prevention in older adults. In a large randomized trial, Li et al. [16] demonstrated that long-term participation in Tai Chi significantly improved postural control and reduced fall incidence among older individuals at elevated risk. These findings support the concept that the effectiveness of martial arts-derived exercise may depend less on exercise intensity and more on the integration of balance training, movement control and cognitive engagement.

Overall, current research suggests that martial arts-derived interventions can improve balance, mobility, gait performance and cognitive-motor integration. However, considerable heterogeneity exists regarding intervention duration, training content, participant characteristics and outcome measures. Further large-scale controlled studies conducted specifically in community-dwelling older adults are therefore required to strengthen the evidence base and clarify the most effective program components.

3.3. Safe-Fall Training and Injury-Related Outcomes

While most fall-prevention programs focus primarily on reducing fall incidence, safe-fall training addresses a complementary and often overlooked goal: minimizing the consequences of falls that cannot be prevented. Given that no prevention strategy can completely eliminate fall risk among older adults, particularly those with multiple health conditions or functional impairments, developing protective responses during a fall may represent an important additional component of injury prevention [22–25].

Safe-fall training originates from martial arts such as judo and jujitsu, where falling techniques (ukemi) are considered essential skills for safe participation in practice. The concept refers to a set of motor behaviours designed to protect vulnerable body structures, distribute impact forces more effectively and reduce injury severity when contact with the ground occurs [22,23,31]. These adaptations may be mediated by improved attentional allocation, sensory integration, and greater automaticity of postural control.

From a biomechanical perspective, injuries occur when the kinetic energy generated during a fall is transferred to a relatively small area of the body in a short period of time. Safe-fall techniques seek to reduce these forces by increasing the duration of impact absorption, enlarging the contact surface and utilizing rolling movements that distribute energy across multiple body segments. Practical applications include lowering the centre of gravity, avoiding rigid support on an outstretched arm, controlling limb positioning and protecting the head through appropriate cervical alignment [23,24,34,35].

Substantial support for this concept comes from studies based on the Susceptibility to Fall Injury (SFI) framework developed by Kalina and colleagues. According to this model, injury risk depends not only on whether a fall occurs but also on the quality of the protective motor responses displayed during body-ground contact [25,26]. To evaluate these responses, the Susceptibility Test to Body Injuries During a Fall (STBIDF) was developed and subsequently adapted for different populations and testing conditions. To date, no prospective studies have demonstrated that STBIDF scores predict real-world fall-related injuries, fractures, or hospitalizations in older adults. Therefore, STBIDF should currently be regarded as an assessment of injury susceptibility rather than a validated clinical predictor of injury occurrence [25,31].

Evidence supporting safe-fall training has also emerged from intervention studies. Klimczak et al. [19] reported that cognitive-behavioural programs based on SFI and INNOAGON principles improved protective motor responses and reduced susceptibility to fall-related nursing injuries among home residents. The authors highlighted the importance of combining physical practice with cognitive strategies aimed at modifying established movement habits and enhancing anticipatory control. However, these findings primarily reflect improvements in surrogate indicators of injury risk and movement

preparedness rather than direct evidence of reductions in real-world fall incidence or clinically confirmed fall-related injuries.

Additional indirect evidence comes from studies involving experienced combat sports practitioners. Long-term participation in martial arts and combat sports has been associated with lower susceptibility to selected fall-related injuries, possibly due to the development of superior body control, force-absorption capacity, and automatic protective reactions acquired through years of training [35]. Nevertheless, these observations are largely based on indirect and mechanistic evidence. Therefore, although they support the biological plausibility of injury-mitigation benefits, they should not be interpreted as conclusive evidence that martial arts-based interventions reduce the frequency of falls, fractures, or other clinically significant fall-related outcomes in older adults.

Importantly, safe-fall programs designed for older adults do not require the execution of advanced martial arts techniques. Current recommendations emphasize progressive learning under controlled and safe conditions, often using soft surfaces and appropriately modified tasks. Suitable activities may include controlled transitions to sitting or lying positions, rolling exercises, floor recovery training, and simplified falling techniques adapted from martial arts practice. Integrating these activities with balance training, spatial orientation exercises and dual-task challenges may further enhance their relevance to real-life situations in which falls typically occur [23,25,29].

Martial arts-based interventions may reduce fall risk, the transferability of these gains to real-life fall situations remains uncertain. Falls typically occur in complex and unpredictable environments involving simultaneous cognitive, sensory, and motor demands. Consequently, improved performance under standardized laboratory dual-task conditions should not be interpreted as direct evidence of reduced fall incidence. Further prospective studies are needed to determine whether training-induced improvements in dual-task capacity translate into safer responses during real-world balance perturbations and fall-threatening situations.

3.4. INNOAGON as a Conceptual Framework

While safe-fall training provides a practical strategy for reducing injury severity, the broader theoretical context for integrating cognitive, motor and behavioural aspects of injury prevention is provided by the INNOAGON framework.

In recent years, there has been a trend towards the development of interdisciplinary models for the prevention of falls, which go beyond the traditional approach focused solely on identifying risk factors and improving physical fitness. One such proposal is the INNOAGON (Innovative Agonology) concept developed by Kalina and colleagues, which integrates the areas of physical activity, health education, personal safety, rehabilitation and defensive behaviours [36,37]. In this framework, the individual is viewed as an agent constantly taking action in response to various environmental threats, amongst which unintentional falls are among the most common and most costly health-related events in the older population.

The central concept of the INNOAGON model is the ‘practical error’, defined as an action or omission that increases the likelihood of an injury occurring. In the context of falls, this implies shifting the focus from the event itself to the cognitive, decision-making and motor processes that precede a loss of balance or determine how the body behaves during a fall [37]. This approach is consistent with recent findings indicating that the risk of falls depends not only on the condition of the musculoskeletal system, but also on executive functions, divided attention and the ability to respond adaptively to changing environmental conditions [10,18].

Despite its originality, however, the INNOAGON model remains relatively little known in the international literature. Most of the publications elaborating on its principles

originate from a single academic community centred around the journals *Archives of Budo* and *Archives of Budo: Journal of Innovative Agonology* [28,37]. The limited number of independent research teams utilising this concept makes it difficult to assess its universality and reduces the model's level of internationalisation. Consequently, the position of INNOAGON in global academia currently remains more conceptual than empirically grounded.

To better understand the potential of this concept, it is worth relating it to models recognised within the scientific community that describe motor behaviour and injury prevention. A comparison with the 'ecological dynamics' approach is particularly interesting, as this is currently one of the most influential schools of thought in sports and motor sciences [38,39]. This concept posits that motor behaviour results from dynamic interactions between an individual's capabilities, the task being performed and the environment. In the context of fall prevention, this implies the need to develop the ability to adapt to unpredictable situations through exposure to a variety of motor challenges. Exercises inspired by combat sports, involving changes in direction of movement, balance disturbances or reactions to external stimuli, align with many of the principles of ecological dynamics. However, INNOAGON extends this perspective to include the conscious shaping of protective behaviours and the analysis of the consequences of practical errors.

Similarities can also be found in relation to contemporary theories of motor learning. Approaches such as Newell's constraints theory, the constraints-led approach and nonlinear pedagogy emphasise the importance of motor exploration, variation in exercises and the learner's independent resolution of motor problems [40,41]. In contrast to traditional programmes based on repetitive, isometric training, these models aim to develop adaptive abilities through exposure to a variety of motor situations. In this respect, the principles of INNOAGON are consistent with the modern understanding of motor learning, as they emphasise the ability to adapt responses to the changing conditions of everyday life. However, there is still a lack of experimental research allowing for a comparison of this model's effectiveness with more established theories of motor learning.

Another point of reference is contemporary models of injury prevention. Of particular significance here are van Mechelen's [8] injury prevention sequence (1992), Finch's TRIPP translational model for sports injury research [42], and the multifactorial approach by Bahr and Krosshaug [43]. These models focus on identifying risk factors, analysing injury mechanisms and evaluating the effectiveness of the interventions implemented. In comparison, INNOAGON adopts a more pedagogical and behavioural perspective, emphasising the importance of preparing individuals to act effectively in hazardous situations. Its strength lies in taking into account protective behaviours and reactions already undertaken during the fall itself. At the same time, there is still a lack of high-quality prospective studies confirming the superiority of this approach over classical models of injury epidemiology.

The principles of INNOAGON can also be analysed in relation to the World Health Organisation's (WHO) Healthy Ageing model. The WHO defines healthy ageing as the process of developing and maintaining functional abilities that enable well-being in older age [44]. In this model, physical abilities, cognitive functions, autonomy, social participation and the ability to adapt to the environment are of key importance. Exercises inspired by martial arts and safe-fall training can support all these areas by developing balance, functional fitness, cognitive-motor skills and a sense of agency. Unlike INNOAGON, however, the WHO model has a much stronger evidence base and is more widely accepted in international health policy.

From a gerontological perspective, the INNOAGON model offers a new perspective on the issue of falls. Instead of an approach focused solely on reducing risk factors, it proposes developing adaptive skills that enable effective responses to hazards encountered

in everyday life. Of particular importance here are exercises inspired by martial arts, which simultaneously help to develop balance, spatial awareness, reaction speed, postural control and the ability to fall safely. Appropriately modified forms of such exercises can be successfully incorporated into physical activity programmes for older adults, becoming an important tool for supporting active ageing and maintaining functional independence.

In light of the principles of innovative agonology, effective fall prevention should not be limited solely to attempts to eliminate the event itself. It is equally important to prepare people to cope with situations that cannot be entirely avoided. The INNOAGON model suggests that a combination of health education, cognitive-motor training and safe-fall training can form the basis of modern prevention programmes, particularly in relation to ageing populations.

The INNOAGON framework provides a novel conceptual perspective that extends traditional fall-prevention approaches beyond risk-factor reduction by emphasising adaptive behaviour, decision-making and preparedness for unavoidable hazardous situations. Although promising, further independent empirical validation is required before the framework can be considered an established evidence-based model for healthy ageing and fall prevention.

A notable limitation of the current evidence base is the insufficient reporting of safety-related outcomes. Most studies focused on balance performance, motor skills, or injury-risk indicators, whereas adverse events, intervention-related injuries, adherence, and supervision procedures were rarely described. Therefore, although safe-fall training appears promising, its safety profile in older adults cannot yet be considered fully established. Future intervention studies should include systematic monitoring of adverse events and detailed descriptions of training progression and safety procedures.

3.5. Limitations

When interpreting the results of this narrative review, several limitations should be taken into account. Firstly, the review methodology did not adhere to a systematic review protocol and may therefore be subject to selection bias. Secondly, the available evidence on martial arts-based interventions in older adults remains heterogeneous in terms of training protocols, participant characteristics and outcome measures. Thirdly, the scientific evidence supporting the INNOAGON model is still evolving and derives largely from studies conducted by a limited number of research groups. Consequently, caution should be exercised when generalising these findings to wider populations. Future randomised controlled trials and multicentre studies are warranted to establish the effectiveness of these approaches. Additionally, most included studies evaluated functional, biomechanical, or behavioural outcomes rather than clinically meaningful endpoints such as fall-related injuries, fractures, hospitalisations, or long-term disability. This limitation restricts the ability to draw firm conclusions regarding the real-world clinical effectiveness of martial arts-derived interventions.

4. Conclusions

Safe-fall training represents a promising adjunct to contemporary fall-prevention strategies for older adults. Current evidence suggests that martial arts-derived interventions may improve several factors associated with fall risk and injury mitigation, including balance, mobility, dual-task performance, fall-related self-efficacy, and the adoption of safer movement responses during loss-of-balance situations. These adaptations may enhance physical preparedness for fall-related events and support the maintenance of functional independence in later life.

However, most available studies have assessed surrogate outcomes and mechanistic indicators rather than clinically meaningful endpoints. Improvements in balance, gait, reaction time, dual-task performance, or safe-falling skills should not be interpreted as direct evidence of reduced fall incidence, fractures, or fall-related injuries. Similarly, favourable changes in indices such as SFI or STBIDF suggest greater preparedness for fall situations but do not, by themselves, confirm injury reduction under real-world conditions.

Consequently, safe-fall training should currently be viewed as a complementary component of multifactorial fall-prevention programmes rather than a stand-alone injury-prevention strategy. While the available evidence supports its theoretical and practical value, definitive conclusions regarding its clinical effectiveness require further investigation.

Future research should focus on well-designed prospective and controlled studies evaluating clinically relevant outcomes, including fall incidence, injury rates, fractures, healthcare utilisation, and the preservation of independence and quality of life among older adults. Particular attention should also be given to determining whether improvements observed in laboratory-based functional measures translate into meaningful benefits in real-world fall situations.

Practical Implications

Fall prevention programmes may include not only balance and muscle strength training, but also safe-fall training.

Exercises inspired by martial arts should be adapted to the participants' age, fitness level and state of health, eliminating elements of competition and physical contact.

Exercises that integrate motor and cognitive tasks (dual-task exercises) are particularly recommended, as they reflect everyday situations in which falls most commonly occur.

Elements of safe-fall can be implemented in day centres, universities of the third age, long-term care facilities and geriatric physiotherapy programmes.

Training for physiotherapists, coaches and instructors of activities for older adults should include the basics of teaching safe-falling and the use of exercises derived from martial arts.

Further research is needed to assess the long-term impact of safe-fall training on the incidence of fractures, hospitalisations and loss of independence in the older population.

Author Contributions: Conceptualization, A.K., B.G.W., D.B., A.A.P. and R.T.; methodology, B.G.W., R.T. and A.K.; software, A.A.P. and A.K.; validation, D.B. and A.K.; formal analysis, A.K. and A.A.P.; investigation, D.B. and A.K.; resources, B.G.W. and A.K.; data curation, B.G.W. and R.T.; writing—original draft preparation, A.K., B.G.W. and D.B.; writing—review and editing, A.K. A.A.P. and R.T.; visualization, A.K.; supervision, A.K. and A.A.P.; project administration, A.K. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The data presented in this study are available on request from the corresponding author.

Conflicts of Interest: The authors declare no conflicts of interest.

References

1. Campbell, A.J.; Robertson, M.C.; Gardner, M.M.; Norton, R.N.; Tilyard, M.W.; Buchner, D.M. Randomised controlled trial of a general practice programme of home based exercise to prevent falls in elderly women. *BMJ* **1997**, *315*, 1065–1069.
2. Tinetti, M.E.; Speechley, M.; Ginter, S.F. Risk factors for falls among elderly persons living in the community. *N. Engl. J. Med.* **1988**, *319*, 1701–1707.
3. Peel, N.M.; Kassulke, D.J.; McClure, R.J. Population-based study of hospitalised fall-related injuries in older people. *Inj. Prev.* **2002**, *8*, 280–283.
4. 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**, *21*, 658–668.
5. Burns, E.R.; Stevens, J.A.; Lee, R. The direct costs of fatal and non-fatal falls among older adults. *J. Saf. Res.* **2016**, *58*, 99–103.
6. Stenhagen, M.; Ekström, H.; Nordell, E.; Elmståhl, S. Accidental falls and health-related quality of life: A prospective study of the general elderly population. *J. Aging Health* **2014**, *26*, 430–450.
7. Yardley, L.; Smith, H. A prospective study of the relationship between fear of falling and avoidance of activity in community-dwelling older people. *J. Am. Geriatr. Soc.* **2002**, *50*, 562–571.
8. Van Mechelen, W.; Hlobil, H.; Kemper, H.C.G. Incidence, severity, aetiology and prevention of sports injuries. *Sports Med.* **1992**, *14*, 82–99. https://doi.org/10.2165/00007256-199214020-00002.
9. Gillespie, L.D.; Robertson, M.C.; Gillespie, W.J.; Sherrington, C.; Gates, S.; Clemson, L.M.; Lamb, S.E. Interventions for preventing falls in older people living in the community. *Cochrane Database Syst. Rev.* **2012**, *2021*, CD007146.
10. Sherrington, C.; Fairhall, N.J.; Wallbank, G.K.; Tiedemann, A.; Michaleff, Z.A.; Howard, K.; Clemson, L.; Hopewell, S.; Lamb, S.E. Exercise for preventing falls in older people living in the community. *Cochrane Database Syst. Rev.* **2019**, *2019*, CD012424.
11. Liu-Ambrose, T.; Nagamatsu, L.S.; Graf, P.; Beattie, B.L.; Ashe, M.C.; Handy, T.C. Resistance training and executive functions: A 12-month randomized controlled trial. *Arch. Intern Med.* **2010**, *170*, 170–178.
12. Howe, T.E.; Rochester, L.; Neil, F.; Skelton, D.A.; Ballinger, C. Exercise for improving balance in older people. *Cochrane Database Syst. Rev.* **2011**, *2012*, CD004963.
13. Kendrick, D.; Kumar, A.; Carpenter, H.; Zijlstra, G.A.R.; Skelton, D.A.; Cook, J.R.; Stevens, Z.; Belcher, C.M.; Haworth, D.; Gawler, S.J.; et al. Exercise for reducing fear of falling in older people living in the community. *Cochrane Database Syst. Rev.* **2014**, *2015*, CD009848.
14. Domingos, J.; Radder, D.; Riggare, S.; Godinho, C.; Dean, J.; Graziano, M.; de Vries, N.M.; Ferreira, J.; Bloem, B.R. Implementation of a community-based exercise program for Parkinson patients: Using boxing as an example. *J. Park. Dis.* **2019**, *9*, 615–623. https://doi.org/10.3233/JPD-191616.
15. Lamb, S.E.; Becker, C.; Gillespie, L.D.; Smith, J.L.; Finnegan, S.; Potter, R.; Pfeiffer, K. Reporting of complex interventions in clinical trials: Development of a taxonomy to classify and describe fall-prevention interventions. *Trials* **2011**, *12*, 125.
16. Li, F.; Harmer, P.; Fitzgerald, K.; Eckstrom, E.; Akers, L.; Chou, L.S.; Pidgeon, D.; Voit, J.; Winters-Stone, K. Effectiveness of a Therapeutic Tai Ji Quan Intervention vs a Multimodal Exercise Intervention to Prevent Falls Among Older Adults at High Risk of Falling: A Randomized Clinical Trial. *JAMA Intern Med.* **2018**, *178*, 1301–1310. https://doi.org/10.1001/jamainternmed.2018.3915.
17. Kruszewski, A.; Cherkashin, I.; Kruszewski, M.; Cherkashina, E.; Zhang, X. Hand-to-hand combat in the 21st century: INNOAGON warrior or modern gladiator, a prospective study. *Front. Sports Act. Living* **2024**, *6*, 1383665. https://doi.org/10.3389/fspor.2024.1383665.
18. Shearin, S.; Braitsch, M.; Querry, R. The effect of a multi-modal boxing exercise program on cognitive locomotor tasks and gait in persons with Parkinson disease. *NeuroRehabilitation* **2021**, *49*, 619–627. https://doi.org/10.3233/NRE-210218.
19. Klimczak, J.; Dobosz, D.; Balewska-Juras, K.; Kalina, A.; Kruszewski, A.; Orłowska-Bojarska, I.; Staniszewska, M.; Subkowska, M.; Gąsienica-Walczak, B. Cognitive-behavioural effects of reducing the susceptibility to body injuries during falls by nursing home care patients under the influence of innovative interventions. *Arch. Budo J. Innov. Agonol.* **2024**, *20*, 100–117.
20. Staniszewski, M.; Kruszewski, A.; Łopuszańska-Dawid, M. Short-Term Effects of Rock Steady Boxing Exercise on the Balance Ability of People with Parkinson's Disease: An Interventional Experimental Study. *Appl. Sci.* **2025**, *15*, 12107. https://doi.org/10.3390/app152212107.
21. Liang, D. The impact of martial arts on physical health: A bibliometric and visualization analysis. *Arch. Budo J. Innov. Agonol.* **2025**, *21*, 1–12.
22. Kalina, R.M. *Teoria I Praktyka Sportów Walki*; COS: Warszawa, Poland, 1997.

23. Groen, B.E.; Weerdesteyn, V.; Duysens, J. Martial arts fall techniques decrease the impact forces at the hip during sideways falling. *J Biomech*. **2007**, *4*, 458–462. https://doi.org/10.1016/j.jbiomech.2005.12.014
24. Zanotto, T.; Chen, L.; Fang, J.R.; Tabatabaei, A.; He, J.; Bhattacharya, S.B.; Alexander, N.B.; Sosnoff, J.J. Strategies to Minimize Fall-related Injuries in Older Adults at Risk of Falls: The Falling Safely Training Study. *J. Gerontol. A Biol. Sci. Med. Sci.* **2025**, *80*, glaf076. https://doi.org/10.1093/gerona/glaf076.
25. Kalina, R.M.; Dłubacz, N.; Zachwieja, J.; Pilarska, E.; Dobosz, D.; Gąsienica-Walczak, B.; Kruszewski, A. Innovative method of diagnosing the susceptibility to body injuries during the fall of children from 2 to 6 years. *Arch. Budo Sci. Martial Arts Extrem. Sports* **2022**, *18*, 211–228.
26. Kalina, A.; Kruszewski, A.; Gąsienica-Walczak, B. Motor modifications versus movement habits in measuring the SFI phenomenon. *Arch. Budo J. Innov. Agonol.* **2024**, *20*, 250–269.
27. Löklüoğlu, B.; Yılmaz, S.; Özcan, S.; Tatlıcı, A. Investigation of balance performance of wrestling and kickboxing athletes. *Phys. Educ. Stud.* **2024**, *28*, 37–42. https://doi.org/10.15561/20755279.2024.0104.
28. Kalina, R.M.; Kruszewski, A. INNOAGON is an acronym for "innovative agonology", but is not synonymous with "science of martial arts". *Arch. Budo* **2023**, *19*, 193–204.
29. Montero-Odasso, M.; van der Velde, N.; Martin, F.C.; Petrovic, M.; Tan, M.P.; Ryg, J.; Aguilar-Navarro, S.; Alexander, N.B.; Becker, C.; Blain, H.; et al. World guidelines for falls prevention and management for older adults: A global initiative. *Age Ageing* **2022**, *51*, afac205. https://doi.org/10.1093/ageing/afac205. Correction in *Age Ageing* **2023**, *52*, afad188. Correction in *Age Ageing* **2023**, *52*, afad199.
30. Pauelsen, M.; Nyberg, L.; Röijezon, U.; Vikman, I. Both psychological factors and physical performance are associated with fall-related concerns. *Aging Clin. Exp. Res.* **2018**, *30*, 1079–1085. https://doi.org/10.1007/s40520-017-0882-9.
31. Kruszewski, A.; Litwiniuk, A.; Waszkiewicz, E. Reliability and objectivity of the new version of the susceptibility test for body injuries during a fall (STBIDF-M) in physiotherapy students. *Phys. Educ. Stud.* **2024**, *28*, 303–312. https://doi.org/10.15561/20755279.2024.0507.
32. Kalina, R.M.; Kruszewski, A.; Jagiełło, W.; Włoch, G. *Combat Sports Propedeutics: Basics of Judo*; Akademia Wychowania Fizycznego: Warszawa, Poland, 2003.
33. Boguszewski, D.; Kerbaum-Visser, K.; Adamczyk, J. Susceptibility to injury during falls in men practicing combat sports. *Arch. Budo J. Innov. Agonol.* **2024**, *20*, 149–161.
34. Rudd, J.; Woods, C.; Correia, V.; Seifert, L.; Davids, K. Skill acquisition and ecological dynamics. *Sports Med.* **2021**, *51*, 933–948.
35. Robinovitch, S.N.; Feldman, F.; Yang, Y.; Schonnop, R.; Leung, P.M.; Sarraf, T.; Sims-Gould, J.; Loughin, M. Video capture of the circumstances of falls in elderly people. *Lancet* **2013**, *381*, 47–54.
36. Kalina, R.M. BUDO & INNOAGON–historical complexity but similar missions. *Arch. Budo J. Innov. Agonol.* **2024**, *20*, 1–15.
37. Kalina, R.M.; Bagińska, J. Language of Innovative Agonology: A guide in combining micro and macro scales of preventive, therapeutic and defensive actions. *Healthc. Med. Devices* **2023**, *79*, 307–315. https://doi.org/10.54941/ahfe1003501.
38. Araújo, D.; Davids, K.; Woods, C.T.; Rocha, L.; Passos, P.; Shuttleworth, R. The ecological dynamics of decision making in sport. *Psychol. Sport Exerc.* **2020**, *48*, 101685. https://doi.org/10.1016/j.psychsport.2020.101685.
39. Button, C.; Seifert, L.; Chow, J.Y.; Araújo, D.; Davids, K. *Dynamics of Skill Acquisition: An Ecological Dynamics Approach*, 2nd ed.; Human Kinetics: Champaign, IL, USA, 2020.
40. Newell, K.M. Constraints on the development of coordination. In *Motor Development in Children: Aspects of Coordination and Control*; Wade, M.G., Whiting, H.T.A., Eds.; Martinus Nijhoff: Dordrecht, The Netherlands, 1986; pp. 341–360.
41. Renshaw, I.; Davids, K.; Newcombe, D.; Roberts, W. *The Constraints-Led Approach: Principles for Sports Coaching and Practice Design*; Routledge: London, UK, 2019.
42. Finch, C.F. A new framework for research leading to sports injury prevention. *J. Sci. Med. Sport.* **2006**, *9*, 3–9. https://doi.org/10.1016/j.jsams.2006.02.009.
43. Bahr, R.; Krosshaug, T. Understanding injury mechanisms: A key component of preventing injuries in sport. *Br. J. Sports Med.* **2005**, *39*, 324–329. https://doi.org/10.1136/bjsm.2005.018341.
44. World Health Organization. *Decade of Healthy Ageing 2021–2030*; World Health Organization: Geneva, Switzerland, 2020.

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.