Brief Report

A Randomized Trial of Two Forms of Therapeutic Activity to Improve Walking: Effect on the Energy Cost of Walking

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Background. Therapeutic activities to improve mobility often include walking practice and exercises to improve deficits in endurance, strength, and balance. Because walking may also be energy inefficient in people with decreased mobility, another approach is to reduce energy cost by improving timing and coordination (TC) of movement.

Methods. This pilot randomized trial of older adults with slow and variable gait offered two types of therapeutic activity over 12 weeks. One addressed Walking, Endurance, Balance, and Strength (WEBS) and the other focused on TC. Outcomes were energy cost of walking and measures of mobility.

Results. Of 50 participants (mean age, 77.2 ± 5.5 years, 65% women), 47 completed the study. Baseline gait speed was 0.85 ± 0.13 m/s and energy cost of walking was 0.30 ± 0.10 mL/kg/m, nearly twice normal. Both interventions increased gait speed (TC by 0.21 m/s and WEBS by 0.14 m/s, $p < .001$). TC reduced the energy cost of walking 0.10 ± 0.03 mL/kg/m more than WEBS ($p < .001$) and reduced the modified Gait Abnormalities Rating Scale 1.5 ± 0.6 more points than WEBS ($p < .05$). TC had a 9.8 ± 3.5 points greater gain than WEBS in self-reported confidence in walking ($p < .01$).

Conclusions. In older adults with slow and variable gait, activity focused on TC reduced the energy cost of walking and improved confidence in walking more than WEBS while generating at least equivalent gains in mobility. To optimize mobility, future larger studies should assess various combinations of TC and WEBS over longer periods of time.

Key Words: Exercise—Gait—Energy cost.

D IFFICULTY walking results in reduced activity, loss of independence, falls, and injuries (1–4) and has been associated with lower extremity muscle weakness (5–9), poor balance(9,10), and deconditioning (8,11). Therapeutic interventions to improve walking traditionally focus on walking practice and remediation of deficits in strength, balance, and endurance, under the assumption that gains in physiological capacity will contribute to improved walking (10,12–14). Such interventions improve walking speed modestly and may help prevent serious mobility disability (10–13,15–18).

Older adults with difficulty walking also use more energy to walk, which might contribute to the problem (6,19–22). Although normal gait is associated with an energy cost of about 0.15 mL/kg/m (23), gaits with altered timing and posture can double or even triple the cost (21,24,25). Interventions that focus on timing and coordination (TC) of gait might reduce the energy cost of walking. Such interventions are based on concepts of motor learning (26,27) and have been shown to enhance motor skill in animal and human studies (28–32).

This randomized clinical trial was designed to compare effects on mobility and energy cost of walking of two programs of therapeutic activity; (a) gait training with exercise to improve strength, balance, and endurance versus (b) stepping and walking practice that focused on TC of gait.

METHODS

Overview

This 12-week randomized, controlled, single-blind trial compared two forms of therapeutic activity in older adults with objective evidence of walking difficulty. The study was approved by the Pittsburgh Institutional Review Board, and all participants gave informed consent.

Participants

Eligible older adults had mild-to-moderate mobility difficulty based on gait speed and variability. Gait speed was less than or equal to 1.0 and greater than or equal to 0.6 m/s (33).

Gait variability was assessed on a pressure-sensitive walkway. Abnormal step length variability was defined as a coefficient of variation (CV) of 4.5% or higher (4). Abnormal step width variability was defined as either too little or too much variability (CV of less than 7% or greater than 30%) because both have been associated with falls risk (34). Participants had to have a Mini-Mental State Examination (35) score greater than or equal to 24.

Measures

All measures were collected at baseline prior to randomization and after 12 weeks of intervention by assessors masked to treatment arm.

Energy cost of walking.—The energy cost of walking reflects the energy used for all bodily actions during walking (36). Participants walked on a treadmill at a self-selected pace while oxygen consumption data were collected using open circuit spirometry and analysis of expired gases with a VO2000 portable metabolic measurement system, Medgraphics, Minneapolis, MN. All participants had one to two practice sessions to become familiar and comfortable with the treadmill prior to oxygen consumption measurement. The mean rate of oxygen consumption and carbon dioxide production was determined over 3 minutes after steady state was reached (27,36–38). We used two standard methods to estimate cost. The energy cost of walking, reported in mL/kg/m, represents an estimate of energy expenditure per unit of gait speed (23,32,39–43) and relates to metabolic equivalents (METS). It is time independent, repeatable, reflects the physiological cost of gait (36,38,44), is little influenced by fitness (38,44), and can be compared across individuals and over time, regardless of changes in gait speed (38,42,44). The metabolic cost of transport, a dimensionless measure of the energy expenditure of moving a unit weight over a unit distance, was determined from the mean flow rates of oxygen and carbon dioxide collected and the standard equation by Brockway (45–47) to estimate average metabolic power. The average metabolic power was divided by body mass (W/kg), the constant for gravity (9.81 m/s^2), and walking speed (m/s) to achieve the dimensionless metabolic cost of transport (W/N/(m/s) (47–49). We estimated total rather than net energy cost. Net estimates require correction for resting energy expenditure, which uses different methods and requires additional testing (50). We were interested in change over time and expected resting energy expenditure to remain constant; thus, we used total energy cost to reduce respondent burden.

Clinical gait assessment.—The modified Gait Abnormality Rating Scale (GARSM), a seven-item criterion-based, observational rating of gait abnormalities associated with fall risk (51,52) was used to assess gait characteristics. Reliability is excellent (intraclass correlation coefficient 0.95 to 0.99) among experienced assessors. Each item is scored 0–3, for a total score of 0–21. Higher scores reflect poorer performance (51).

Gait speed and variability.—Participants walked at their usual speed on a 4-m instrumented walkway, the GaitMatII (E.Q. Inc., Chalfont, PA) (53), with 2-m noninstrumented sections at either end to allow for acceleration and deceleration. After two practice walks, two walks were used for data collection. Gait speed was averaged over the two walks. Step length and step width variability were calculated as the CV based on the average standard deviation of all right and left steps over the two walks divided by the mean step length or step width (54,55). The number of steps used to estimate variability is somewhat less than used by some others (3,56–58) but allows for measures of spatial variability during natural walking not on a treadmill and has acceptable reliability (59,60).

Gait Efficacy Scale.—The Gait Efficacy Scale is a self-reported 10-item scale of perceived confidence in walking for a range of challenges from level walking to walking on uneven surfaces, curbs, or stairs. Item scores range from 1 for *no confidence* to 10 for *complete confidence*, with a possible total score of 10–100 (61,62).

Short Physical Performance Battery.—The Short Physical Performance Battery (SPPB) consists of three tasks: gait speed, balance, and chair stands, using 4-point scales for each and a summary score that ranges from 0 to 12 (63,64). We used the repeated chair rise task and the balance component to reflect changes in lower extremity strength and balance after intervention.

Comorbidity index.—This is a self-report of having been told by a doctor you have any of 18 common conditions. Eight domains (cardiovascular, respiratory, musculoskeletal, neurological, general, cancer, diabetes, and visual) are derived (65).

Interventions

General.—Both protocol driven, physical therapist–led interventions for small groups of two to three participants, lasted 60 minutes twice a week for 12 weeks. The interventions were conducted at different times to avoid cross contamination. Therapists were trained and assessed for study protocol adherence initially and periodically. The protocols defined each activity and gave standards for progression based on accuracy and ease of performance. Time spent on walking alone was monitored to be equal between the two treatment arms (Table 1, summary of interventions). Protocols available on request.

Walking, Endurance, Balance, and Strength (WEBS). This program was based on current physical therapy standards for

Table 1. Characteristics of Two Types of Therapeutic Physical Activity[*]

Timing and Coordination in Walking	Minutes
Flexibility (stretching)	5
Stepping pattern	25
Forward and backward steps	
Step across—forward and backward	
Step across step—forward and backward	
Walking patterns	15
Ovals	
Spirals	
Serpentines	
Complex walking patterns	
Cross path of others	
Opposite direction of others on ovals	
With object manipulation—bounce, toss	
Treadmill paced walking	15
2–3 min usual pace	
30–60 s at 10% increased speed	
1–2 min at usual speed	
Repeat pattern up to 3 times	
Total min	60
Walking, Endurance, Balance, and Strength Practice	
Flexibility (stretching)	5
Strength (cuff weights)	10
Ankle dorsi and plantar flexors	
Knee extensors	
Hip extensors, abductors, flexors	
Gait training	25
Heel–toe pattern	
Lengthen stride and increase speed	
Walk from feet, trunk centered or upright	
Balance	5
Standing balance, tandem, one leg	
Stand with reach forward, up, down	
Stand with ball catch	
Endurance	15
Nustep, stationary cycle	
Total min	60

Note: [*]All activities progress in difficulty according to a standardized protocol with operational definitions of mastery of each stage.

gait and balance retraining. Sessions began with leg and trunk stretches. Strengthening used progressive resistance in lower extremity muscles, with increasing repetitions to a maximum of 20 followed by increasing resistance using cuff weights. Balance tasks redistributed the center of mass over the base of support (66), with and without destabilizing activities. Endurance was trained either with a seated, stair climbing–like activity (NuStep; NuStep, Inc., Ann Arbor, MI), or a stationary cycle, at a submaximal workload (self-reported rating of perceived exertion (RPE) of 10–13, somewhat hard) (67). Heart rate and blood pressure were monitored according to guidelines (68,69). After participants progressed to the ability to sustain a 10–13 RPE level for 15 minutes, workload was increased. Gait training involved verbal instructions by the therapist to correct abnormalities of gait or posture during walking on an indoor track.

Timing and coordination.—This program was based on principles of motor learning that enhance "skill" or smooth and automatic movement control (26,30,31,70–72). TC used goal-oriented progressively difficult stepping and walking patterns to promote the TC of stepping, integrated with the phases of the gait cycle (26,30,71,72). Progression was based on increasing aspects such as speed, amplitude, or accuracy of performance prior to undertaking a more complex task that combined these aspects (73). The progression of stepping patterns was (a) self-paced forward and across, (b) increase speed, (c) alternate side, and (d) alternate forward with backward. Walking patterns incorporated sequences of interlimb timing from stepping into walking. Walking patterns progressed by altering speed, amplitude (eg, narrowing oval width), or accuracy of performance (eg, without straying from the desired path) and then to complex patterns such as walking past other walkers and combined upper extremity tasks such as carrying, bouncing, or tossing a ball (72). Rhythmic stepping was reinforced with treadmill pacing. This treadmill walking was done at preferred walking speed with very brief mildly increased speed intervals to train timing, did not raise the RPE, and was not designed to increase endurance (74).

Data Analysis

All statistical analyses were performed using SAS version 9.1 (SAS Institute, Inc., Cary, NC). Participant characteristics and baseline measurements were compared between arms using t tests for continuous variables and chi-square tests for categorical variables. Unadjusted comparison of change in outcomes between treatment arms used t tests. To obtain adjusted comparison of outcomes between treatment arms, we fitted an analysis of covariance model using baseline to follow-up change in each outcome as the response variable; treatment arm as the main factor of interest; and age, gender, and baseline value of the outcome as covariates. To detect possible different treatment effects in those with low and high baseline energy cost of walking, we included treatment arm, baseline energy cost (dichotomized at the median into low and high), and treatment arm × baseline energy cost interaction as primary factors of interest and made appropriately constructed contrasts to compare treatment effect within only those with low (high) baseline energy cost.

RESULTS

Of 286 persons screened, 111 underwent onsite screening. Fifty participants met all criteria and were randomized and 47 completed the study (Figure 1). The three dropouts developed medical conditions unrelated to the study and did not differ in baseline characteristics from completers (Table 1).

Participants had a mean age of 77.2 years and slow and variable gait (Table 2). The baseline mean energy cost of walking was 0.30 mL/kg/m, almost twice the energy cost of normal walking (0.15 mL/kg/m) (23), and the metabolic
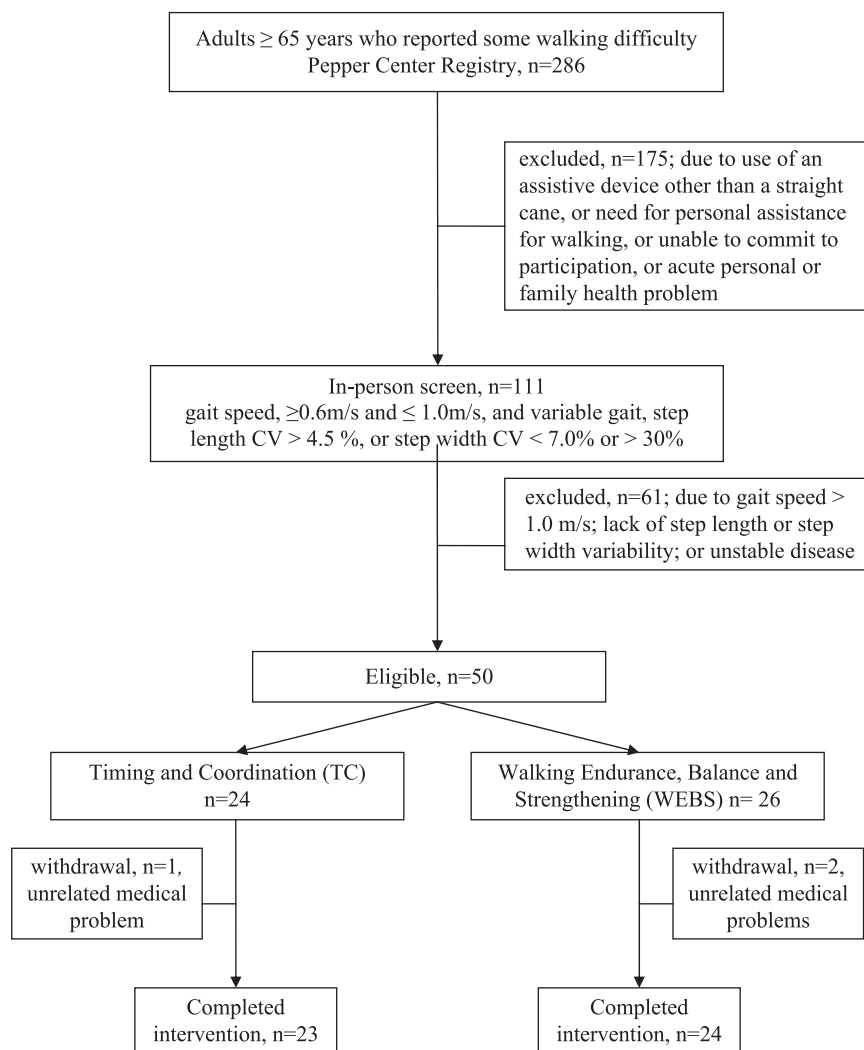
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┌─────────────────────────────────────────────────────┐
│ Adults ≥ 65 years who reported some walking difficulty │
│            Pepper Center Registry, n=286              │
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                          │    ┌─────────────────────────────────┐
                          │    │ excluded, n=175; due to use of an │
                          │    │ assistive device other than a straight │
                          ├────│ cane, or need for personal assistance │
                          │    │ for walking, or unable to commit to │
                          │    │ participation, or acute personal or │
                          │    │ family health problem │
                          │    └─────────────────────────────────┘
                          ▼
┌─────────────────────────────────────────────────────┐
│              In-person screen, n=111                  │
│ gait speed, ≥0.6m/s and ≤ 1.0m/s, and variable gait, step │
│   length CV > 4.5 %, or step width CV < 7.0% or > 30% │
└─────────────────────────────────────────────────────┘
                          │
                          │    ┌─────────────────────────────────┐
                          │    │ excluded, n=61; due to gait speed > │
                          ├────│ 1.0 m/s; lack of step length or step │
                          │    │ width variability; or unstable disease │
                          │    └─────────────────────────────────┘
                          ▼
              ┌─────────────────────────┐
              │      Eligible, n=50      │
              └─────────────────────────┘
                  │                 │
                  ▼                 ▼
    ┌──────────────────────┐  ┌──────────────────────────┐
    │ Timing and Coordination (TC) │  │ Walking Endurance, Balance and │
    │         n=24          │  │ Strengthening (WEBS) n= 26 │
    └──────────────────────┘  └──────────────────────────┘
              │                           │
  ┌─────────────────┐           ┌─────────────────┐
  │ withdrawal, n=1, │           │ withdrawal, n=2, │
  │ unrelated medical│───┤       │ unrelated medical│───┤
  │    problem       │   │       │    problems      │   │
  └─────────────────┘   │       └─────────────────┘   │
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              ┌──────────────────┐           ┌──────────────────┐
              │    Completed      │           │    Completed      │
              │ intervention, n=23│           │ intervention, n=24│
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Figure 1. Study flow chart.

cost of transport was 0.63, also twice usual (0.34) (47). The mean GARSM rating of gait abnormalities was 6.6, twice that found in community-dwelling older adults without walking problems (51).

Despite randomization, there were baseline differences between the two treatment arms, with lower energy cost of walking, metabolic cost of transport, and fewer gait abnormalities in the TC compared with the WEBS group. There were nonsignificant but potentially meaningful differences between groups in gender and gait speed. All 47 completers participated in at least 22 of 24 sessions.

Forty-five of the 47 completers performed both preintervention and postintervention tests of the energy cost of walking. The energy cost of walking decreased in the TC group but did not change in the WEBS group. The adjusted difference in change of energy cost between groups was −0.10 mL/kg/m ($p = .0001$) Table 3. Similar results and between-group differences were found for the metabolic cost of transport (Table 3). There was a marginally signifi-

cant interaction between baseline energy cost of walking and intervention group ($p = .0587$). Among the 21 completers with energy cost below the median (TC $n = 14$; WEBS, $n = 7$), there was no evidence of a treatment effect with either intervention (Table 3). Among the 24 participants with energy cost above the median (TC $n = 8$; WEBS, $n = 16$), TC reduced energy cost 0.15 mL/kg/m more than WEBS (Table 3). The relation between baseline energy cost and treatment effect was plotted for each individual (Figure 2). Among the participants with higher baseline energy cost, WEBS intervention resulted in four with decreased, four with increased, and eight with no change in energy cost, whereas all eight in the TC intervention reduced energy cost. TC compared with WEBS yielded greater gains in clinical gait assessment and marginally greater gains in gait speed (Table 3). Gait variability did not change with either intervention. Confidence in walking improved 10.8 points in TC but did not change in WEBS (Table 3).

Table 2. Baseline Participant Characteristics by Intervention Group

	Total (*n* = 50)	Completed Intervention Treatment Group		Dropout (*n* = 3)
		TC (*n* = 23)	WEBS (*n* = 24)	
Age, y, *M* (*SD*)	77.2 (5.4)	76.2 (5.5)	78.4 (5.5)	76.0 (3.5)
MMSE, 0–30, *M* (*SD*)	28.7 (1.4)	28.5 (1.5)	28.8 (1.3)	29.0 (1.7)
Comorbidities, number, *M* (*SD*)*	2.6 (1.1)	2.8 (1.1)	2.3 (1.2)	3.3 (0.6)
Gender, female, *n* (%)	32 (65.3)	17 (73.9)	13 (54.2)	3 (100)
Race, black, *n* (%)	6 (12.2)	3 (13.0)	2 (8.3)	1 (33.3)
Education, ≥high school, *n* (%)	33 (67.4)	16 (69.6)	15 (62.5)	2 (66.7)
Difficulty walking 2–3 blocks, *n* (%)†	34 (72.3)	17 (73.9)	17 (70.8)	2 (66.7)
Disease history *n* (%)*				
Cardiac	7 (14.9)	4 (17.4)	3 (12.5)	1 (33.3)
Arthritis	34 (72.3)	17 (73.9)	17 (73.9)	2 (66.7)
Osteoporosis	18 (38.3)	10 (43.5)	8 (33.3)	1 (33.3)
Diabetes	4 (8.5)	2 (8.7)	2 (8.7)	0 (0.0)
Depression	8 (17.0)	5 (21.7)	3 (12.5)	2 (66.7)
Vision	31 (66.0)	14 (60.9)	17 (70.8)	2 (66.7)
Hearing	15 (31.9)	6 (26.1)	9 (37.5)	1 (33.3)
Gait speed, m/s, *M* (*SD*)‡	0.85 (0.13)	0.88 (0.13)	0.82 (0.13)	0.75 (0.20)
Step length variability, CV, *n* (%)§	39 (78.0)	18 (50.0)	18 (50.0)	3 (100.0)
Step width variability, CV, *n* (%)‖	39 (78.0)	19 (82.6)	17 (70.8)	3 (100.0)

Notes: *Based on the Comorbidity Index of 8 domains.

†In response to query, "How much difficulty do you have walking several blocks"? Dichotomized as none versus any difficulty (a little, some, quite a lot, cannot do).

‡Between-group mean difference at baseline, marginally significant, $p \le .12$.

§*n* (%) of participants with step length CV greater than 4.5%.

‖*n* (%) of participants with step width CV less than 7% or greater than 30%. CV = coefficient of variation; MMSE = Mini-Mental State Examination.

We assessed the effect of the two interventions on strength and balance using components of the SPPB. Repeated chair rise time is a reflection of lower extremity strength (63,75–77). Chair rise time in seconds changed somewhat, although not significantly more with WEBS than TC (mean change $\pm$ *SD* for TC, -2.08 ± 2.50, $p = .0025$; -2.44 ± 2.12, $p = .0001$ for WEBS), supporting a strength training effect of WEBS. The balance component of the SPPB did not change with either intervention (0.04 ± 1.11, $p = .852$ in TC and 0.13 ± 0.90, $p = .503$ in WEBS).

DISCUSSION

Among older adults with walking difficulty, a therapeutic activity program based on TC of gait resulted in greater improvement in the energy cost of walking, clinical gait assessment, speed, and perceived confidence in walking compared with a program of gait training based on walking practice and remediation of deficits in endurance, balance, and strength. The treatment effects were greatest in persons with higher energy cost of walking. A focus on TC might help make walking "easier" energetically (31) and appears to

Table 3. Baseline Status and Postintervention Outcomes by Treatment Group

	Treatment Group*								Adjusted Group Differences	
	TC				WEBS					
	Pre-Mean (*SD*)	Post-Mean (*SD*)	Change Mean (*SD*)	*p*	Pre-Mean (*SD*)	Post-Mean (*SD*)	Change Mean (*SD*)	*p*	Adjusted Difference (*SE*)	*p*
Energy expenditure										
Energy cost of walking, mL/kg/m†	0.26 (0.10)	0.21 (0.06)	−0.04 (0.10)	.0266	0.34 (0.09)	0.35 (0.10)	0.01 (0.10)	.6647	−0.10 (0.03)	.0002
Below *Md* <0.284 mL/kg/m	0.20 (0.04)	0.19 (0.06)	−0.00 (0.05)	.9452	0.24 (0.05)	0.28 (0.09)	0.04 (0.08)	.1993	−0.05 (0.04)	.1509
Above *Md* >0.284 mL/kg/m	0.37 (0.08)	0.24 (0.05)	−0.13 (0.10)	.0076	0.38 (0.06)	0.38 (0.10)	−0.01 (0.10)	.7861	−0.15 (0.03)	<.0001
Metabolic cost of transport, W/N/(m/s)†	0.54 (0.21)	0.44 (0.13)	−0.10 (0.20)	.0232	0.71 (0.18)	0.72 (0.22)	0.02 (0.21)	.6755	−0.21 (0.05)	.0003
Observed gait and mobility										
GARSM, 0–21†	5.7 (2.5)	3.0 (2.3)	−2.6 (1.5)	<.0001	7.4 (2.5)	6.0 (2.9)	−1.46 (2.1)	.0025	−1.5 (0.6)	.0221
Gait speed, m/s‡	0.88 (0.13)	1.09 (0.13)	0.21 (0.14)	<.0001	0.82 (0.13)	0.96 (0.19)	0.14 (0.15)	.0002	0.07 (0.04)	.1038
Self-reported mobility										
Gait Efficacy Scale, 0–100	69.5 (20.2)	80.3 (13.9)	10.8 (17.2)	.0065	72.6 (13.5)	71.3 (11.2)	−1.3 (13.8)	.6504	9.8 (3.5)	.0081

Notes: *n* = 23 for TC and 24 for WEBS except for energy expenditure data where *n* = 22 for TC and 23 for WEBS.

†Between-group mean difference at baseline, $p \le .05$.

‡Between-group mean difference at baseline, $p \le .12$. GARSM = modified Gait Abnormality Rating Scale; TC = Timing and Coordination; WEBS = Walking, Endurance, Balance, and Strength.
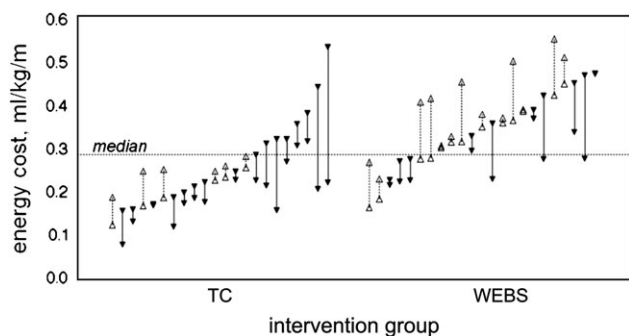
Figure 2. Individual participant change in energy cost from before to after intervention by intervention group, Timing and Coordination (TC) *n* = 22; Walking, Endurance, Balance, and Strength (WEBS), *n* = 23.

offer an additional strategy to reduce walking difficulty. Perhaps, the optimal intervention should combine aspects of both interventions and reduce deficits and improve timing.

In older adults with slow gait speed (eg, <1.0 m/s), prior exercise trials have shown mean improvements in gait speed of about 6% (range, 0%–13%) with strength, flexibility, balance and aerobic exercise training (10,11,13,16,17,78,79), functional training (80), and Tai Chi (81). Few studies have examined the effect of exercise on energy cost of walking. Mian and colleagues (14) found that a 12-month conditioning exercise for healthy older adults improved balance and walking ability but did not change the metabolic cost of walking. Survivors of a stroke who participated in aerobic training improved in mean peak workload capacity more than expected based on the mean increase in maximal oxygen consumption (32,82). The authors attributed the extra gain to increases in gait efficiency (32).

How might reducing the energy cost of walking benefit the older adult with walking difficulty? Consider a typical older adult with chronic stable cardiopulmonary disease and an estimated maximum aerobic capacity of 5 METS or 17.5 mL/kg/min oxygen rate (83). At the mean energy cost of walking and gait speed found in our study (0.30 mL/kg/m, 0.85 m/s), usual walking will consume 15.3 mL/kg/min of oxygen or 4.4 METS, approximately 87.4% of maximum aerobic capacity. If the energy cost of walking improved by 0.10 to 0.20 mL/kg/m, as in this study, then the energy cost of walking at 0.85 m/s is reduced to 10.2 mL/kg/min or 2.91 METS, only 58% of maximum aerobic capacity. In older adults with high energy cost of walking, reducing the energy cost of walking could change the amount of work required to perform daily activities, perhaps reducing fatigue and increasing activity.

This study has substantial strengths. We targeted a highly clinically relevant population with demonstrated deficits in walking and typical comorbid conditions. We adhered to numerous quality standards for clinical trials, including randomization, predefined primary outcome measures, masked outcome assessment, and protocolized exercise interventions. Our dropout rate was low. The interventions

should be feasible in clinical practice; they employed low- to moderate-intensity exercise and a relatively low frequency of treatment of twice a week.

The study has limitations as well. The study was powered to detect treatment differences in physiological and performance measures but not in more distal outcomes. We did not directly measure endurance using a 400-m walk or submaximal treadmill test. Despite randomization, treatment groups had differences at baseline. However, because the TC group appeared to have lower energy cost of walking at baseline, several possible sources of bias are unlikely. If regression to the mean influenced the findings, the WEBS group would have tended to greater decreases in energy cost. Because the TC benefit to energy cost appears to be attenuated in persons with lower baseline energy cost and the TC group had more participants with low baseline energy cost, then the overall opportunity to detect change in TC was reduced but was still highly significant. Our TC intervention did not appear to change gait variability. The best way to measure gait variability is not known (57–59,84). Our measures might have been insensitive to change or the TC intervention worked through a mechanism other than gait variability. The TC intervention paced gait using a treadmill. Because the energy cost of walking is measured on a treadmill, familiarity with the treadmill may have biased the measurement of energy cost. We think this is unlikely because all participants had 1–2 treadmill sessions at baseline in order to become familiar with the treadmill and comfortable with testing. We also note that independent measures of gait such as speed and GARSM changed in a way that is consistent with a true chance in energy cost. Finally, there was overlap between the two interventions: both included walking practice for 20–30 minutes per session. The approaches were designed to differ mainly in the approach to gait training. The treadmill was expected to "pace walking" to train sequencing and timing to become more "automatic", whereas the therapist-led gait training was based on cueing, instructions, and feedback typical in rehabilitation practice.

Interventions that reduce the energy cost of walking have potential to improve gait speed and mobility performance, especially among older adults with an initially high energy cost of walking. Future studies should assess gait coordination interventions, perhaps in combination with other training approaches, on longer term clinical and physiological effects and more distal mobility outcomes.

CORRESPONDENCE

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