ONLINE FIRST

Effect of Music-Based Multitask Training on Gait, Balance, and Fall Risk in Elderly People

A Randomized Controlled Trial

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Background: Falls occur mainly while walking or performing concurrent tasks. We determined whether a music-based multitask exercise program improves gait and balance and reduces fall risk in elderly individuals.

Methods: We conducted a 12-month randomized controlled trial involving 134 community-dwelling individuals older than 65 years, who are at increased risk of falling. They were randomly assigned to an intervention group (n=66) or a delayed intervention control group scheduled to start the program 6 months later (n=68). The intervention was a 6-month multitask exercise program performed to the rhythm of piano music. Change in gait variability under dual-task condition from baseline to 6 months was the primary end point. Secondary outcomes included changes in balance, functional performances, and fall risk.

Results: At 6 months, there was a reduction in stride length variability (adjusted mean difference, −1.4%; $P<.002$) under dual-task condition in the intervention group, compared with the delayed intervention control group. Balance and functional tests improved compared with the control group. There were fewer falls in the intervention group (incidence rate ratio, 0.46; 95% confidence interval, 0.27-0.79) and a lower risk of falling (relative risk, 0.61; 95% confidence interval, 0.39-0.96). Similar changes occurred in the delayed intervention control group during the second 6-month period with intervention. The benefit of the intervention on gait variability persisted 6 months later.

Conclusion: In community-dwelling older people at increased risk of falling, a 6-month music-based multitask exercise program improved gait under dual-task condition, improved balance, and reduced both the rate of falls and the risk of falling.

Trial Registration: clinicaltrials.gov Identifier: NCT01107288

Arch Intern Med.
Published online November 22, 2010.
doi:10.1001/archinternmed.2010.446

FALLS ARE COMMON AND DEVastating among elderly people.[1-4] Each year, one-third of the population 65 years and older experiences at least 1 fall, and half of those fall repeatedly.[1,3-5] This problem will continue to grow as the number of older adults increases over the coming decades.[6] Thus, preventing falls in elderly individuals is a major concern. Measures to reduce falls are often of limited benefit.[7] Exercise can counteract key risk factors for falls, such as poor balance, and consequently reduce risk of falling in elderly community-dwelling individuals.[7,8]

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A large proportion of falls in elderly people occurs during walking.[9,10] Moreover, older adults are more likely to fall when performing concurrent tasks, such as walking while performing other motor or cognitive tasks.[11,12] Gait variability (ie, stride-to-stride fluctuations in walking), particularly during dual-task walking conditions, can objectively characterize gait impairment, with greater variability reflecting a more unstable gait pattern, that in turn leads to an increased risk of falling.[1,13-17] There is little information regarding effective measures to improve or even reverse age-related gait impairment under dual-task conditions in elderly people.

Jaques-Dalcroze eurhythmics is a music education through movement method developed by the composer Emile Jaques-Dalcroze (1865-1960) in Geneva, Switzerland, in the early 20th century. It is now practiced worldwide in the field of music, as well as dance, theater, and therapy. Practitioners are introduced to music's basic elements with special emphasis on musical rhythm and body movements through vari-

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ous multitask exercises performed to the rhythm of improvised piano music.[18] Recently, specific classes for older adults have been developed. The integrated motor and cognitive components are key features of this program, which involves a greater interest for dual- or multiple-task practice than other multicomponent attention-demanding exercise forms (eg, Tai Chi). In a cross-sectional study of older, long-term practitioners of Jaques-Dalcroze eurhythmics, age-related increase in stride-to-stride variability in a dual-task context appeared to be attenuated.[19]

We conducted a randomized controlled trial to determine whether a 6-month music-based multitask exercise program (ie, Jaques-Dalcroze eurhythmics) would improve gait and balance and reduce fall risk in community-dwelling older adults at high risk of falling. Change in gait variability under dual-task condition from baseline to 6 months was the primary end point. Secondary end points were to assess changes in other quantitative gait and balance measures, functional test performances, and falls and to determine through a 6-month postintervention follow-up whether the benefit due to the intervention could be maintained over time.

METHODS

STUDY DESIGN

In this 12-month monocenter, randomized controlled trial, subjects were randomly assigned to either a music-based multitask exercise program or a delayed intervention control group for 6 months (or 25 weeks). The primary end point was assessed at 6 months. During the second 6-month period, the delayed intervention control group participated in the intervention program, while the early intervention group returned to their usual habits (ie, no more intervention). Both groups were assessed at baseline and months 6 and 12. Enrollment began in February 2008, and the follow-up period ended in December 2009. The study was approved by Geneva University Hospitals ethics committee. All study participants provided written informed consent.

STUDY PARTICIPANTS

Participants were recruited in the local community through multiple strategies, including advertisements in local newspapers. The inclusion criteria were (1) adults 65 years or older, (2) living in the community, (3) without previous experience of Jaques-Dalcroze eurhythmics, except during childhood, and (4) at increased risk of falling. Participants were considered at risk of falls if they met at least 1 of the following criteria: (1) 1 or more self-reported falls after the age of 65 years, (2) balance impairment as assessed by a simplified Tinetti test with a score higher than 2 of 7,[3,20] and (3) 1 or 2 criteria of physical frailty.[21] Subjects were excluded if their medical history or physical examination revealed (1) a neurological disease associated with motor deficit or an orthopedic disease with a significant impact on gait and/or balance that would compromise outcomes assessment (2) or any other medical conditions that would limit participation (eg, terminal illness). Participants fully dependent on an assistive device were excluded.

RANDOMIZATION

Eligible subjects were randomized to either the intervention or the delayed intervention control group in a 1:1 ratio according to a computer-generated list prepared by an independent statistician, without stratification, using a permuted block randomization design. Allocation assignment was concealed from the enrolling assessors.

INTERVENTION

The intervention was a structured 1-hour weekly class exercise program led by an experienced instructor. It featured various multitask exercises, sometimes involving the handling of objects (eg, percussion instruments or balls), which became gradually more difficult over time.[22] Basic exercises consisted of walking in time to the music and responding to changes in the music's rhythmic patterns. Exercises involved a wide range of movements and challenged the balance control system mainly by requiring multidirectional weight shifting, walk-and-turn sequences, and exaggerated upper body movements when walking and standing.

Subjects in the delayed intervention control group were instructed to maintain their usual physical and social activities, as was the early intervention group after the program ended, ie, during the second 6-month period. Both groups were asked to avoid any new additional exercise programs during the course of the study. No instructions were provided to perform any specific exercise outside class time. Adherence to the Jaques-Dalcroze eurhythmics program was verified by weekly attendance records.

FOLLOW-UP VISITS

Participants were assessed by a trained multidisciplinary team blind to the participants' group allocations and to information from previous evaluations. Functional tests and instrumental gait and balance analysis were conducted using a standardized protocol, as detailed in the following subsection. Interviews collected sociodemographic characteristics, fall history, nutritional status,[23] physical activity level,[24] and neuropsychological status.[25-29] All participants also underwent a complete physical examination.

ASSESSMENT OF GAIT, BALANCE, AND FUNCTIONAL PERFORMANCE

Gait and balance were assessed using an electronic pressure sensitive walkway (GAITRite; CIR Systems Inc, Havertown, Pennsylvania) and angular velocity transducers (SwayStar; Balance International Innovations GmbH, Iseltwald, Switzerland), respectively. Gait parameters were collected according to the spatiotemporal gait analysis guidelines.[30] The subjects were asked to walk at their self-selected usual, slow, and fast speed as a single task. Then, they were asked to walk at a self-selected speed and to simultaneously count aloud backward by 1 starting from 50, as a dual task, without specific instruction to prioritize either task. Coefficient of variation (CV) was used as a measure of variability for stride time and stride length parameters (CV = [standard deviation/mean] × 100). The relative and absolute test-retest reliability of gait outcome measures was examined in a random sample of 30 study participants. Under the dual-task condition, intraclass correlation coefficients (2,1) for gait variability measures were all above 0.68. The standard error of measurement values were 1.59% and 0.99% for CV of stride time and stride length, respectively.

The SwayStar system consists of 2 angular velocity transducers worn on the lower trunk.[31] Each participant was tested for a 2-legged stance task for 20 seconds and a 1-legged stance task for 10 seconds with eyes open and for 1 dynamic task (ie, getting up from a chair, sitting down, standing up again, and remaining standing).[32] Four outcome variables were calculated for each task, in addition to task duration, ie, 90% range of both trunk angular displacement and angular velocity, in me-

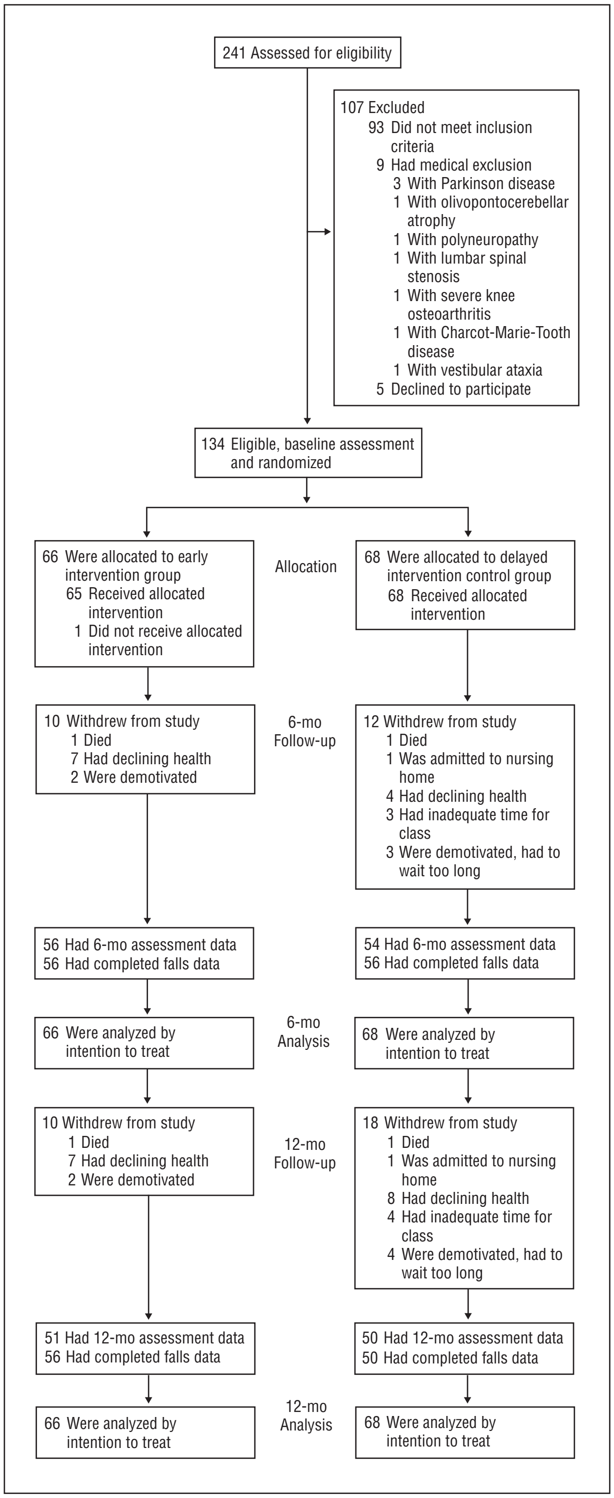

Figure 1. Flowchart for enrollment, randomization, and follow-up of study participants.

diolateral and anteroposterior directions.[33] For functional tests, each participant underwent Timed Up & Go[34,35] and simplified Tinetti tests.[3,20,36]

ASSESSMENT OF FALLS

Falls were defined as "unintentionally coming to rest on ground, floor, or other lower level."[37] Falls were prospectively monitored for 12 months and recorded daily using a diary mailed monthly to the study coordinator.[37] Participants who failed to return the diary or provided incomplete data were contacted by telephone.

SAMPLE SIZE CALCULATION

The sample size was determined using data from a previous study.[19] Ninety-six participants (ie, 48 in each group) were needed for a statistical power of 90% to detect a difference between groups at a 2-sided significance level of 5% on the primary outcome gait variability in dual-task condition, assuming that gait variability in this population was 4%. This allowed us to detect a difference of 1% in gait variability between the intervention and the control groups at completion of the first 6-month intervention. With 10% mortality and 20% dropout rates, a sample size of 130 participants was targeted.

STATISTICAL ANALYSIS

All analyses were based on intention-to-treat, with the last value carried forward for missing values. The χ^2 test, *t* test, or Wilcoxon rank sum test were used, as appropriate, to compare baseline characteristics. Changes from baseline to 6 months were summarized as means and standard deviations. Estimates of between-group mean differences, adjusted for baseline values, were computed, together with 95% confidence intervals (CIs). Analyses of covariance were performed to examine differences in changes across groups, with baseline value as covariate. Because gait velocity may represent a potential confounder when evaluating gait variability,[38] additional analyses with adjustments for changes in gait velocity were performed for all variability measures. Data were also analyzed at a normalized velocity of 100 cm/s (ie, within the individual range of velocities and close to the mean usual gait velocity) using an interpolation procedure, pooling the 3 walking conditions under a single task (ie, self-selected slow, usual, and fast speeds), as described elsewhere.[39,40] Six- to 12-month changes were summarized as means and standard deviations. Crossover analyses were performed using a specific Stata procedure (command pkcross) that enables analysis of crossover experiments and provides significance values for sequence, period, intervention, and carryover effects. The data were reanalyzed (1) without adjustment for baseline covariates, (2) using per-protocol analysis of study completers without imputation, and (3) using linear mixed-effects regression models (with Stata "xtmixed" command) to predict the primary end point, with visit, intervention, and visit by intervention interaction as exploratory variables.

For fall outcomes, log-binomial regression models were used to calculate relative risks comparing both the number of subjects with 1 or more falls and subjects with multiple falls (≥2 falls during the study period) in both groups. The incidence rate ratio for the number of falls was analyzed using a negative binomial regression model. In addition, survival analyses were conducted: hazard ratios were estimated from a Cox proportional hazards model for the first fall, and its extension, the Andersen-Gill model,[41] for all falls. In these models, subjects who did not achieve expected follow-up were censored at the time of last follow-up.

All statistical significance tests were 2-sided, and $P < .05$ was considered statistically significant. Analyses were performed using Stata software version 11.0 (StataCorp, College Station, Texas).

RESULTS

As shown in the flowchart (**Figure 1**), 241 individuals were screened and 134 (56%) enrolled. Of these, 22 (16%) and 28 (21%) dropped out of the study at 6 and 12 months, respectively. There was no difference between groups in the number of participants with incomplete follow-up. Mean attendance rate at the exercise program was 78% and did not vary by group. The attendance rate of the participants completing the intervention was 83%, 77% of whom attended at least 20 classes (ie, 80% of the classes). The main reasons for not attending classes included health problems, family constraints, or difficulties related to travel. No major adverse events occurred during the study, and there were no adverse effects, such as falls, cardiovascular events, or any injury during or following the exercise classes.

The mean (SD) age of the participants was 75.5 (6.9) years, and 96% were women (**Table 1**). Baseline characteristics were identical in both groups, except for height ($P = .04$), with no differences in study outcomes (**Table 2** and **Table 3**). Participants in both groups displayed similar baseline fall history profiles in the year before the study. Completers and dropouts did not differ significantly on baseline characteristics.

Under the single-task condition, intervention group subjects increased their usual gait velocity (adjusted mean difference [AMD], 4.7 cm/s; 95% CI, 0.5 to 8.8; $P = .03$), and their stride length (AMD, 3 cm; 95% CI, 0.5 to 5.6; $P = .02$) compared with the delayed intervention control group (Table 2). In the intervention group, the stride time variability improved (AMD, −0.4%; 95% CI, −0.7 to −0.1; $P = .01$). When normalized for a gait velocity of 100 cm/s (see the “Methods” section), the change in gait variability was no longer significant. Under the dual-task condition, intervention group subjects increased their stride length (AMD, 3.1 cm; 95% CI, 0.1 to 6.1; $P = .04$) and decreased their stride length variability (AMD, −1.4%; 95% CI, −2.3 to −0.6; $P < .002$) (**Figure 2**) compared with controls. Adjustments for gait velocity changes did not influence gait variability modifications. Other statistical approaches (ie, without adjustment, per-protocol analysis as well as mixed-effects regression model) provided similar results in both magnitude and direction for the primary end point.

By comparison with the delayed intervention controls, the intervention group improved stance time for the 1-legged stance task (AMD, 0.9 s; 95% CI, 0.3 to 1.6; $P = .006$) (Table 3) and decreased mediolateral angular velocity (AMD, −4.6 degrees/s; 95% CI, −8.6 to −0.6; $P = .02$). In the Tinetti and Timed Up & Go tests, the intervention group did better than the controls (Table 3).

Compared with the control group, the intervention group experienced fewer falls during the first 6-month period: the unadjusted incidence rate ratio for falls was 0.46 (95% CI, 0.27 to 0.79; $P = .005$) and remained similar when adjusted for age, falls history over the previous 12 months, Tinetti test performance, and the number of frailty criteria (according to Fried et al[21]) met (**Table 4**). The number of subjects with 1 or more falls was also statistically different between both groups (relative risk, 0.61; 95% CI, 0.39 to 0.96; $P = .03$) with a number needed to treat of 5 (95% CI, 2.1 to 34.4). The relative risk for multiple falls was 0.19 (95% CI, 0.06 to 0.63; $P = .007$). Using a Cox proportional hazards model, we found that the unadjusted hazard ratio for the time to first fall was 0.53 (95% CI, 0.30 to 0.94; $P = .03$) in the intervention group compared with

Table 1. Baseline Characteristics of Participants

Characteristic	Early Intervention (n=66)	Delayed Intervention (n=68)
Age, mean (SD), y	75 (8)	76 (6)
Sex, No. (%)		
Male	2 (3)	3 (4)
Female	64 (97)	65 (96)
Marital status, No. (%)		
Married	16 (24)	21 (31)
Other	50 (76)	47 (69)
Home help services, No. (%)	21 (32)	19 (28)
Educational level, No. (%)		
Primary school	7 (11)	13 (19)
Middle school	45 (68)	45 (66)
High school	14 (21)	10 (15)
Height, mean (SD), cm	161 (6)	158 (7)[a]
Body weight, mean (SD), kg	67 (11)	67 (11)
BMI, mean (SD)	26 (4)	27 (4)
History of falls, No. (%)	60 (91)	58 (85)
Fall(s) in the past 12 mo, No. (%)	37 (56)	37 (54)
Frailty components, No. (%)[b]		
Unintentional weight loss	10 (15)	5 (7)
Exhaustion	20 (30)	15 (22)
Low physical activity level	0	1 (1)
Slow walking speed	10 (15)	9 (13)
Grip strength	27 (41)	33 (49)
Physical activity level, mean (SD), kcal/wk	2336 (1036)	2714 (1370)
SF-12, mean (SD), score		
Physical health component	44 (9)	47 (8)
Mental health component	45 (12)	47 (9)
MNA short-form, mean (SD), score	12 (2)	13 (1)
≤11, No. (%)	14 (21)	7 (10)
HADS anxiety subscale, mean (SD), score	7 (4)	7 (3)
≥8, No. (%)	25 (38)	32 (47)
HADS depression subscale, mean (SD), score	4 (3)	4 (3)
≥8, No. (%)	11 (17)	5 (7)
MMSE, mean (SD), score	26 (3)	26 (3)
<24, No. (%)	14 (21)	11 (16)
Clock-drawing test, mean (SD), score	9 (0)	9 (2)
<8, No. (%)	9 (14)	12 (18)
FAB, mean (SD), score	16 (2)	15 (2)
<16, No. (%)	27 (41)	28 (41)
Self-rated health status, mean (SD)[c]	3 (1)	3 (1)
Total No. of medications, mean (SD)	4 (2)	3 (2)
Current use of psychotropic medication, No. (%)	18 (27)	13 (19)
Medical condition, No. (%)		
Trouble with vision	14 (21)	10 (15)
Dizziness or balance disorder	8 (12)	8 (12)
Arthritis of the lower limb	7 (11)	12 (18)
Central nervous system disorder	6 (9)	4 (6)
Peripheral nervous system disorder	7 (11)	5 (7)
Rhythm disorder	5 (8)	1 (1)
Prosthesis (lower limb)	7 (11)	8 (12)
Tendon rupture (lower limb)	1 (2)	1 (1)
Osteoporosis	23 (35)	28 (41)
Charlson comorbidity index, mean (SD), score[d]	1 (1)	1 (1)

Abbreviations: BMI, body mass index (calculated as weight in kilograms divided by height in meters squared); FAB, Frontal Assessment Battery; HADS, Hospital Anxiety and Depression Scale; MMSE, Mini-Mental State Examination; MNA, Mini-Nutritional Assessment; SF-12, 12-item Short-Form Health Survey.
[a] Significant difference between groups ($P < .05$).
[b] According to Fried et al.[21]
[c] Five-point Likert scale from 1 (excellent) to 5 (bad).
[d] According to Charlson et al.[42]

Table 2. Change in Gait Outcome Measures by Groups

Outcomes	Mean (SD): Baseline, Early Intervention (n=66)	Mean (SD): Baseline, Delayed Intervention (n=68)	Mean (SD): Changes at 6 mo[a], Early Intervention (n=66)	Mean (SD): Changes at 6 mo[a], Delayed Intervention (n=68)	Adjusted Between-Group Mean Difference (95% CI)	*P* Value[c]	Mean (SD): Changes at 12 mo[b], Early Intervention (n=66)	Mean (SD): Changes at 12 mo[b], Delayed Intervention (n=68)	Effect,[d] *P* Value: Sequence	Effect,[d] *P* Value: Inter-vention	Effect,[d] *P* Value: Carry-over	Effect,[d] *P* Value: Period
Single-Task Condition												
Gait speed												
Gait velocity, cm/s	104.2 (19.0)	102.4 (18.8)	5.5 (12.8)	1.2 (12.7)	4.7 (0.5 to 8.8)	.03	−2.5 (10.9)	2.1 (12.7)	. . .	. . .	. . .	. . .
Stride length, cm	115.6 (15.4)	113.6 (16.0)	3.0 (8.0)	0.2 (7.0)	3.0 (0.5 to 5.6)	.02	−1.6 (7.0)	1.3 (7.2)	. . .	<.05	. . .	. . .
Cadence, steps/min	108.1 (10.6)	108.2 (9.5)	2.9 (7.3)	1.3 (7.9)	1.7 (−0.8 to 4.1)	.18	−1.1 (6.8)	0.9 (6.9)	. . .	. . .	. . .	. . .
Dynamic balance												
Double support phase, %	23.8 (3.4)	23.8 (3.5)	−0.7 (2.2)	−0.2 (2.5)	−0.5 (−1.3 to 0.2)	.18	−0.9 (2.3)	−0.8 (2.6)	. . .	. . .	. . .	. . .
Support base, cm	8.4 (3.1)	8.3 (3.2)	−0.4 (3.9)	0.3 (1.6)	−0.7 (−1.7 to 0.3)	.14	0.4 (3.8)	0.0 (1.5)	. . .	. . .	. . .	. . .
Gait variability												
Stride time variability, %CV	2.3 (1.0)	2.6 (1.1)	−0.2 (1.1)	0.0 (1.1)	−0.4 (−0.7 to −0.1)	.01	0.4 (1.3)	0.0 (1.4)	. . .	. . .	. . .	. . .
Stride length variability, %CV	2.9 (1.1)	2.8 (1.0)	−0.3 (1.2)	0.2 (1.7)	−0.4 (−0.9 to 0.0)	.07	0.4 (1.2)	−0.1 (1.7)	. . .	< .05	. . .	. . .
Dual-Task Condition[e]												
Gait speed												
Gait velocity, cm/s	83.8 (23.0)	84.7 (23.0)	7.1 (17.2)	3.6 (14.3)	3.3 (−1.6 to 8.1)	.19	−2.7 (11.8)	3.0 (16.2)	. . .	. . .	. . .	. . .
Stride length, cm	109.2 (17.1)	107.7 (17.6)	4.2 (10.5)	1.3 (7.4)	3.1 (0.1 to 6.1)	.04	−1.7 (7.3)	1.6 (8.0)	. . .	. . .	. . .	. . .
Cadence, steps/min	91.5 (16.3)	93.9 (16.5)	4.5 (13.4)	3.0 (11.7)	0.3 (−3.1 to 3.8)	.84	−1.6 (9.3)	2.0 (11.9)	. . .	. . .	. . .	. . .
Dynamic balance												
Double support phase, %	25.9 (7.2)	25.3 (4.5)	−1.5 (6.2)	−0.5 (4.3)	−0.9 (−2.4 to 0.6)	.25	−1.1 (3.1)	−1.2 (3.7)	. . .	. . .	. . .	. . .
Support base, cm	8.8 (3.9)	8.6 (3.4)	−0.1 (2.3)	0.1 (1.8)	−0.1 (−0.8 to 0.5)	.68	0.0 (2.4)	0.0 (1.8)	. . .	. . .	. . .	. . .
Gait variability												
Stride time variability, %CV	5.3 (6.3)	5.1 (6.0)	−1.8 (6.1)	−0.3 (6.6)	−1.6 (−3.5 to 0.4)	.11	0.2 (2.2)	−0.4 (4.7)	. . .	. . .	. . .	. . .
Stride length variability, %CV	4.8 (3.9)	4.2 (3.1)	−1.6 (3.9)	0.2 (1.6)	−1.4 (−2.3 to −0.6)	<.002	0.4 (1.3)	−0.9 (1.9)	. . .	<.001	<.01	. . .

Abbreviations: CI, confidence interval; CV, coefficient of variation.
[a] Changes were calculated as 6-month follow-up minus baseline.
[b] Changes were calculated as 12-month follow-up minus 6-month follow-up.
[c] Analyses of covariance on change in measures with the baseline value as covariate.
[d] Crossover analysis of variance on change in measures using a specific procedure dealing with the analysis of crossover experiments, which provides significance values for respectively sequence, period, intervention, and carryover effects. Ellipses represent nonsignificant values.
[e] One subject under the dual-task condition had to be excluded from the analysis due to technical failure of GAITRite; CIR Systems Inc, Havertown, Pennsylvania.

the control group. This remained significant after adjustment for baseline covariates. When comparing the 2 groups using an Andersen-Gill model, the unadjusted hazard ratio of 0.46 (95% CI, 0.27 to 0.78; $P = .004$) remained significant after multiple adjustment.

Using a crossover analysis of variance, we found significant carryover effects for some outcomes, indicating that several changes in the early intervention group had been maintained at 12-month follow-up (Table 2 and Table 3). The improvement in gait variability under dual-task condition was retained 6 months after the intervention had ended, as were improvements in 1-legged stance duration and in Tinetti performance. At the 12-month follow-up, when both groups had taken part in the intervention program, the crossover analysis revealed improvements in stride length and stride length variability under the single-task condition and stride length variability under the dual-task condition, as well as in 1-legged stance duration and Tinetti test performance.

Between 6 and 12 months, 56 participants in each group were followed up for falls. Sixteen subjects (29%) in the early intervention group had at least 1 fall and 4 (7%) had fallen repeatedly, with 20 reported falls. The incidence of falls, proportion of subjects with 1 or more falls and those with multiple falls in this group did not differ between the intervention and the follow-up period ($P = .63$, $P = .64$, and $P = .71$, respectively). During the same period, while the intervention was dispensed, 19 subjects (34%) of the former delayed intervention group had at least 1 fall, of whom 6 (11%) had fallen repeatedly, with 28 reported falls. The incidence of falls was significantly reduced during this period of intervention compared with the first 6 months ($P = .02$), as was the proportion of participants with multiple falls ($P = .01$). The reduction in the proportion of subjects with 1 or more falls failed to reach significance ($P = .06$).

COMMENT

To our knowledge, this is the first evidence of a reversibility in age-dependent increase of gait variability under cognitive-motor dual-task condition in older adults. Indeed, dual-task gait performance improved in the music-based multitask exercise program group, with reduction in stride length variability, regardless of gait velocity modification. All statistical analyses showed similar results, which confirm the robustness of our findings. Few studies to date have demonstrated an improvement of dual-task gait performance with training, including studies in patients with stroke, Parkinson disease, or dementia or in older adults, but most of their sample sizes were small.[43-47] Our study also indicates that gait variability may be improved under a single-task condition, as was pre-

Table 3. Change in Balance and Functional Outcomes

	Mean (SD)						Mean (SD)					
	Baseline		Changes at 6 mo[a]				Changes at 12 mo[b]		Effect,[d] *P* Value			
Outcomes	Early Intervention (n=66)	Delayed Intervention (n=68)	Early Intervention (n=66)	Delayed Intervention (n=68)	Adjusted Between-Group Mean Difference (95% CI)	*P* Value[c]	Early Intervention (n=66)	Delayed Intervention (n=68)	Sequence	Inter-vention	Carry-over	Period
One-legged stance task												
Displacement M-L, degrees	4.0 (2.9)	5.1 (3.4)	0.2 (2.9)	0.5 (3.1)	−0.6 (−1.6 to 0.3)	.20	−0.1 (3.0)	−0.8 (3.5)	. . .	. . .	. . .	. . .
Angular velocity M-L, degrees/s	14.6 (13.2)	16.6 (11.9)	−1.6 (12.7)	1.4 (14.5)	−4.6 (−8.6 to −0.6)	.02	−1.2 (8.2)	−3.7 (12.7)	. . .	. . .	. . .	. . .
Displacement A-P, degrees	3.6 (2.3)	4.1 (2.3)	0.6 (2.5)	0.9 (3.1)	−0.5 (−1.4 to 0.5)	.33	0.0 (2.1)	−0.6 (3.1)	. . .	. . .	. . .	<.01
Angular velocity A-P, degrees/s	10.8 (7.0)	12.4 (5.9)	1.2 (7.7)	3.2 (15.7)	−2.9 (−7.2 to 1.4)	.19	0.2 (9.3)	−3.1 (15.6)	. . .	. . .	. . .	<.01
Duration, s	7.3 (3.4)	7.4 (3.1)	0.9 (2.3)	−0.1 (1.7)	0.9 (0.3 to 1.6)	.006	−0.3 (1.4)	0.4 (2.2)	. . .	<.01	<.05	. . .
Two-legged stance task												
Displacement M-L, degrees	0.4 (0.3)	0.3 (0.2)	0.04 (0.3)	0.05 (0.2)	0.00 (−0.1 to 0.1)	.90	0.0 (0.3)	0.0 (0.2)	. . .	. . .	. . .	. . .
Angular velocity M-L, degrees/s	0.6 (0.3)	0.6 (0.3)	0.01 (0.3)	0.02 (0.2)	0.00 (−0.1 to 0.1)	.93	0.0 (0.3)	0.0 (0.2)	. . .	. . .	. . .	. . .
Displacement A-P, degrees	1.3 (0.6)	1.2 (0.5)	0.01 (0.6)	0.00 (0.5)	−0.01 (−0.2 to 0.2)	.94	0.1 (0.7)	0.1 (0.5)	. . .	. . .	. . .	. . .
Angular velocity A-P, degrees/s	1.7 (0.6)	1.7 (0.7)	0.02 (0.7)	0.02 (0.4)	0.00 (−0.2 to 0.2)	.99	0.0 (0.8)	0.1 (0.4)	. . .	. . .	. . .	. . .
Dynamic task												
Displacement M-L, degrees	4.1 (1.9)	4.1 (2.3)	−0.1 (1.7)	−0.01 (1.8)	−0.1 (−0.7 to 0.5)	.71	0.1 (1.5)	−0.2 (2.4)	. . .	. . .	. . .	. . .
Angular velocity M-L, degrees/s	9.1 (3.8)	9.4 (4.1)	−0.1 (2.7)	−0.9 (2.8)	0.7 (−0.2 to 1.5)	.11	0.0 (3.0)	0.0 (3.3)	. . .	. . .	. . .	. . .
Displacement A-P, degrees	30.6 (7.3)	29.2 (9.1)	−3.0 (6.1)	−2.4 (5.5)	0.0 (−1.8 to 1.9)	.97	0.6 (4.9)	−0.5 (5.3)	. . .	. . .	. . .	<.01
Angular velocity A-P, degrees/s	79.3 (16.4)	77.4 (21.8)	−4.6 (18.7)	−5.5 (13.1)	2.0 (−3.1 to 7.2)	.43	−4.8 (15.1)	−5.2 (14.6)	. . .	. . .	. . .	<.01
Functional tests												
Timed Up & Go test, s	10.4 (2.8)	10.8 (2.7)	−0.5 (1.6)	−0.2 (1.2)	−0.5 (−0.9 to −0.1)	.02	0.1 (1.2)	−0.3 (1.5)	. . .	. . .	. . .	. . .
Simplified Tinetti test, score	1.2 (1.3)	1.1 (1.3)	−0.6 (0.8)	−0.03 (0.6)	−0.6 (−0.8 to −0.3)	<.001	0.2 (0.6)	−0.2 (0.6)	. . .	<.001	<.001	<.01

Abbreviations: CI, confidence interval; A-P, body sway in anteroposterior direction; M-L, body sway in mediolateral direction.
[a] Changes were calculated as 6-month follow-up minus baseline.
[b] Changes were calculated as 12-month follow-up minus 6-month follow-up.
[c] Analyses of covariance on change in measures with the baseline value as covariate.
[d] Crossover analysis of variance on change in measures using a specific procedure dealing with the analysis of crossover experiments, which provides significance values for respectively sequence, period, intervention, and carryover effects. Ellipses represent nonsignificant values.

viously suggested in older adults, in particular after training or pharmacological interventions.[48-52] The same finding was also recently reported in healthy older adults after 6 weeks of intense balance training.[53]

We can only speculate on the factors responsible for the detected improvements in dual-task gait variability: they could be related to more automated tasks, to task coordination skills development, or to both.[46,54] The intervention effect under other dual-task conditions (eg, motor interference tasks) needs to be further explored. Also, the intervention may involve increased gait performance by improving attention and executive function.[55-58] An association between gait variability and executive function, particularly during dual tasking, has been reported in elderly fallers (those with ≥1 fall).[59] Further work is needed to fully assess the impact of this program on cognitive performances, using a comprehensive neuropsychological battery for executive functions.

The current findings extend the existing knowledge of the efficacy of physical exercise interventions to improve gait, balance, and functional capacity in elderly people.[8,60] The improvement observed in gait velocity is consistent with a meta-analysis that reported a success rate of 57% after exercise training to improve usual gait speed.[60] This finding may have an important practical im-

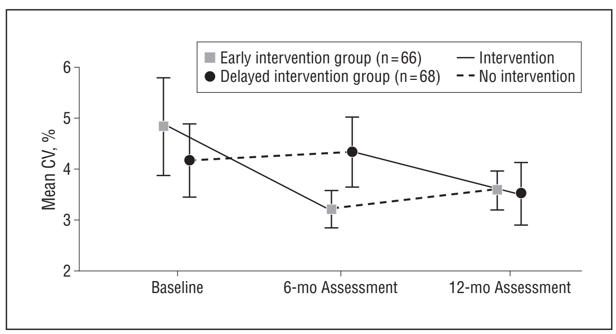

Figure 2. Stride length variability under the dual-task condition for both groups. Values represent means using last observation carried forward. Error bars represent 95% confidence intervals.

plication for older adults, since a low gait speed was found to be a consistent risk factor for disability, institutionalization, and mortality.[61] An increase in self-confidence may explain these findings.[62] An improvement of balance in 1-legged stance is also consistent with previous reports of improved 1-legged stance time following a wide range of exercise programs.[63] These changes were also accompanied by small but significant gains in functional performances. Modifications in the Tinetti score after the intervention were mainly due to an improve-

Table 4. Falls at the 6-Month Follow-up

Outcomes	Early Intervention (n=66)	Delayed Intervention (n=68)	Unadjusted	Adjusted[a]	Method
Falls, rate[b]	24 (0.7)	54 (1.6)			
IRR (95% CI)			0.46 (0.27-0.79)[d]	0.49 (0.27-0.91)[c]	Negative binomial regression model
Participants with ≥1 fall, No. (%)	19 (28.8)	32 (47.1)			
RR (95% CI)			0.61 (0.39-0.96)[c]	0.69 (0.44-1.07)	Log-binomial regression model
Participants with multiple (≥2) falls, No. (%)	3 (4.6)	16 (23.5)			
RR (95% CI)			0.19 (0.06-0.63)[d]	0.21 (0.06-0.67)[d]	Log-binomial regression model
Survival analysis					
HR (95% CI)			0.53 (0.30-0.94)[c]	0.55 (0.31-0.99)[c]	Cox proportional hazards model
HR (95% CI)			0.46 (0.27-0.78)[d]	0.46 (0.27-0.79)[d]	Andersen-Gill model

Abbreviations: CI, confidence interval; HR, hazard ratio; IRR, incidence rate ratio; RR, relative risk.
[a] Adjusted for age, history of falls over the previous 12 months, simplified Tinetti test performance, and total number of frailty criteria (according to Fried et al[21]) met.
[b] Fall rates per person per year.
[c] $P < .05$.
[d] $P < .01$.

ment in the performance of the 1-legged stance task. Unexpectedly, there were no differences in sway parameters in the 2-legged stance task and the dynamic task of sitting to standing. The latter task mainly requires greater lower extremity strength, which was only a small training component of the program.

Although the study was not powered to detect between-group differences in falls, a reduction in the incidence of falls, and in the risk of falling was found. While comparisons between trials are difficult when there are differences in study design, core components of the interventions, population targeted, intervention duration, or assessments of falls, the 54% reduction in falls observed in our study compares favorably with the rates observed in the most effective exercise-based interventions reported so far, with a meta-analysis demonstrating an overall fall reduction of 37% for Tai Chi interventions.[7,8] Our results are in agreement with another meta-analysis, which showed that interventions involving a large balance component are the most effective for preventing falls among older people.[8] The fall risk reduction in our trial may have been related to the multimodal nature of the intervention and to improvements in major risk factors for falls, such as gait variability.[1,13,17,64]

Jaques-Dalcroze eurhythmics seems to be able to change patterns of physical activity in elderly people by providing a strong motivation for the initiation and maintenance of exercise behavior, especially in women (96% of the participants in this trial) who are often less physically active than men.[65,66] The adherence to the intervention program was high (78%), compared with the mean rate of 63% reported in a review that examined exercise adherence in elderly people,[67] possibly in relation to the music component, which has been shown to facilitate exercise adherence in older adults.[68] Fifty-six percent of participants have registered in new fee paying sessions after the study.

Our study had some limitations. First, the nature of the intervention precluded blinding participants, which may have resulted in reporting bias. Second, the results should be interpreted in light of the eligibility criteria and with regard to the gender imbalance in the study population. The overwhelming predominance of women recruited may be partly explained by demographic factors (ie, in Switzerland, women 65 years and older outnumber men by approximately 1.35 to 1) and movement to music activities being more attractive for women. In addition, the participants who enrolled in this trial probably had a greater interest in health issues than the general population of elderly people. This might have resulted in the inadvertent selection of more motivated individuals. Third, there was no attention control group. Fourth, the number of withdrawals could be a limitation, but it was taken into account in the power calculation. Finally, there was only 1 class instructor and the outcomes achieved took place at 1 center. Therefore, further studies are needed to confirm the generalization potential of this program.

In conclusion, this randomized controlled trial is the first, to our knowledge, to show that participation in music-based multitask exercise classes once a week over a 6-month period can improve gait performance under single and cognitive-motor, dual-task conditions, as well as improve balance, and reduce both the rate of falls and the risk of falling in at-risk elderly community-dwelling adults. Our findings suggest that this program may be useful for fall prevention and rehabilitation in community-based settings such as senior centers.

Accepted for Publication: September 17, 2010.
Published Online: November 22, 2010. doi:10.1001/archinternmed.2010.446
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Author Contributions: Dr Trombetti had full access to the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.
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Study concept and design: Trombetti, Hermann, Kressig, Ferrari, and Rizzoli. *Acquisition of data:* Trombetti and Hars. *Analysis and interpretation of data:* Trombetti, Hars, Hermann, Kressig, Ferrari, and Rizzoli. *Drafting of the manuscript:* Trombetti and Hars. *Critical revision of the manuscript for important intellectual content:* Hermann, Kressig, Ferrari, and Rizzoli. *Statistical analysis:* Trombetti, Hars, and Hermann. *Administrative, technical, and material support:* Hermann and Kressig. *Study supervision:* Trombetti, Ferrari, and Rizzoli.
Financial Disclosure: None reported.
Funding/Support: This study was funded by the following organizations and foundations: Loterie Romande Geneva, Carigest SA, Gertrude Hirzel Foundation, Leenaards Foundation, Oltramare Foundation, Eagle Foundation, Foundation for Geneva (Georges Junod Fund), Delta réseau de soins Geneva, Helsana.
Role of the Sponsors: The funding sources had no role in the design and conduct of the study; in the collection, management, analysis, and interpretation of the data; or in the preparation, review, or approval of the manuscript.
Additional Contributions: We thank the staff of the Jaques-Dalcroze Institute of Geneva for their contribution, input and support. We are grateful to other members of the project team for their invaluable assistance with this trial and to all the participants. Olivier Beauchet, MD, PhD (University Hospital of Angers, France), and Stéphane Armand, PhD (University Hospitals of Geneva, Switzerland), revised the study protocol; Anne Winkelmann assisted in project coordination; and Ruth Giannada conducted the classes. Praveen Bhalla and Roswitha Rehm provided a careful reading of the manuscript. We appreciate the technical assistance provided by the city of Grand-Saconnex (Geneva), Petit-Saconnex nursing home (Geneva), Association de défense et de détente des retraités (AVIVO) (Geneva), Université du Troisième Âge (Geneva), and Innovage.

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