



## Health promotion and prevention: The impact of specifically adapted judo-inspired training program on risk factors for falls among adults

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### ABSTRACT

Globally, falls and fall-related injuries constitute a severe threat to public health at all ages. New approaches are warranted since existing knowledge and actions have failed to reduce the incidence of falls and fall-related injuries, both at work and during leisure time. The purpose of this quasi-experimental study was to investigate the impact of a 10-week supervised judo-inspired exercise program, Judo4Balance, provided in a workplace setting among men and women targeting: physical functions, activity level, fall-related self-efficacy, and techniques for safe landing when falling. A total of 79 adults from seven different workplaces in Sweden, mean age 45 years (18–68), participated in the program. The study was conducted from May 2018 to June 2019. The 10-week exercise program performed in a workplace setting improved physical and psychological functions, as well as techniques for falling safely, factors of great importance to prevent falls and fall-related injuries among men and women. Therefore, it is suggested that the judo-inspired exercise program may be an effective tool in the quest to promote health and prevention of risk factors for falls and fall-related injuries among those of working age.

### 1. Introduction

Falls are the second leading cause of accidental injury deaths worldwide, and each year an estimated 646,000 individuals die from falls globally (World Health Organisation, 2018). Falls constitute a common and severe threat to public health and are not only a problem of advanced age. Studies have reported that falls are a problem at all ages (Timsina et al., 2017). Injuries from occupational slips, trips, and falls on the same level constitute a major health problem worldwide (Wen-Ruey et al., 2016).

Sweden is no exception regarding the burden placed on the public as well as to occupational health because of falls. Falls are also the most common work incident, with more than 11,000 falls occurring at work annually (Försäkring, 2019). On average, an employee in Sweden who has suffered an injury in a ground level fall is on sick leave for two months causing considerable costs (such as general payroll taxes, overhead costs, and substitute cost) for the employer (Försäkring, 2018).

Individuals in the young and the middle age groups (19–64 years)

have shown to predominately die from ground level falls, and the mortality rates increase with age (James et al., 2018). However, the proportion of fall-related injuries has been reported to be equal in all age groups. This indicates that falls and fall-related injuries represent a significant threat to public health at all ages (Verma et al., 2016; Talbot et al., 2005). Measures that have been suggested in the literature to prevent falls at the workplace include muscle strengthening exercises, coordination and balance, as well as environmental hazard prevention at work (Haslam and Stubbs, 2006).

In addition, the engagement of adults in recommended global physical activity guidelines is generally low. In a recently performed cross-sectional study, eight out of ten adults in the United States (18–80 years) did not meet the recommended global physical activity guidelines (Bennie et al., 2019).

Risk factors contributing to falls and fall-related injuries have been well documented (Deandrea et al., 2010). Common risk factors include age, gender (women are more prone to falls), physical functions (mainly strength and balance deficits), and psychological functions (fear of falling, low self-efficacy), among others (Deandrea et al., 2010;

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Boelens et al., 2013; Grundstrom et al., 2012; Hellström et al., 2013). Evidence suggest that structured exercises, targeting strength and balance, are effective actions that have shown to significantly reduce falls among older adults (Fairhall, 2019; Sherrington et al., 2019; Campbell et al., 1997). In addition, exercise has shown to have a positive effect on fear of falling and fall-related self-efficacy, which should be considered as important aspects and risk factors for falls (Halvarsson et al., 2011; Halvarsson et al., 2015; Kumar et al., 2016). Research have shown that effective fall prevention programs for older adults include challenging balance exercises and strength training (Sherrington et al., 2017; Sherrington et al., 2019; Guirguis-Blake et al., 2018). However, for younger and middle age adults, corresponding evidence in fall prevention research is not available.

In addition to balance and strength exercise in fall prevention, learning landing strategies has been suggested to be important for mitigating fall-related injuries, especially hip fractures (Robinovitch et al., 2003). However, knowledge of such exercise programs that include the learning of breakfall and landing strategies is lacking. One exercise form that includes elements likely to be relevant for fall prevention (balance and strength training) as well as exercises that reduce the likelihood of fall-related injury such as teaching breakfalls and landing strategies is judo (Bohannon, 2012). The level of physical fitness, tactical skills, and techniques required in judo is high (Bohannon, 2012; Franchini et al., 2005). Judo is a form of martial arts (MA), which means training for combat, and is commonly described as arranged or systematized techniques for throwing or takedown styles (Bohannon, 2012; Franchini et al., 2005). Falling (breakfall) techniques used in judo, which are characterized by rolling movements, have shown to reduce the impact to the hips, and may have a protective effect on the risk of femoral fractures (Moon and Sosnoff, 2017; van der Zijden et al., 2012). Therefore, it is suggested that breakfalls and landing strategies may reduce the impact load during a fall, especially in young and middle aged adults but also in older ages, to some extent. (Groen et al., 2007). Thus, judo training includes important factors to achieve strength, stability, and balance skills (Agostinho et al., 2015; Franchini et al., 2011), skills which are included in known fall prevention exercise programs.

In 2017, a specific exercise program Judo4Balance was developed by experts in exercise physiology reviewed by MT and KSB in our research team. The Judo4Balance is a progressive, structured and standardized exercise program, which includes strength and balance exercises as well as techniques for falling in all different directions.

Interventions in workplace settings have shown that facilitators such as social influence and environmental context are important for engaging in physical activity (Garne-Dalgaard et al., 2019). Since most of the adult working population spend a large portion of their time at work, it was of great interest to apply this in our study. To our knowledge, there are no reported studies that investigate the effects of judo exercises in a workplace setting, targeting known risk factors for falls (such as strength and balance) and teaching safe techniques for falling among men and women at work.

Our hypothesis was that a developed standardized judo-inspired exercise program provided in the workplace, including both physical exercises (such as balance and strength) and falling techniques, is an effective program to address the physical and psychological risk factors for falls among working age adults.

Therefore, the aim of this study was to investigate the impact of a workplace provided 10-week supervised judo-inspired exercise program, Judo4Balance, on physical functions, fall-related self-efficacy, activity level, and falling techniques among both men and women.

## 2. Method

This was a quasi-experimental study with a 1-group pretest–posttest design investigating the effects of a 10-week judo-inspired exercise program for physical functions, fall-related self-efficacy, activity level,

and falling techniques among working age adults.

The study was conducted in accordance with the Declaration of Helsinki. This study was approved by the Ethical Committee of the Uppsala Region (Dnr 2018/239). Each participant voluntarily provided a written informed consent before participating. Participants were informed that they could withdraw from participation at any time for any reason without any consequences. The participants received no compensation for participating in the study. The study included 79 participants from various workplaces in Sweden. Inclusion criteria were: being over 18 years of age, ability to understand written and verbal Swedish language, and being available at the workplace for testing and the training sessions.

### 2.1. Setting

A total of seven different workplaces from different parts of Sweden participated in the study of the judo-inspired exercise program (construction and steel industry, healthcare, pre-school, insurance office, advertising, and health and safety consultants). Employers from different locations in Sweden offered the program as part of their preventive health and safety at the workplace program. Workplaces reported an interest in participating and viewed their participation as part of their systematic work to promote health and safety among employees. Information and an invitation to participate in the 10-week program were provided to employees at the workplace. After an acceptance to participate, written consent was obtained. Measurements were performed at the workplace by a qualified judo instructor. A total of three qualified Judo instructors, familiar with the physical tests, performed the pre- and post-assessments. A total of 14 qualified judo instructors from seven different Judo Clubs provided the training to the different groups (on average, two instructors per group of 10–18). The instructors teaching the special exercise program were required to have at least a blue belt in judo (which means a minimum of five years of regular judo and breakfall training). All the instructors teaching the classes in the study had black belts. To teach the program, there was also a requirement to have a valid coaching license from the Swedish Judo Federation and to have undergone a specific weekend course in the Judo4Balance program, with a focus on teaching judo-related exercises and falling techniques to adult and elderly beginners. The program was delivered in a 50-minute session once a week at the respective workplace.

### 2.2. Intervention

The intervention included 10 sessions, using a 10-week 50 min /week pre-established program called Judo4Balance, a structured exercise program which includes three blocks:

- 1) Practicing breakfall techniques and strength exercises, body awareness, mobility training, build up load of resistance in muscles, tendons, joints and skeletons, as well as challenging exercises to train balance by performing movements that are not usually carried out in everyday life activities, e.g., getting up and down from the floor.
- 2) Continuing breakfall techniques and strength exercises, increasing load in strength exercises, highly challenging balance and coordination ability, greater range of movements in exercises, possibly power in exercises, continuing to build up load resistance in muscles, tendons, joints and skeletons.
- 3) Training the ability to develop power (the product of strength and speed), power in strength exercises, and more challenging breakfall techniques, challenging one's balance with increased difficulty.

The Judo4Balance is a structured and standardized exercise program, and all judo instructors were well acquainted with the program as well as experienced in leading group exercises. Each training session

has a similar pattern, starting with warm up, proprioception and breakfall techniques, strength training, cool down and relaxation. Many of the exercises are performed in pairs (a common practice in judo).

### 2.3. Measurements

Measurements in this study have been done primarily for people over 55 years of age, known as the group at greatest risk for falls. Therefore, three of the well-known instruments in this study have been expanded, to be adapted purposefully for this study targeting people of working age.

Outcomes for physical performance, balance, activity level, fall-related self-efficacy, and MA falling techniques were collected using the following measures:

Short Physical Performance Battery (SPPB) (Guralnik et al., 1994) was used to assess the physical performance in the lower extremities, which was expanded with an additional difficulty progression to suit people of working age. The additional progression included advanced items in each of the three components: balance (tandem with heel raise, and tandem with heel raise with closed eyes), gait speed (backwards), and lower body power (chair stand on one leg -left/right). The original scale scores range from 0 to 4 for three components, with an additional score of 20 for the additional items. A total score of 12 represents the best performance for the original test and 32 for the expanded test. The original SPPB has shown to predict the risk of falls in adults over the age of 60 (Gawel et al., 2013). The test has shown to have good test-retest reliability and being sensitive to changes Guralnik et al. (2000). HYP-ERLINK "SPS:refid::bib35"

The Frändin/Grimby Activity Scale was used to measure the level of physical activity. Three different questionnaires were used to capture the activity levels during summer, winter, and at the workplace. The scales range from 1 to 6, with 1 representing 'hardly active at all' and 6 representing 'intensive exercise regularly and several times per week.' The scale has been evaluated and shown to have good validity. (Frändin and Grimby, 1994)

The Falls Efficacy Scale-Swedish version (FES-S) and Falls Efficacy Scale-Swedish version for working age (FES-S-W) were used to measure the self-confidence in the ability to perform various daily activities without falling (Hellström et al., 2003). The FES-S-W was extended with six additional questions, with the aim to ask people of working age about their confidence related to falling. The original instrument consists of 13 items and the extended test 19 items. Each item is rated from 0 to 10, with a maximum score of 130/190 points, which represents the highest level of self-efficacy. The original instrument has been shown to have high test-retest reliability Hellström and Lindmark (1999) HYP-ERLINK "SPS:refid::bib38"

The Mini-BESTest and Mini-BESTest-W were used to measure balance (Franchignoni et al., 2010). The original test includes 14 different tasks on four subscales. The extended test includes six additional items: feet shoulder-width apart, on toes for extended time (30 s); feet together, eyes closed and on toes; walking backwards; walking backwards on a line; standing on one leg on a foam surface left/right; change in gait speed backwards; and step over obstacles backwards. All tasks are graded from 0 to 2 points, with a total maximum score of 28 points for the original test and 40 points for the extended test. The original test has high reported test-retest reliability and interrater reliability (Tsang et al., 2013).

Since there are no previously known tests for the evaluation of MA falling techniques for those who are of working age or for elderly populations, two tests were developed to test the acquired skills for falling backwards as well as falling forwards in a safe setting, with progressive difficulty. The judo falling techniques were graded on a 0–4 scale. Four judo puzzle crash mats were used for the exercises.

Falling backwards: The person is asked to lay down on his/her back on the mat and to stand up again. If the person manages to perform the task, he/she scores one point. If the participant refuses because of fear

of not getting up again or for fear of getting hurt or fails to stand up independently after laying down, the score is zero.

The next step is to sit up on the mat on one's buttocks and fall backwards. If the person manages to do this without any harmful maneuver, he/she scores two points. Harmful maneuvers include, for example, not rolling up with legs, not holding up one's head, or putting out a straight arm or elbows (there is a checklist provided). If a harmful maneuver is discovered, the testing will be terminated. The next step is to fall backwards safely from a squatting position (3 points), and the final step is to fall down safely from a standing position, which results in four points if done correctly.

Falling Forwards/Sideways: A similar progression is made for the forwards/sideways breakfall strategies. First, laying on the stomach. Then, falling from the knees, falling from a squatting position, and falling from a standing position (rolling or "cat breakfall") without any harmful maneuvers results in four points.

### 2.4. Statistical analysis

Non-parametric methods were used for all the measurements. To test the difference between the baseline and the follow-up after 10 weeks, Wilcoxon Signed Ranks Test was used (two related samples). The difference between men and women was tested with Chi Square Test.

Two-tailed p-values were used with a critical significance level of 0.05.

All analyses were performed using the statistical program SPSS 22.0 for Windows (SPSS Inc., Chicago, IL).

## 3. Results

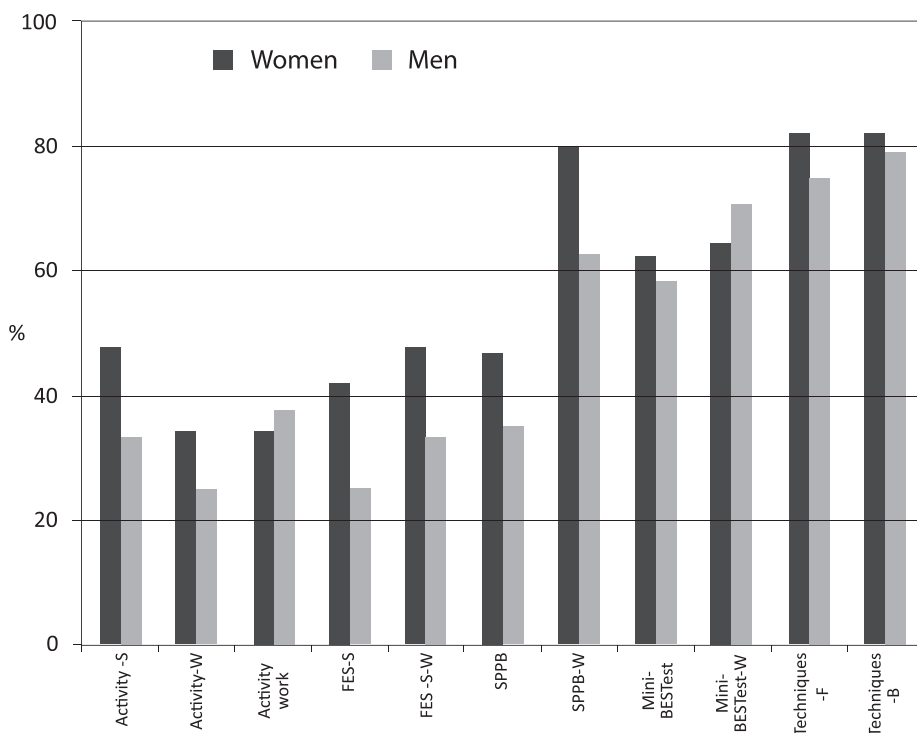
A total of 79 persons throughout Sweden participated at various workplaces in the 10-week program, including 48 women and 31 men. The average age was 45 years (18–68). Out of a total of 79 people, 68 people conducted tests both before and after the 10-week program. In the total group, all measures displayed significant improvements in the measurements, except for FES-S and physical activity level (winter), see Table 1. The mean value for session attendance was 7.42, confidence intervals (CI) (6.89–7.95). The main reasons for dropouts were change of work, long vacation, long-term sick leave, and one refusal to perform follow-up tests. No injuries occurred during the training sessions.

**Table 1**

Results from the Wilcoxon rank sum test for all measurements.

Outcomes (min–max score)	Baseline n = 79 median (range)	10-week n = 68 median (range)	P
Falling techniques forwards (0–4)	1.0 (2)	3.0 (3)	< 0.001
Falling techniques backwards (0–4)	1.0 (4)	4.0 (3)	< 0.001
FES-S (0–130)	130.0 (55)	129.0 (1 0 4)	0.195
FES-S-W (0–190)	179.0 (1 0 3)	180.5 (1 5 3)	0.026
SPPB (0–12)	11.5 (5)	12.0 (3)	< 0.001
SPPB-W (0–32)	22.0 (21)	26.0 (19)	< 0.001
Mini-BESTest (0–28)	25.0 (18)	27.0 (10)	< 0.001
Mini-BESTest-W (0–40)	31.0 (22)	32.0 (15)	< 0.001
Activity level, Frändin Grimby (1–6)	4.0 (5)	4.0 (5)	0.011
Summer	4.0 (5)	4.0 (5)	0.144
Winter	4.0 (5)	4.0 (5)	0.002
Workplace			

Note. FES-S = Falls Efficacy Scale- Swedish version, FES-S-W = Falls Efficacy Scale-Swedish version-Working age, SPPB = Short Physical Performance Battery, SPPB-W = Short Physical Performance Battery-Working age, P = p-value, bold figures indicate a significant value  $\leq 0.05$ . Higher score on the measurements represent better performance.



**Fig. 1.** Proportions of participants who improved on the respective measures. *Note.* Activity-S = Activity Summer, Activity-W = Activity-Winter, FES-S = Falls Efficacy Scale-Swedish version, FES-S-W = Falls Efficacy Scale-Swedish version-Working age, SPPB = Short Physical Performance Battery, SPPB-W = Short Physical Performance Battery-Working age, Mini-BESTest-W = Mini-BESTest-Working age, Techniques-F = Falling techniques Forwards, Techniques-B = Falling techniques Backwards.

SPPB and SPPB-W showed a significant improvement on both the standard test ( $p = < .001$ ) and the extended test ( $p = < .001$ ). The physical activity level measured using Frändin Grimby displayed significant improvements for physical activity (summertime),  $p = .011$ , and physical activity (at workplace)  $p = .002$ . The FES-S and FES-S-W showed significant improvements only on the extended test of the validated instrument ( $p = .026$ ). Balance ability measured with original Mini-BESTest and Mini-BESTest-W displayed significant improvements on both the standard test ( $p = < .001$ ) and the extended test ( $p = < .001$ ). MA falling techniques, measured by using Judo4Balance, displayed a significant improvement on both the backwards ( $p = < .001$ ) and forwards ( $p = < .001$ ) items.

A description of proportions of improvement from baseline in men and women for all measures is presented in Fig. 1. The results show that men and women increased their values in all of the measurements equally. There were no significant differences in any of the measurements between men and women tested with Chi Square Test.

#### 4. Discussion

The judo-inspired exercise program, Judo4Balance, was successfully conducted in workplace setting, and the 10-week exercise period significantly improved physical function, fall-related self-efficacy, activity level, and falling techniques among the participants. After the 10-week session, the participants had the confidence and correct technique to fall backwards on the mat from a standing up position. This indicates that adults can learn how to effectively breakfall in a controlled situation within a 10-week period. The presented results displayed equal benefits for men and women and displayed no significant differences between the sexes, which was important knowledge since sex is known to be a major factor influencing physical performance and trainability (Thibault et al., 2010).

The measurements used were considered to meet the study aim, despite the fact that these measurements are commonly used to evaluate functions related to risk of falling among older adults (Guralnik et al., 1994; Frändin and Grimby, 1994; Hellström et al., 2003; Franchignoni et al., 2010). The additional items in the instrument included progression in both strength and balance performance, known

functions associated with preventing falls. Among women, the incidence of fractures has been reported to be the highest in young age, with a significant increase up to 60–69 years (Court-Brown et al., 2017). Therefore, exercises to increase bone strength and to prevent falls are of the utmost importance, especially for women prone to getting fractures. Components in judo exercises may provide e.g., bone strength, muscle strength exercise, balance, and break-falling techniques.

Some behavioral aspects should also be considered in this study since we also investigated fall-related self-efficacy. This aspect has been addressed in previous studies as being important in fall prevention among older adults (Culos-Reed et al., 2000). This study implies that the additional items in FES-S-W provided new insight on differences in self-confidence in the ability to perform various daily activities without falling in this sample of adults, compared to older adults, since the original FES displayed no significant results in this study. This should be highlighted, with recommendations to further investigate in future studies since the results indicate that different activities are of importance at different ages for fall-related self-efficacy.

The new aspect in this study was learning specific falling techniques; this was particularly interesting since it is well known that exercising to strengthen muscles and to improve balance is effective in fall prevention studies (Fairhall, 2019; Sherrington et al., 2019; Campbell et al., 1997). However, the addition of learning falling techniques is sparsely investigated and therefore deemed to be important; furthermore, it is recommended for investigation in future studies.

The setting provided insight on the importance of the environment, and the impact of social context. Previous research have shown that the social context is an important facilitator for engaging in physical activity among older adults, which is also important for the effectiveness of the exercise when being supervised by a professional trainer (Lacroix et al., 2017). This study's clinical implications suggest that a workplace setting may serve as a practical setting to initiate and motivate adults to engage in exercises that effectively target important risk factors for falls.



#### 4.1. Limitations

There are some limitations with this study that need to be addressed. There was no comparison with a control group, which needs to be further investigated to be able to establish whether this exercise form should be recommended in fall prevention measures in the future. Nevertheless, the results from this study could serve as a pilot for further planning and also to perform appropriate power calculation. Also, the main outcome was not falls; this study only investigated known physical and psychological functions known to be associated with the risk for falls. But since falls in those under age 65 are sparsely investigated, we believe that the results from this study may be beneficial. The instruments used may be a limitation, since all of the instruments are mainly tested and used on older adults. However, we believe the items used in the instruments, with the addition of the complementary items, capture functions known to be indicators for falls, despite the age of the study sample.

#### 5. Conclusion

The 10-week judo-inspired exercise program, Judo4Balance, performed in a workplace setting could be an effective intervention targeting strength, balance, fall-related self-efficacy, and falling techniques. This study shows improvements in both physical and psychological functions, which are important for both reducing the risk of falls and fall-related injuries among men and women. Furthermore, the participants' falling technique increased significantly, which is an important research finding and recommended for inclusion in further fall prevention research. The intervention was deemed to benefit both men and women equally; future research should explore judo-inspired exercises and falling techniques in larger trials, including comparisons with controls, irrespective of sex.

#### 6. Availability of data and materials

The Judo4Balance program is available upon request to the corresponding author.

#### 7. Author's contributions

MA wrote the first draft of the manuscript. KSB and MT formulated the research questions and contributed to drafting the manuscript. AE performed the statistical analysis in the manuscript. All authors have made a substantial contribution to the manuscript and have been involved in drafting the manuscript. All authors read and approved the final manuscript.

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#### Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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