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## **Functional Benefits of Hard Martial Arts for Older Adults: A Scoping Review**

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### **ABSTRACT**

*International Journal of Exercise Science 15(3): 1430-1443, 2022.* The present scoping review focused upon the functional benefits of hard martial arts training for older adults. The AXIS Critical Appraisal Tool was used to appraise all studies included in the review. A systematic literature search identified 265 papers via electronic database and ten papers from additional sources. Of these, six studies featuring 240 participants were included in the final scoping review. Of the included studies, three were randomized control trials and three were comparative studies with concurrent controls. The available studies outlined improvements in functional fitness parameters for older adults participating in hard martial arts training (strength 9.3–34%; mobility 9.5–13.6%; aerobic endurance 13.4%; flexibility 11.1–316.7%; balance 20.5%). However, inconsistencies in training stimulus and a limited number of studies highlight the need for further research before hard martial arts can be recommended for older adults. Based upon the limited available literature, to improve functional fitness, hard martial arts training should be conducted for 60 to 90 minutes, at least twice a week for a minimum of eleven weeks.

**KEY WORDS:** Aging, physical activity, functional fitness, Taekwondo, Jiu-Jitsu

### **INTRODUCTION**

In recent years, there has been increasing interest in the benefits of hard martial arts training on functional fitness in older adults (12, 14, 34). Differing from the popular ‘soft’ or internal focused martial arts such as Tai Chi and Aikido, hard martial arts focus upon the delivery of powerful punching, blocking, kicking techniques, whilst meeting force with an opposing force as performed within striking martial arts such as Karate and Taekwondo (4, 38) and grappling martial arts such as Judo and Brazilian Jujitsu (8, 12). Originally purposed for self-defense, more recently, martial arts training is being widely used for fitness training, self-confidence, and health (13). When completed in groups, martial arts exercise training promotes increased socialization and, thus, greater physical activity compliance in older adults (21).

Current physical activity guidelines for older adults recommend a minimum of 150 to 300 minutes of moderate or vigorous intensity aerobic exercise, or 75 to 150 minutes vigorous intensity aerobic exercise and to reduce the amount of time being sedentary (33). Prolonged periods of physical inactivity may negatively impact individuals' health and increases pressure on the world's health systems. Physical activity rates are lowest among adults above the age of 50 years (24, 34) and as individuals age they are more susceptible to age-related chronic diseases and conditions. The Australian Health Department reported approximately 55 percent of Australian adults do not meet the recommended physical activity guidelines (3), whereas in the United States, it is reported that 17 to 48 percent were inactive, depending upon the state (6). Moreover, conventional exercise programs are associated with high drop-out rates among older adults (35), therefore alternative physical activity interventions that promote functional fitness deserve further investigation. Recent interest in martial arts for social and health-related benefits may be a practical option for the older adult population (4).

Older adults are at increased risk of falls (one adult in three per annum) based upon age-related declines in functional fitness parameters such as balance and walking ability (11). Falls prevention is key to avoid fragility fractures which have been shown to lead to disability or loss of independence in older adults (44). Adequate functional fitness allows for unrestricted participation in activities of daily living (27). Functional fitness measures include flexibility, balance, strength, agility and endurance (41). A comparison of young, middle-age and older females (>65 years of age) reported greater decline in balance and agility with increasing age (28). Consequently, a higher prevalence of falls are observed in older adults compared to their younger aged counterparts (2).

Balance, flexibility and agility in older adults have been shown to improve when supervised martial arts programs have been implemented as the training intervention (9). Tai Chi, a slow, passive martial art has previously been the focus of martial arts related research and has reported improvements in balance and a reduction of falls in older populations (23, 45). The health benefits of hard martial arts training have recently focused on adults of all ages (34, 38) however, there remains a gap in the literature targeting adults older than 60 years of age. Older adults, particularly those with inadequate physical activity levels have the most to gain with exposure to alternative training methods such as hard martial arts as physical activity. Therefore, the aim of this scoping review was to investigate the reported benefits of hard martial arts training on functional fitness in older adults.

## **METHODS**

This study followed the methodologies as described in the Preferred Reporting Items for Systematic Reviews (29). The authors independently screened the results by title and abstract following the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines. This review was aimed to identify articles that focused upon hard martial arts training in older adults only. This scoping review followed the PICOS format for eligibility;

population (P) being adults over 60 years of age, intervention (I) focusing on hard martial arts training, comparison (C) between hard martial arts versus other training modalities, outcomes (O) identified in changes in functional fitness parameters and study design or settings (S) as randomized control or comparative studies. Ethical standards for this scoping review are in line with the position stand outlined by the International Journal of Exercise Science (32).

A systematic search, conducted by the lead author from May 2021 to June 2021 (inclusive), was employed utilizing the following electronic databases: CINAHL, Medline, Scopus, ProQuest and SPORTDiscus. Search criteria included terms relating to 'functional fitness criteria' AND 'hard martial arts' AND 'older adults' (Supplementary Material 1). An online search was used to help identify additional journals not discovered via electronic database sources and the Canadian Agency for Drugs and Technologies in Health (CADTH) was used to search for grey literature relevant to this scoping review (5). No prior registration with PROSPERO or Open Science Framework was requested prior to the systematic search.

The AXIS Critical Appraisal Tool (17) was used to examine the quality of each of the included studies. The AXIS scores were converted into percentages, with a score of  $\geq 74\%$  considered as 'good', between  $\geq 55\%$  and  $\leq 73.9\%$  as 'fair',  $\leq 54.9\%$  considered as 'poor'. The appraisal process was conducted by two of the authors independently, with the interrater reliability of the two authors' appraisal scores determined with SPSS (Version 28.0, IBM SPSS Statistics for Windows, IBM Corp., Armonk, NY, USA), using the Cohen's Kappa Coefficient (k) (26).

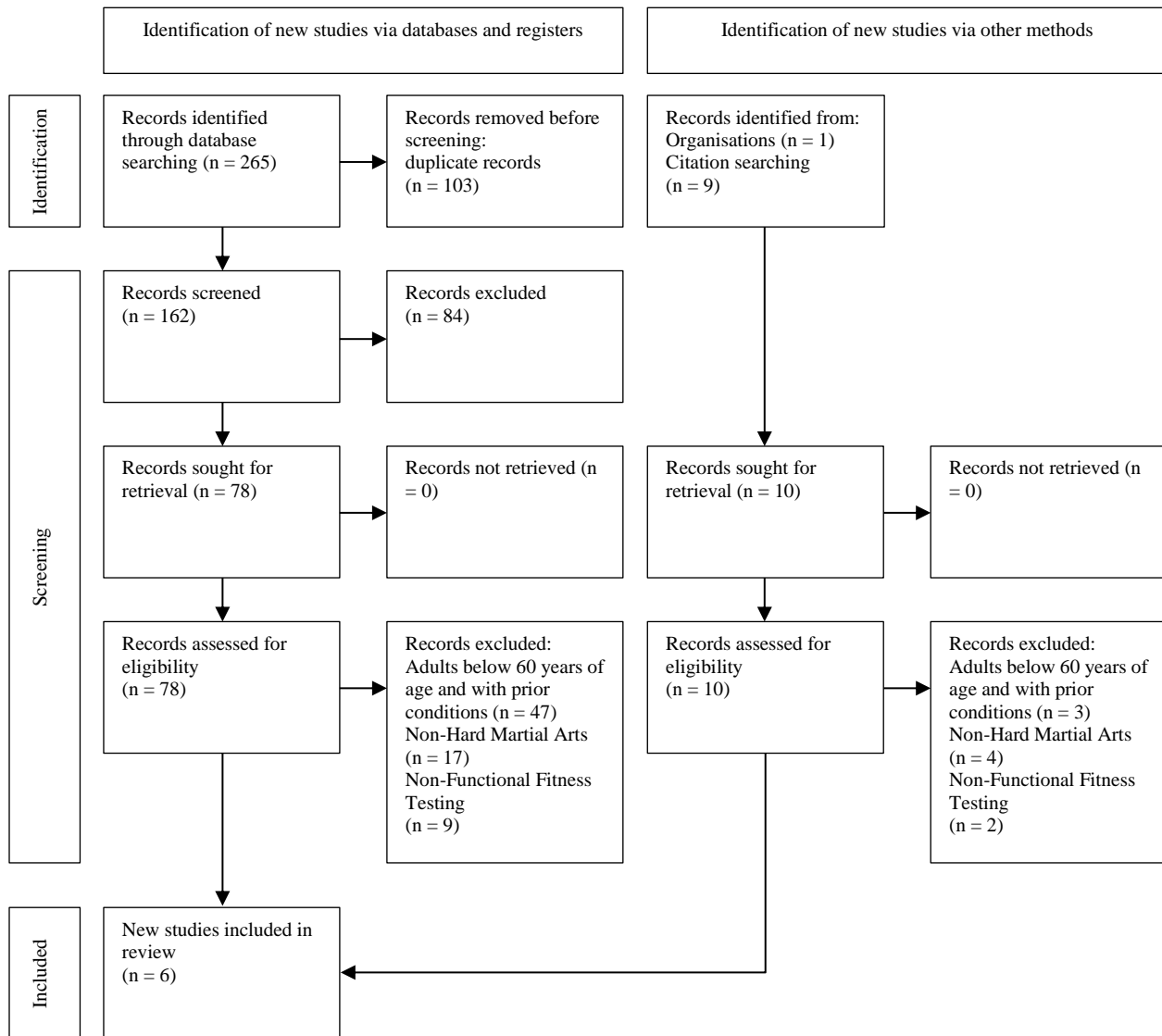
Reference management software (EndNote, Version x9. 3.3., Clarivate Analytics Philadelphia, PA, USA) was employed to import the search results. Following removal of duplicates, full-text articles were screened and sought for retrieval. Studies for inclusion in this review required meeting the following criteria: males and females over the age of 60; reporting of functional fitness parameters; and hard martial arts related training modalities. During the screening and data extraction process, any disagreements or differences of opinion were resolved via consultation with the senior investigators.

## RESULTS

A total of 264 studies plus an additional ten studies were identified by electronic database and additional search criteria (Figure 1). Following duplicate removal, full-text retrieval and screening for inclusion criteria, a total of six studies (7, 8, 11, 12, 14, 25) were included in this review. The six studies had a total of 240 participants (102 males, 138 females), with ages ranging between 60 to 83 years for the hard martial arts trained group. All studies were conducted between 2007 to 2021 and were randomized control trials or comparative designs.

Of the six studies included in this review, three studies reported on functional fitness changes following Taekwondo training (7, 11, 14), one study from Brazilian Jiu-Jitsu training (12), one study from Judo training (8) and one from Taekkyon training (25). Of the six studies, three studies incorporated both genders (8, 11, 14) whilst three studies focused upon only males or

females (7, 12, 25). Frequency of training varied from two to five sessions a week with the duration of sessions ranging from 60 (n=5; (7, 8, 11, 14, 25)) to 90 (n=1; (12)) minutes.



**Figure 1.** PRISMA flow diagram for scoping review.

Of the six studies that were included in this review, one half (n=3) did not report any dropout amongst its participants (11, 12, 14). However, three studies did report dropouts ranging from 7.5 to 18.9 percent (7, 8, 25). A randomised control trial (8) which involved judo training had the greatest dropout (n=7) however, the majority of dropouts (71%) were not specified. A comparative study (25) reported a total of four dropouts, equally divided between the Tai Chi group and the Taekkyon group. All dropouts were attributed to medical conditions. An additional comparative study (7) reported only a single dropout in their Taekwondo training groups, which was attributed to unspecified personal reasons. The intervention period of all the studies ranged from six weeks to four months.

The overview of our search process is depicted in the PRISMA flow diagram (Figure 1) which specifies the selection of articles included in the review, removal of duplicates and the final screening (36). With regard to critical appraisal results, all six articles were rated as 'good' quality independently by two authors as shown in Table 1. The mean critical appraisal rating was 76.25 percent (SD  $\pm$ 2.26). The Cohen's Kappa (k) identified a 'substantial agreement' ( $k = 0.93$ ,  $p < 0.001$ ) between the two raters. With regard to National Health and Medical Research Council levels of evidence (31), articles included in the review were either Level II, a randomised control trial (7, 12, 25) or Level III-2, a comparative study with concurrent controls (8, 11, 14).

**Table 1.** Study design, level of evidence, Modified AXIS scores and allocated quality rating for included articles.

Author Year Country	Title	Study Design	Level of Evidence*	Modified Axis (Average for reviewers)	Percentage (%)	Quality Rating
Del Vecchio et al. 2022 Australia	The Effects of Modified Taekwondo on Measures of Functional Fitness in Older Adults	Randomised Control Trial	III-2	15/20	75%	Good
Kim et al. 2020 Korea	Effects of Tai Chi versus Taekkyon on balance, lower-extremity strength, and gait ability in community-dwelling older women: A single-blinded randomized clinical trial.	A Comparative Study	II	15.5/20	77.5%	Good
Ciaconini et al. 2019 Italy	Effects of a 4-month judo program on gait performance in older adults.	Randomised Control Trial	III-2	15.5/20	77.5%	Good
Cho & Roh 2019 Korea	Taekwondo Enhances Cognitive Function as a Result of Increased Neurotrophic Growth Factors in Elderly Women.	A Comparative Study	II	15.5/20	77.5%	Good
de Queiroz et al. 2016 Brazil	12 weeks of Brazilian jiu-jitsu training improves functional fitness in elderly men.	A Comparative Study	II	15/20	75%	Good
Cromwell et al. 2007 USA	Tae Kwon Do: An Effective Exercise for Improving Balance and Walking Ability in Older Adults.	Randomised Control Trial	III-2	15/20	75%	Good
				k = 0.93	Mean = 76.25% (SD $\pm$ 2.26%)	

\* Level of evidence (31)

The characteristics of the six included studies in this scoping review are shown in Table 2. A total of four studies (7, 8, 12, 14) assessed upper body muscular strength using the 30-second arm curl test (for reps) of which Brazilian Jiu-Jitsu (12) and Judo (8) reported significant improvements over the training period (13.4 – 34.6%). Lower limb strength was assessed in five studies (7, 8, 12, 14, 25) via the 30-second sit to stand test (for reps) of which all but one study (7, 8, 12, 25) reported significant improvements (9.3 – 26.3%). To assess mobility, five studies (7, 11,

12, 14, 25) utilized a timed up and go test; three studies (11, 12, 25) reported significant improvements (9.5 – 13.6%) at the end of the training period. Where evaluated, aerobic fitness was assessed using the two-minute step test; two studies (7, 14) failed to report significant improvements over the training period. A single study (12) utilized the six-minute walk test to evaluate aerobic fitness, and a significant improvement (13.4%) was observed over the 12-week period.

**Table 2.** Characteristics of included studies.

Author Year Country	Design (n = number)	Age (years $\pm$ SD)	Genders (n = number)	Intervention	Relevant Reported Outcomes	Findings	Improvements (%, f = females, m = males)	Dropout number, percent & reason
Del Vecchio et al. in press Australia	RCT TKD: n = 15 CON: n = 10	TKD: 74.4 $\pm$ 5.0 CON: 72.5 $\pm$ 3.0	Females (n = 12) and Males (n = 13)	TKD training 60mins, 2 times a week for 6 weeks	2S, AC, BS, CS, FTNT, SLS, SR and TUG	TKD: no sig improvements in functional fitness parameters. TC sig improvement over TA for SLS. TC and TA: sig improvements CS, SLS and TUG.	N/A	No dropouts
Kim et al. 2020 Korea	CS TC: n = 23 TA: n = 23	TC 71.4 $\pm$ 3.3 TA 70.9 $\pm$ 4.3	Females (n = 46)	TC or TA training 60mins, 2 times a week for 12 weeks	CS, FR, SLS and TUG	TC and TA: sig improvements CS, SLS and TUG.	TC - CS: 44.4 TC - SLS: 83.2 TC - TUG: 10.9 TA - CS: 26.3 TA - SLS: 20.5 TA - TUG: 13.6	4 in total, 8%, Unstable medical conditions
Ciacconi et al. 2019 Italy	RCT JU: n = 16 CON: n = 14	JU: Females 67.6 $\pm$ 3.7 Males 71.0 $\pm$ 3.5 CON: Females 70.1 $\pm$ 5.0, Males 70.2 $\pm$ 4.0	Females (n = 13) and Males (n = 17)	JU training 60mins, 2 times a week for 4-months	AC, BS, CS and SR	JU: sig improvements in AC, BS, CS and SR	AC: 34.6 (f), 27.5 (m) BS: 316.7(f) 79.2 (m) CS: 13.6 (f), 9.3 (m) SR: 70.6 (f) 68.3 (m)	7 in total, 18.9%, 5 dropped out with no apparent reason; 1 increased physical activity levels; 1 due to health concerns
Cho & Roh 2019 Korea	CS TKD: n = 19 CON: n = 18	TKD: 68.9 $\pm$ 4.2 CON: 69.0 $\pm$ 4.4	Females (n = 37)	TKD training 60mins, 5 times a week for 16 weeks	2S, AC, BS, CS, SR and TUG	TKD: sig improvements in 2S, CS and SR	2S: 7.6 CS: 17.1 SR: 16.9	3 in total, 7.5%, Personal reasons
de Queiroz et al 2016 Brazil	CS BJJ: n = 31 CON: n = 31	BJJ: 70.7 $\pm$ 6.4 CON: 69.5 $\pm$ 6.1	Males (n = 62)	BJJ training 90mins, 2 times a week for 12 weeks	6MWT, AC, BS, CS, SR and TUG	BJJ: sig improvements for 6MWT, AC, BS, CS, SR and TUG	6MWT: 13.4 AC: 13.4 BS: 46 CS: 22.1 SR: 111.5 TUG: 13.6	No dropouts
Cromwell et al. 2007 USA	RCT TKD: n = 20 CON: n = 20	TKD: 72.7 $\pm$ 6.1 CON: 73.8 $\pm$ 7.0	Females (n = 30) and Males (n = 10)	TKD training 60mins, 2 times a week for 11 weeks	SLS, SR and TUG	TKD: sig improvements for SR and TUG	SR: 11.1 TUG: 9.5	No dropouts

CT = Comparative study, RCT = Randomized control Trial, CON = Control, TC = Tai Chi, TA = Taekkyon, TKD = Taekwondo, BJJ = Brizilian Jiu-Jitsu, JU = Judo, 2S = two-minute step test (reps), 6MWT = six-minute walk test, AC = 30 second arm curl (reps), BS = Back scratch (cms), CS = 30 second sit to stand (reps), FR = functional reach test (cms), FTNT = finger to nose test (seconds), SLS = single leg stance (seconds), SR = Sit and Reach (cms), TUG = Timed up and go (seconds)



Of the available studies, four (7, 8, 12, 14) evaluated upper body flexibility via the Apleys back scratch test where Judo (8) was the only study which reported significant improvements (79.2% males, 316.7% females). Conversely, for lower body mobility, four out of six studies (7, 8, 11, 12) identified significant improvements (11.1 – 111.5%) over the training period via the use of a seated chair sit and reach test. To investigate static balance, a single leg stand test (time in seconds) was reported in three studies (11, 14, 25), with one study (25) identifying significant improvement (20.5%). A single study (14) assessed coordination via a finger to nose test (time in seconds) and reported a non-significant finding over six-weeks of taekwondo training.

## DISCUSSION

The aim of this scoping review was to collect, critically appraise and summarize the research available on the effects of hard martial arts training in older adults on functional fitness outcome measures. The mean methodological rating for the studies included in this scoping review was 76.25 percent which is of good quality. Although there were a limited number of studies included in this review, this quality needs to be considered when evaluating our findings.

This scoping review investigated the reported benefits of hard martial arts training on functional fitness in older adults. We identified a total of six studies that met our inclusion criteria and all studies demonstrated varying degrees of benefits in physiological parameters within older adults who completed supervised hard martial arts training. Based upon the limited available literature, training stimulus required a minimum of two sessions a week over a period of greater than eleven weeks, irrespective of previous martial arts exposure to demonstrate benefits. Participants in the six included studies had no prior experience completing hard martial arts training, no severe cardiovascular or musculoskeletal conditions and exercise levels ranged from non-structured to moderately active.

### *Strength*

Declines in muscular strength are associated and well documented to the aging process and can result in an individual's inability to maintain independent living (37). There is a higher mortality risk for older adults who spend more sedentary time compared with their more active compatriots (24). Ciaccioni et al (8) investigated the effects of a four-month judo training program on functional fitness in older adults ( $69.7 \pm 4.2$  years). Following the training period, the researchers observed significant improvements ( $p < 0.05$ ) in both upper (male 27.5%, female 34.6%) and lower body strength (male 9.3%, female 13.6%). Similar findings were identified by de Quieroz et al (12) when older adults ( $69.5 \pm 6.1$  years) undertook twelve weeks of Brazilian Jiu-Jitsu training. Cho and Roh (7) identified strength improvements in the lower limbs ( $p < 0.05$ ; 17.1%) following sixteen-weeks of Taekwondo training in older women ( $68.9 \pm 4.2$  years). In addition, lower limb strength improvements ( $p < 0.05$ ; 26.3%) were reported by Kim et al (25) when older women ( $70.9 \pm 4.3$  years) completed twelve-weeks of Taekkyon training. Contrary to these findings, Del Vecchio et al (14) investigated the effects of modified Taekwondo training on functional fitness in older adults ( $74.4 \pm 5.0$  years). A small effect size (upper limb 5.0%, lower



limb 1.2%) was identified between pre and post-test measures, however no significant improvement on upper or lower limb strength was found. The authors noted promise in the modified Taekwondo training program to improve functional fitness in older adults, however, cited six weeks as possibly insufficient time (i.e., stimulus) for a notable training adaptation.

The current research available suggests hard martial arts training may be effective at improving overall body strength favoring lower limbs in older adults. The positive effects support a previous systematic review which reported improvements in lower limb strength when adults (51 to 93 years) participated in Karate and Taekwondo training (38). Furthermore, the review highlighted lower limb favored movement patterns upwards of 75% for Taekwondo training. Fong and Tsang (20) have previously reported that lower limb strength adaptations are more dependent on the velocity of kicking techniques, opposed to time spent performing Taekwondo training.

Fell and Williams (18) have previously highlighted older muscle takes longer to repair than younger muscle. Shorter time periods of training stimulus may not be sufficient for adequate recovery and supercompensation training response. Consequently, additional studies are required before hard martial arts can be recommended to older adults as a complimentary form of training alongside traditional strength training programs.

### ***Mobility***

Older adults are more likely to experience a decline in quality of life with a loss of mobility (10). There is evidence to suggest a combination of gross motor skills, cognitive and aerobic training are key to improving mobility for older adults and healthy aging (40). Five studies reported the effects of hard martial arts training on mobility in older adults. Kim et al (25) examined twelve-weeks of Taekkyon training in lower extremity strength and gait ability in older women ( $70.9 \pm 4.3$  years). The researchers reported a significant improvement ( $p < 0.05$ ; 13.6%) in mobility following the training period. Similarly, de Quieroz et al (12) investigated the effects of Brazilian Jiu-Jitsu training on the functional fitness in older males ( $69.5 \pm 6.1$  years). Significant improvements ( $p < 0.05$ ; 13.6%) in mobility were reported with bi-weekly hard martial arts training. Additionally, Cromwell et al (11) investigated the effects of an eleven-week Taekwondo training program on balance and walking ability in a group of older adults ( $72.7 \pm 6.1$  years). Significant improvements in mobility ( $p < 0.05$ ; 9.5%) and walking velocity ( $p < 0.05$ ; 22%) were reported, following the training period. In contrast, more recent Taekwondo studies by Del Vecchio et al (14) as well as Cho and Roh (7) failed to reproduce significant improvements in mobility following hard martial arts training, although a small positive effect on mobility (3.6 – 9.5%) was noted in both studies. Taken together, the current research suggests hard martial arts training improves mobility in older adults.

### ***Aerobic Endurance***

Declining aerobic endurance is associated with complications of the cardiovascular system (42). Limiting age related declines in aerobic endurance for older adults is paramount to maintaining independent living and quality of life. Cho and Roh (7) assessed the effect of a sixteen-week

Taekwondo training program, on the physical fitness in older women ( $68.9 \pm 4.2$  years). Following the training period, the researchers identified significant improvement ( $p < 0.05$ ; 7.6%) in aerobic endurance. Furthermore, de Queiroz et al (12) investigated twelve-weeks of Brazilian jiu-jitsu training on the functional fitness in older males ( $69.5 \pm 6.1$  years). Similarly, the researchers noted significant improvement ( $p < 0.05$ ; 13.4%) in aerobic fitness. In contrast to the previous studies, Del Vecchio et al (14) studied the effect of six-weeks of Taekwondo training on functional fitness in older adults ( $74.4 \pm 5.0$  years). The researchers reported a non-significant improvement (15.5%) in aerobic fitness that may necessitate further study over an extended training period. Taken as a whole, the data suggests that hard martial arts training may improve aerobic fitness in older adults; however further studies are required before hard martial arts can be recommended to older adults as an alternative to conventional training modalities.

### ***Flexibility***

Reduced flexibility impairs normal muscle performance and is associated with increased risk of falls in the elderly (22). Ciaccioni et al (8) examined the effects of a four-month Judo training program on functional fitness in older adults ( $69.7 \pm 4.2$  years). The researchers reported significant improvements ( $p < 0.05$ ) for both upper (male 79.2%, female 316.7%) and lower body flexibility (male 68.3%, female 70.6%). In addition, two Taekwondo related studies (7, 11) identified an increase in lower limb flexibility. Firstly, Cho and Roh (7) noted significant improvement ( $p < 0.05$ ; 16.9%) in flexibility when older women ( $68.9 \pm 4.2$  years) participated in sixteen-weeks of Taekwondo related exercise. Secondly, Cromwell et al (11) observed flexibility improvements ( $p < 0.05$ ; 11.1%) when older adults ( $72.7 \pm 6.1$  years) participated in eleven-weeks of Taekwondo training.

The available literature suggests hard martial arts can improve flexibility for older adults. To the authors knowledge this is first review that highlights flexibility benefits to older adults following hard martial arts intervention. A review by Guo et al (21) has previously reported on flexibility improvements for older adults when exposed to traditional Chinese sports. The researchers reported an increase in flexibility following a mixture of soft techniques (Qigong and Yangko dance) and more vigorous movement patterns (Tai Ji Quan). Further studies are required to help strengthen the link between flexibility in older adults and hard martial arts training intervention.

### ***Balance and Coordination***

Falls prevention strategies for older adults are well advised to incorporate both strength and balance exercises (44). Hard martial arts may encourage both falls prevention and safe falling techniques in older adults (2). A study by Kim et al (25) compared twelve-weeks of Tai Chi and Taekkyon training in lower extremity strength and walking gait in older women ( $70.9 \pm 4.3$  years). The researchers reported significant improvements ( $p < 0.05$ ; Taekkyon 20.5%, Tai Chi 83.2%) in balance for both martial art modalities. Moreover, Tai Chi showed a greater improvement in single leg stance over Taekkyon. However, this was not supported by the three Taekwondo related studies (7, 11, 14). Del Vecchio et al (14) identified a non-significant

improvement (5.6%) in reaction time when older adults completed five finger coordination tests following Taekwondo training.

Balance improvements have previously been reported when adults (41-71 years) are exposed to a yearlong Taekwondo training program (39). Furthermore, Douris et al (16) identified significant improvements when middle aged adults are exposed to Soo Bahk Do, a Korean based martial arts similar to karate. Fong et al (19) investigated hand eye coordination following Ving Tsun Kung-fu training in middle to older adults ( $68.5 \pm 6.7$  years). The researchers reported significant improvements ( $p = 0.002$ ; 2.9%) between pre and post testing data. Considering the current evidence, further research is required before hard martial arts can be recommended for older adults acquiring balance and coordination improvements.

### ***Strengths and Limitations of this Scoping Review***

This scoping review has several limitations. Firstly, the small body of research available on the benefits of hard martial arts training in older adults on functional fitness measures. Secondly, the movement patterns between 'hard' and 'soft' martial arts styles are often similar. This makes it difficult to attribute functional benefits for older adults solely to 'hard' or 'soft' martial arts style. Thirdly, the heterogeneity between different hard martial art styles limits the generalizability to the broader population of older adults.

However, the strength of this scoping review is its focus upon the benefits of hard martial arts training on measures of functional fitness in older adults. The focus on older adults of all skill levels brings greater relevance for the results on the broader population. We postulate these benefits are primarily attributed to the static and dynamic muscular contractions involved in hard martial arts training. Further, the muscular contractions associated with striking actions have been estimated at 60% of one-repetition maximum load (43), which may meet the minimum threshold for improving strength in older populations. Whereas the kicking and punching and stances may provide adequate training stimulus for improvements in static and dynamic balance (30).

This review provides recommendation of a minimum training stimulus for potential functional benefits for future studies in the hard martial arts style. Kicking on one leg may cause an improvement in single-leg balance (39), which may be reflected in improved single-leg balance time. Striking a static or dynamic moving target may enhance hand-eye coordination (19), leading to improved finger-to-nose times. Long, wide stances may improve leg strength due to the sustained isometric contraction of the quadriceps (15), which may be reflected in improved sit-to-stand scores. Finally, kicking motions stretch the hamstrings (1), which may enhance sit and reach scores.

### ***Conclusions and Recommendations***

This scoping review demonstrates the potential of hard martial arts as a viable evidence-based option for improving functional fitness in older adults. Further research is needed to support

the recommendations for hard martial arts training in older adults compared with conventional training. In spite of this, hard martial arts may be seen as a viable, evidence-based choice of exercise regime that offers variety and socialization which may enhance both functional fitness and exercise adherence for older adults. Of the available studies, hard martial arts training was recommended to last 60 to 90 minutes per session for a minimum of two times a week. No upper limit of training duration has been identified, however a minimal training stimulus of at least eleven weeks is supported by the current literature.

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