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Multifactorial exercise and dance-based interventions are effective in reducing falls risk in community-dwelling older adults: A comparison study

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ABSTRACT

Background: Falls and injuries related to falls in older adults are a significant health care issue that affects the elderly population. Research suggests that exercise interventions can be effective in improving falls risk factors.
Research question: Are there differences in falls risk reduction between two exercise interventions (The Lebed Method - TLM and Stay Active and Independent for Life – SAIL) for community-dwelling older adults?
Methods: A quasi-experimental pre- and post-test design was used for this study. One hundred and sixty-three older individuals aged between 60–79 years of age participated in the study. Assessments of falls risk (using the physiological profile assessment), simple reaction time, bilateral knee extension strength, proprioception, balance, visual acuity, and mobility (using timed-up-and-go, TUG) were performed. Analysis of covariance was conducted to compare the differences between the two interventions. Pre-intervention assessments were used as the covariate.
Results: SAIL participants' falls risk were reduced more than TLM. Reaction and TUG times were faster for SAIL participants. However, those individuals who participated in TLM had greater knee extension strength for both legs compared to SAIL participants.
Significance: Overall, both interventions were effective in reducing falls risk for older adults. The greater number of improved falls risk factors attained with the SAIL program suggests that multifactorial interventions may be more effective at reducing falls risk. However, since TLM also showed better improved strength, both dance-based and multifactorial interventions can be effective at reducing falls risk factors for older adults.

Falls and injuries related to falls in older adults are a significant health care issue affecting the elderly. In the United States in 2014, 28.7% of surveyed older adults ages 65 or older reported experiencing at least one fall, totaling an estimated 29 million falls [1]. Falls account for two thirds of accidental deaths in adults over the age of 65 [2], and the Centers for Disease Control reported 2.8 million people, ages 65 or older, are treated annually for fall-related injuries, including head trauma and hip fractures [1,2]. The associated healthcare costs are an estimated $31 billion in the United States each year [3].

A significant number of intrinsic and extrinsic risk factors have been linked with falls [4]. These include polypharmacy, decreased mobility, declines in muscular strength, visual impairments, and loss of postural control [5,6]. While various risk factors have been identified, the most modifiable for older adults are muscular weakness, balance control, and walking ability [7]. Exercise interventions have been shown to increase strength and muscle mass [8], decrease cardiovascular stress [8], and improve reaction times [9]. These progressions lead to a general slowing of age-related disability development [10]. While there are numerous studies about benefits of exercise for reducing falls, the majority have been conducted in a controlled environment. Given barriers to participation in supervised exercise programs in controlled environments (e.g., travel, lack of variety, cost of memberships, and/or equipment), it is important to assess whether the specified interventions are successful when applied in community settings.

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The Lebed Method (TLM) [11] and Stay Active and Independent for Life (SAIL) [12] are two community-based interventions designed specifically to target risk factors which contribute to falls. An advantage of both programs is they are designed to be implemented in community settings, thereby allowing for assessment of a larger proportion of community-dwelling older adults. While both interventions target falls risk factors, there has been little direct research on the effectiveness of these interventions to reduce falls risk.

Dance-based therapies have been shown to be an effective and enjoyable form of exercise for older adults [11]. TLM is a dance-based therapy that employs low-impact dance and was developed for persons with lymphedema and physical limitations [11,13]. TLM has not had a statistically significant effect on general balance ability and mobility in older adults [11]; one reason may be that TLM does not include a specific strength component. It remains unclear whether TLM is challenging enough to elicit changes in a community-dwelling population. Previous research is limited as to whether TLM is effective for reducing falls risk, therefore, there is a need to further investigate the effectiveness.

SAIL is a multifactorial exercise program developed to reduce falls risk in older adults by targeting strength, balance, aerobic fitness, and flexibility [14]. Multifactorial interventions have been shown to decrease falls risk and increase balance confidence [15] of older adults and improve their ability to successfully complete activities of daily living. SAIL has improved strength and balance in older adults in the community setting [16] and incorporates components that specifically target falls risk factors; although research is still limited. The multicomponent approach of SAIL, when compared to TLM, may impact a greater number of fall risk factors. However, determining the most beneficial intervention can be challenging because interventions differ in methods, dose, and length. Consequently, it is of interest to compare the effects of SAIL and TLM on effectiveness of reducing falls risk.

The purpose of this study was to compare the effects of TLM and SAIL on falls risk in community-dwelling older adults. The impact of these two interventions was assessed using falls risk (Physiological Profile Assessment, PPA), knee extension strength, lower limb proprioception, simple reaction time (hand and foot), and functional mobility [i.e., timed up and go (TUG)]. It was hypothesized that SAIL would lead to larger decreases in falls risk as compared to TLM. Additionally, SAIL participants would exhibit greater increases in leg strength, faster reaction times, and decreased TUG times as compared to those participating in TLM.

1. Methods

1.1. Participants

A quasi-experimental pre- and post-test design was used for this study and was conducted over two years using convenience samples recruited from the community. During the first year, TLM was implemented at six sites; SAIL was implemented at eight sites during year two. Participants included in the study were community-dwelling adults aged 55 or older. Participants were excluded if they did not complete baseline and post-assessments, did not have mental capacity to properly complete assessments, had health issues that significantly affected assessments (i.e. peripheral neuropathy, significant Parkinson's disease), or were repeat participants in the intervention. SAIL participants who began the study were 70.7 ± 6.9 years, 1.64 ± 0.1 m, 78.9 ± 15.8 kg, and those who completed the intervention were 71.3 ± 7.0 years (1.64 ± .0.1 m, 79.3 ± 17.7 kg). TLM participants were 73.4 ± 7.7 years, 1.61 ± 0.1 m, 81.2 ± 20.1 kg at the start of the intervention, and 72.8 ± 7.6 years, 1.60 ± .0.1 m, 80.4 ± 20.5 kg at the conclusion. Fig. 1 depicts the study design.

Prior to the start of the program, research staff informed participants about the program, and all individuals signed an informed consent. All procedures complied with University Institutional Review Board guidelines. Prior to beginning the intervention, baseline assessments of each person's falls risk (PPA) [16], simple reaction time for hand (HRT) and foot (FRT), right and left leg extension strength (RLS and LLS), lower limb proprioception, visual acuity, balance, and TUG were performed. Normative data on these measures have been reported elsewhere [16,17]. Height, mass, and falls history (number of falls in past 12 months) were also assessed. Following the final exercise session, the same pre-exercise assessments were performed.

1.2. Assessments

1.2.1. Physiological profile assessment

Risk of falling was determined using short-form PPA which included PPA HRT, RLS, proprioception, balance, and visual acuity [17]. The PPA has been validated in prospective studies of falls in both community and institutional settings. Data from individual physiological assessments were used to determine an aggregate overall falls risk score. PPA scores range from –2 (very low falls risk – better outcome) to +4 (very marked falls risk – worse outcome) with higher values reflecting an increased risk of falling [16].

1.2.2. Reaction time

Participants responded as quickly as possible to a light stimulus by depressing a timing switch with either their finger or foot. For HRT, participants depressed a button on a modified mouse after the light illuminated. For FRT, participants pressed down on a foot pedal once the light illuminated. Each person completed 20 trials for hand and foot. The middle 10 HRT scores, beginning with trial six, were used for PPA.

1.2.3. Knee extension strength

Participants completed a series of isometric knee extension contractions with both limbs. Individuals were seated on a chair with a 63.5 cm seat height with their knees at 90°. An adjustable strap was positioned above the malleoli and attached to a strain gauge affixed to a crossbar between the back legs of the chair. Three maximum isometric contraction trials were performed with up to 2-min rest between trials. Peak force was measured in kg; the highest measurement was used and normalized to participant's mass.

1.2.4. Proprioception

Participants sat in a chair, closed their eyes, then raised both legs and attempted to match great toes to touch on either side of an acrylic sheet inscribed with a protractor. Five trials at varying heights, starting at the top of the sheet and moving incrementally lower, were performed. The difference in great toe placement was recorded in degrees.

1.2.5. Balance

Individuals stood in an upright stance on a 15 cm, medium-density foam surface. A swaymeter (a metal rod with a pen attached to the end), was secured to participants' waist using a belt. The swaymeter was positioned parallel to the floor and extended to a table behind individuals. Participants stood still on the foam pad while looking straight ahead for 30 s; the pen recorded participant's movement onto a piece of paper on the table. Participants were instructed on procedures prior to testing and were given assistance while stepping on and off the foam pad, if necessary. The range of sway in the medial-lateral and anterior-posterior directions were measured in millimeters (mm) and recorded.

1.2.6. Visual acuity

The Melbourne Edge Test (Edge) was used to assess edge contrast sensitivity. Participants were seated 50–60 cm from an angled desk and attempted to correctly identify the orientation of the edges of 20 circular patches containing edges of reducing contrast. The last circle identified, with the least contrast, was recorded in decibel units ($dB = -10\log_{10}$ contrast).

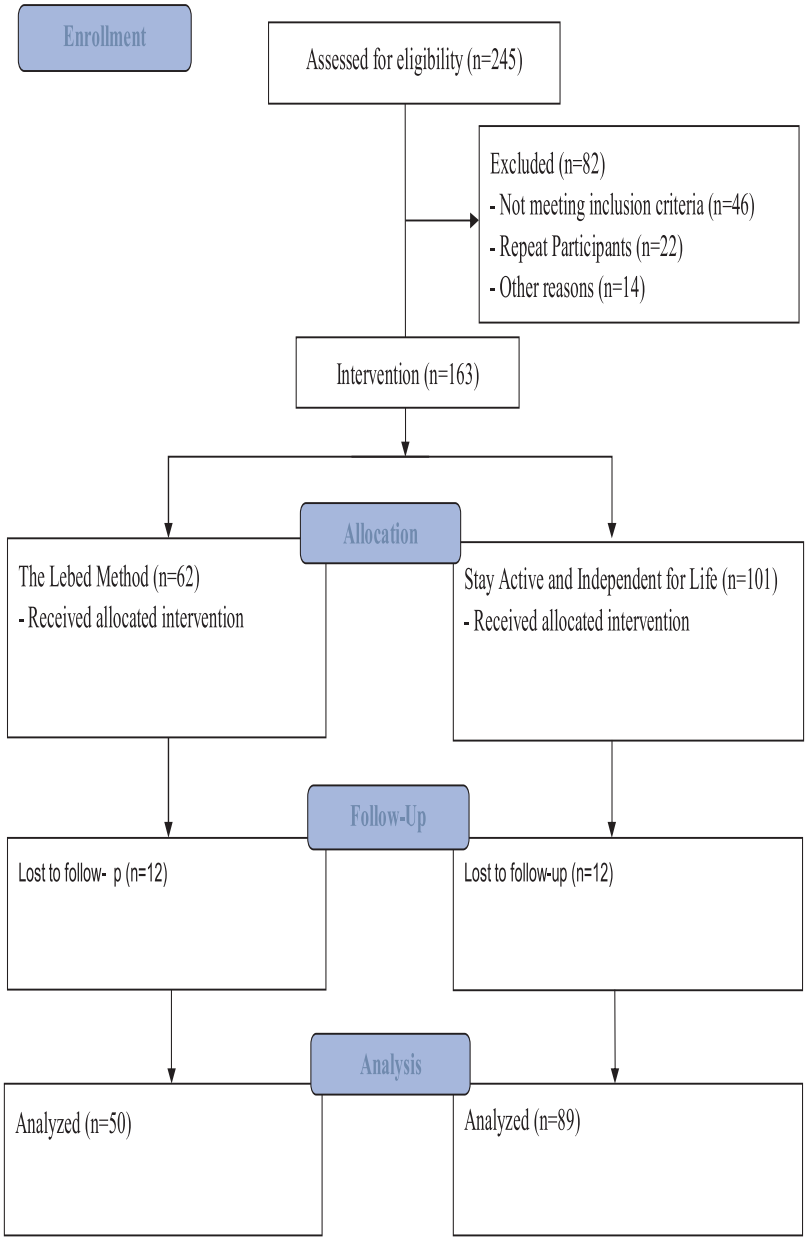

Fig. 1. CONSORT flow chart depicting the study design.

1.2.7. Timed up and go

TUG has been shown to be a valid measure for functional mobility and identifying frail members of the older adult population [18]. Reference values for TUG have been previously reported [19]. Participants began seated in a chair, stood up, walked a 3-meter distance around a cone, walked back to the chair, and sat down. Time was recorded (s). Three trials were completed.

1.3. Interventions

Qualified instructors completed a training course prior to delivery of exercise interventions. TLM instructors completed a two-day in-person training course, while SAIL training consisted of a 10-week online training course. Instructors were present for each class and for assessments. Both interventions were implemented in the community (e.g., senior centers, community fitness facilities, places of worship, etc.).

1.3.1. The Lebed Method

TLM was an eight-week intervention offered twice a week for one hour per session. Props such as pinwheels and canes were used to enhance the class. Within each class, the instructor demonstrated each exercise, completed exercises with the class, and provided verbal instructions, modifications, feedback, and encouragement.

Each session consisted of a 10-min lymphatic system warm up (breathing exercises, full body active range of motion exercises, and stretches) followed by six choreographed dance sequences. Dance sequences were comprised of low-impact ballet, jazz, and aerobic movements. Class concluded with a 10-min cooldown that incorporated progressive relaxation and stretching. A full description of the movements is described elsewhere [11].

1.3.2. Stay active and independent for life

SAIL was offered three times a week for one hour per session for 10 weeks. SAIL included a 3 to 5-min warm-up, 18–20-min aerobic component, 10-min balance and cool down, 15–18-min strength training, and 8–10-min stretch. During each class, the instructor demonstrated exercises, provided verbal instructions, modifications, feedback, and encouragement.

The warm-up consisted of full body movements followed by aerobic exercises. Static and dynamic balance exercises included weight shifts, change in base of support, and vestibular activities. Upper body strength exercises included bicep curls, triceps extensions, lateral arm raise, frontal arm raise, overhead press, and seated crunch. Lower body strength incorporated hamstring curl, knee extension, hip flexion, hip extension, lateral leg raise, calf raises. Three sets were completed, one set of 10 repetitions of each exercise for upper body, one set of 10 for lower body exercises, and one set of 10 of lower or upper body exercises, alternating between upper and lower body each class. Stretches addressed upper and lower body muscle groups.

Each participant used a chair with no armrests and had access to cuff weights ranging from one to five pounds. Weight could be increased throughout the program. Modifications were given for each exercise, so participants could modify the program to fit their needs. Further information about SAIL can be found in previous research [12,20].

1.4. Data analyses

Data analyses were conducted using R (R Core Team; Vienna, Austria) [21]. Case-wise diagnostics were performed to assess data normalcy. Descriptive statistics were conducted for all dependent measures by intervention (i.e., TLM and SAIL) and time (i.e., pre- and post-intervention). All dependent measures were normalized for the relative time of each intervention. For participants in TLM, dependent measures were normalized to 16 h of practice, whereas for SAIL, dependent measures were normalized to 30 h of practice. ANCOVA was conducted to compare the effectiveness of the two interventions whilst controlling for pre-intervention values; the normalized dependent measures were used for inferential statistical analysis. Levene's test and normality checks were carried out and assumptions met. Alpha level was set a priori at 0.05. Effect sizes were calculated using Cohen's *d*.

2. Results

2.1. Attrition and attendance

Sixty-two participated in TLM and 101 participated in SAIL. Each intervention lost 12 persons, yielding an attrition rate of 20% and 12% for TLM and SAIL, respectively. Reasons for dropout were not documented. Attendance was recorded throughout the intervention (TLM, 61 ± 28.9%; SAIL, 69 ± 23.5%). Descriptive statistics are presented in Table 1.

2.2. Intervention outcomes

Falls Risk: There was a statistically significant difference in falls risk between interventions ($F_{1,\ 120} = 16.121$, $p < 0.001$, $\eta 2 = .118$). At post-test, participants in SAIL had significantly lower falls risk than those in TLM when adjusted for pre-test values.

2.3. Reaction time

SAIL participants had a significantly lower FRT when compared to TLM counter-parts ($F_{1,\ 120} = 43.446$, $p < 0.001$, $\eta 2 = .266$) when adjusted for pre-test values. Similar statistical difference was attained for HRT; SAIL participants presented a significantly lower HRT than TLM counterparts ($F_{1,\ 120} = 31.554$, $p < 0.001$, $\eta 2 = .208$).

2.4. Lower limb strength

For LLS, TLM participants were significantly stronger than SAIL ($F_{1,\ 120} = 17.662$, $p < 0.001$, $\eta 2 = .129$). A similar finding was attained for RLS; TLM participants had significantly increased RLS when compared to SAIL ($F_{1,\ 120} = 17.969$, $p < 0.001$, $\eta 2 = .131$).

TUG: There was a statistically significant difference between interventions ($F_{1,\ 120} = 11.982$, $p = 0.001$, $\eta 2 = .091$). TUG times were significantly lower for SAIL participants when compared to TLM.

3. Discussion

This study was designed to compare the effects of two exercise interventions (i.e., SAIL and TLM) on falls risk and related risk factors for community-dwelling older adults. The results of our study partially supported our hypothesis; SAIL participants had lower risk of falls than TLM after normalizing for training hours and controlling for pre-intervention values. Additionally, SAIL displayed faster reaction and TUG times. Our findings indicate multifactorial exercise interventions can be effective at reducing falls risk and beneficial for older adults. Multifactorial exercise programs address modifiable risk factors associated with falls risk [22]. It is noteworthy that TLM participants demonstrated better strength outcomes compared to SAIL. However, while significant differences were observed, effect sizes were small. This suggests danced-based exercise may be similarly effective for reducing falls risk and improving measures related to stability (e.g., strength, balance). Despite the strength improvements noted for TLM, the results of this study suggest a multifactorial intervention may be more effective than a dance-based program at reducing falls risk in older adults.

SAIL demonstrated significantly better results in multiple outcomes when compared to TLM; particularly, falls risk scores were lower for SAIL. These findings are consistent with previous reports that found PPA improvements after exercise interventions, and significant differences between exercise and control groups [9,23]. Lord et al. (2005) implemented a multifactorial exercise program similar to SAIL, which targeted strength, balance, and flexibility [23]. SAIL also displayed faster FRT and HRT. Results from previous literature are conflicting. While some studies reported no significant differences after an aerobic exercise program [24], others found significant improvement subsequent to a multifactorial intervention [25]. Faster reaction times allow older adults to react more quickly to unexpected obstacles or tripping hazards, so they can prepare for a fall or avoid falling altogether [26]. The basis for any improvement in reaction time due to exercise is unclear; increases in cerebral perfusion and improved neural connectivity have been suggested as possible explanations [27]. Unexpectedly, TLM participants were stronger (leg strength) compared to SAIL. This may be due to the lower pre-intervention leg strength scores for the TLM group compared to SAIL; with TLM participants being weaker, it may have been easier to achieve initial strength increases. The basis for strength increases have been linked to increases in motor unit activation rather than muscle size [28]. A systematic review investigating effects of dancing on falls risk factors reported improvements in strength for two studies [29]. Age-related strength deficits is a modifiable risk factor for older adults; strength improvements are associated with decrease falls risk [5]. Previous research showed 10 weeks of resistance exercise improved force production in older adults, which was largely influence by neural adaptions, rather than muscle hypertrophy [30]. Overall, the positive outcomes noted on modifiable risk factors suggest SAIL and TLM can be beneficial for decreasing falls risk in older adults.

Functional mobility is imperative for older adults to successfully complete activities of daily living and maintain independence [8,9]. SAIL participants displayed improved functional mobility as demonstrated through faster TUG times. A study that employed a multifactorial intervention reported similar improvements in TUG [20]. The small effect size observed for TUG may be due to a floor effect. Further improvements in TUG may not be possible because participants' times were fast for their age. Post-intervention values were in the 60-to-69 year old range normative reference values [19], while our participant average age was above 70. SAIL participants were more mobile, which suggests SAIL may be more effective for mobility improvements.

Table 1
Descriptive statistics (mean and standard deviations (SD) of non-normalized and normalized values) of pre and post assessment data for both interventions (The Lebed Method, TLM) and Stay Active and Independent for Life, SAIL), and percentage change from pre to post test for the normalized data.

	TLM					SAIL				
	Pre		Post			Pre		Post		
	Mean	SD	Mean	SD	*% Change*	Mean	SD	Mean	SD	*% Change*
PPA										
Non-normalized values	1.3	0.9	1.2	1.0		0.7	1.0	0.4	0.9	
Normalized values	0.09	0.07	0.08	0.06	−31%	0.02	0.03	0.01	0.03	−130%
TUG										
Non-normalized values (s)	9.1	4.2	7.8	2.7		8.2	2.3	7.7	2.0	
Normalized values	0.52	0.17	0.51	0.17	0.1%	0.27	0.07	0.25	0.06	−5.1%
HRT										
Non-normalized values (ms)	301	70	288	66		259	60	252	41	
Normalized values	19.1	4.41	18.2	4.27	−3.3%	8.63	2.03	8.36	1.33	−0.3%
FRT										
Non-normalized values (ms)	362	85	347	65		314	67	298	41	
Normalized values	22.7	4.54	21.5	3.92	−3.9%	10.4	1.95	9.91	1.35	−2.3%
LLS										
Non-normalized values	0.18	0.09	0.27	0.10		0.24	0.09	0.28	0.09	
Normalized values	0.01	0.005	0.02	0.006	31%	0.01	0.003	0.01	0.003	19%
RLS										
Non-normalized values	0.18	0.09	0.26	0.11		0.24	0.09	0.28	0.10	
Normalized values	0.01	0.005	0.02	0.006	24%	0.01	0.003	0.01	0.003	41%

Notes. Abbreviations defined: PPA (Physiological Profile Assessment), TUG (Timed Up and Go) HRT (Hand Reaction Time), FRT (Foot Reaction Time), LLS (Left Leg Strength), RLS (Right Leg Strength). Non-normalized LLS and RLS are reported as ratio of the participants body mass. Negative values on PPA, TUG, HRT and FRT denotes an improvement in the outcome.

3.1. Study limitations

A convenience sample was used for a quasi-experimental study, which limits the generalizability of the impact of these interventions. We also noted heterogeneous differences in baseline measures between groups. While we observed significant differences, our effect sizes were small. Future research should consider increased duration to assess for a larger impact. Additionally, we did not monitor intensity, which should be considered in future research.

4. Conclusions

In conclusion, structured exercise programs can be beneficial for older adults in reducing risk of suffering a fall and maintaining ability to accomplish activities of daily living [8]. Our study demonstrated better overall falls risk, reaction time, and mobility outcomes for SAIL over TLM; however, TLM displayed greater leg strength. These outcomes highlight the benefits of both interventions for improving modifiable risk factors and decreasing falls risk. Exercise interventions have been shown to decrease reaction time [9], increase muscular strength [8], and decrease falls risk [20]. Previous literature suggests exercise programs should include multiple components to address falls risk factors [22]. SAIL targets multiple risk factors, and we observed better values for multiple assessments; this suggests multifactorial programs may be a more applicable community outreach program for older adults. TLM also showed outcomes improvements; therefore, it can also be an effective intervention. As both interventions were effective in improving falls risk factors, older adults should choose an enjoyable mode of exercise to help reduce the risk of falling.

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Conflict of interest

The authors report that they have no conflict of interest.

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