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Research Article

Short Term Technology-Assisted-Aerobic Exercise (AlterG$_R$, GlideTrak$_{TM}$, Vasper) in a Community Fitness Center for Patients with Mild to Moderate Parkinson's Disease: Subjective Perceptions and Motor Effects

Nancy Byl[1]*, Jonathan Kretschmer[1], Aaron Chung[1], Allison Thomas[1], Irina Fedulow[1], Molli Bauke[1] and Maurice Garcia[2]

[1]*Department of Physical Therapy and Rehabilitation Science, School of Medicine, University of California, San Francisco, California, USA*

[2]*Department of Urology, School of Medicine, University of California, San Francisco, California, USA*

Abstract

Background: Physical inactivity is a significant health risk, particularly in the growing population of elders with chronic neurodegenerative conditions like Parkinson's Disease (PD).

Purpose: Determine if individuals with mild to moderate PD can achieve aerobic levels of exercise using novel rehabilitative technology (AlterG$_R$, GlideTrak$_{TM}$, Vasper) and if short term aerobic training is associated withmobility performance and subjective perceptions.

Methodology: Two quality assurance, pre-post test design studies were carried out with individuals with PD (Hoehn and Yahr I-III) involved in physical therapy in a health and wellness center. In study I, with a 3 month cross over delay, 12 participants were randomly assigned to daily training (5 days, 40 minutes/session) on two novel body weight supported treadmill systems (Alter-G$_R$ and GlideTrak$_{TM}$). In study II, ten participants trained for 5 weeks (2x/week, 20 minutes/session) on the recumbent NuStep$_{TM}$T5XR recumbent cross trainer with cooling, compression and grounding by Vasper. Self reported signs, symptoms and training challenges were assessed before, during and after training complemented with mobility and balance assessments before and after training (ten meter walk, six minute walk, timed up and go and five times sit to stand).

Results: Twenty participants started and safely completed the assigned technology assisted-aerobic training sessions (each 200 minutes). All but two participants achieved a target heart rate of 60-80% of age relevant maximum with all reaching an exertion level ≥3/10). After each training protocol, participants achieved significant ($p<0.025$) gains in balance and gait, improving by 1-2 seconds on the TUG and FTSST and gaining 0.28 m/sec in walking speed to achieve a community level of participation. Walking endurance increased an average of 80 meters. During aerobic training, participants self reported mild to moderate discomfort, but noted improvement in energy, resilience and gait stability without exacerbation of PD signs and symptoms. Training gains varied by technology assisted exercise groups.

Summary: Novel rehabilitative-technology allowed participants with mild to moderate PD to exercise aerobically and improve mobility, balance and resilience without exacerbating pain, freezing or tremors. Participants recommend the incorporation of technology assisted aerobic equipment in community fitness centers and group exercise programs to enable individuals with PD to independently maintain health and wellness.

Keywords: Aerobic exercise; Balance; Mobility; Parkinson's disease; Self perception

***Corresponding author:** Nancy Byl, Department of Physical Therapy and Rehabilitation Science, School of Medicine, University of California, 1675 Owens Street, Box 0736, San Francisco, California 94158, USA, Tel: +1 4155144816; Fax: +1 4155144817; E-mail: Byln@ptrehab.ucsf.edu

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Introduction

The population is aging with problems of physical inactivity, Parkinson's Disease (PD) and Parkinsonism becoming increasingly common [1,2]. PD is characterized by progressive impairments in motor function including a resting tremor, rigidity, bradykinesia, micrography, poor postural righting and reduced speech volume along with non-motor symptoms of inflammation, pain, depression, gastrointestinal dysfunction, sleep disturbances and decreased memory skills [3]. The most common conservative medical management for PD is based on dopamine replacement medication [4]. These medications may improve but not remediate problems of incoordination, dyskinesia, sensory dysfunction, balance, fall risk, depression, cognition or gastro-intestinal dysfunction. To maintain community independence and participation despite disease related impairments, exercise is recommended to complement medication management [5-13].

Physical immobility is the leading cause of disability and disease worldwide [14,15]. Physical activity facilitates cardiovascular fitness, mobility and musculoskeletal health. Further, aerobic exercise may uniquely maintain dopamine receptors as well as increase endorphins, Brain Derivative Neurotrophic Factors (BDNF), growth hormones, up-regulation of dopamine, motor control, postural righting responses, bone density, oxygen delivery and blood flow [16,17]. Recent animal and human studies of PD suggest intense, aerobic exercise and behavioral training may slow down aging (e.g., maintain telomere length) [18], improve memory [19-23], contribute to the reorganization of the brain and potentially be neuroprotective

in patients with PD [24-28]. Adding learning elements to general exercise programs may further enhance memory and protect from Alzheimer's disease in our aging population, with and without PD [29,30].

Unfortunately, neuromotor control problems associated with PD can challenge the ability to complete safe, vigorous aerobic exercises. Vigorous exercise programs like Tai Chi, Tango dancing, striding, race walking, boxing, cycling, running, hiking and tandem biking have been successfully completed by patients with PD [6,26,30]. While a treadmill can be used to force individuals with PD to move more rapidly, increased ground reaction forces can lead to increased joint and spine pain. Thus, harness systems have been created to protect from falling as well as un-weight individuals to minimize ground reaction forces and facilitate spinal pattern generators for walking/running (body weight supported treadmill training BWSTT) [31-34].

Unfortunately, when walking fast or running, small amounts of un-weighting with a harness (e.g., >20%) can be uncomfortable [35,]. Consequently creative un-weighting systems (e.g., (www.Alter-G.com) [36], or pelvic type suspension systems (www.GlideCycle.com) [37], have been developed to improve comfort, increase the degree of un-loading and allow free limb and trunk movements. Recumbent reciprocal, elliptical cross trainers and recumbent bicycles can also protect against falling and minimize weight bearing loads. More recently, in sports, cooling and compression appear to extend cardiopulmonary benefits, reduce muscle soreness, but increase strength and speed of movement through the release of human growth factors [38,39]. The vasper cooling system (www.vasper.com) provides this option.

Before a health care delivery system, a rehabilitation center, a fitness center or an individual can justify purchasing novel and expensive rehabilitation technology, it is necessary to demonstrate positive benefits without adverse events. In a Physical Therapy Health and Wellness program integrated into a community fitness center, two quality assurance studies (Figure 1) were carried out to determine if individuals with mild to moderate PD (Hoehn and Yahr I-III) could exercise with the AlterG$_R$, the GlideTrak$_{TM}$ or the NuStep with Vasper to: 1) achieve aerobic levels of training; 2) maintain if not improve mobility and balance, and 3) perceive differences in procedural utilization, benefits or exacerbation of signs and symptoms of PD following aerobic training.

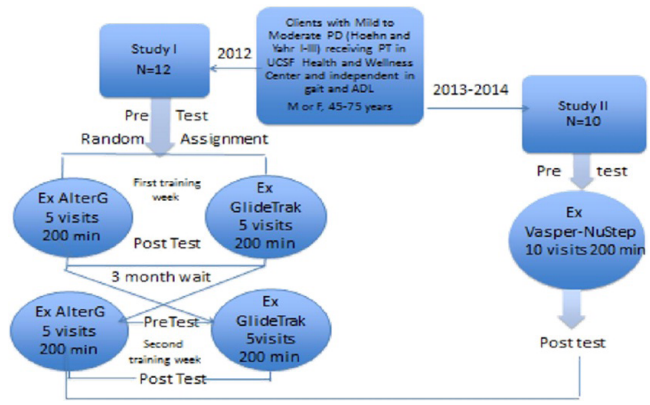

Figure 1: Design of Quality Assurance Studies.

Materials and Methods

Subjects

Two QA studies were planned. (Figure 1) Community independent (≥50% on a measure of functional independence, CAFÉ 40) [40], mentally alert subjects (>24 on the VA mental status exam) [41], between 45 and 75 years of age, diagnosed for over two years with mild to moderate PD (Hoehn and Yahr I-III) without other major neuromuscular impairments were eligible to participate in one or both methodological, quality assurance studies. All individuals had received physical therapy services within the outpatient Physical Therapy Health and Wellness Clinic at the University of California, San Francisco. Participants continued usual activities during QA study participation.

For QA study I, 12 individuals were randomly assigned to daily Body Weight Supported Treadmill training (BWST) for five consecutive days (40 minutes/session; total 200 minutes), beginning either on the AlterG$_R$ (bodyweight supported by positive air pressure over a treadmill) or the GlideTrak$_{TM}$ (body weight supported by a suspended bicycle type seating system over a treadmill). The participants were crossed over after a 3 month delay. For quality assurance study II, 10 participants agreed to attend ten intense, aerobic interval training sessions on the recumbent elliptical cross trainer (NuStep$_{TM}$) with compression and cooling by Vasper (20 minutes, twice a week for 5 weeks; total of 200 minutes). In both studies, 60-80% of age matched maximum heart rate was set as the target exercise heart rate. If individuals were on medications to reduce heart rate or had a pacemaker, physician approval was needed for participation and subjective exertion level (>3/10) served as the target performance in lieu of heart rate.

Assessment

HR and exertion level were monitored for each training session. The primary mobility outcomes were gait speed, endurance and balance. The standardized tests for mobility were administered pre and post training. For gait, the Ten Meter Walk (10MW; walking as fast as possible) [42], and the Six Minute Walk (6MW; walking back and forth along a 10 meter marked area at a speed that could be safely maintained over 6 minutes) were administered [43]. The standardized measurements of balance included: Five Times Sit to Stand (FTSTS) [44] and Timed Up and Go (TUG) [45].

In both QA studies, before, during the workout and at the end of training, the participants were asked to self report signs and symptoms of pain, discomfort, fatigue, incoordination and tremor (ordinal scale from 0 [none or mild] to 10 [severe]). During training, using a non-standardized questionnaire, participants were asked to grade their perceptions of the ease of using the equipment, the quality of the physical training work out and the comfort of the workout. For each type of exercise training, the participants subjectively described what they liked "best and least" about training on the equipment, whether they would like to have the equipment available to use at home or in a fitness center and if they would recommend the technologically enhanced aerobic training to their friends. In QA Study II, the participants also completed standardized, self report questionnaires on sleep, fatigue, resilience and freezing. In Study II, 8 of the participants had experienced exercise training on the AlterG$_R$ as well as the NuStep$_{TM}$-Vasper. Thus, these participants were asked to compare their preferences for each of the technologically-enhanced-aerobic training experiences in terms of the quality of the

workout, ease of set up, comfort during training as well as equipment preference.

Equipment

Alter-G Anti-Gravity Treadmill (Alter-G$_R$) (Figure 2).

Figure 2: AlterG$_R$ Air Distributed Body Un-Weighting Treadmill (Standard M 300).

The AlterG$_R$ (www.Alter-G.com) [36], employs an air distribution system for un-weighting. This technology was developed to study the effects of gravity on bone health and physiology of astronauts in space. The technology was approved by the FDA for fitness and functional rehabilitation for patients with orthopedic and neurological impairments.

The individual dons a pair of polypropylene shorts which zip into a pressurized air bag chamber suspended over a treadmill. With the shorts zipped into the pressure chamber, and the individual standing on the treadmill, the machine "calibrates" the weight by generating an upward "lifting" force (140 to 300 pounds). After "weighing" the individual, the air is released and the calibrated weight is used as a reference for selected un-weighting during exercise (20-80%). There is some air left in the bag which underestimates the weight by about 6# [46]. The accuracy of un-weighting and re-weighting varies by approximately 5% [46].

The treadmill speed and the slope were controlled by the user or the therapist. The faster the speed, the greater the un-weighting needed to keep the ground reaction forces low [31]. The air distributed system allows more comfortable un-weighting than a harness system [35]. With greater un-weighting, individuals may achieve faster running speeds compared to over ground running [31]. For this study, the objective was to un-weight participants by 40-50% and jog with the treadmill speed 3.5 to 7 mph. GlideTrak$_{TM}$ (Figure 3).

The GlideTrak$_{TM}$ bodyweight support system blends un-weighted technology and low impact training indoors over a treadmill, (www.glidecycle.com) [37]. The unit un-weights the individual through support of the pelvis between a seat and a pelvic pad across the Anterior Superior IIiac Spines (ASIS). The unit has a posted seat suspended by two straps in the rear and two in the front. The pelvis is suspended for un-weighting with the angled seat supporting the

Figure 3: GlideTrak$_{TM}$ Body Un-Weighting System.

ischium and a pelvic pad against both Anterior Superior Iliac Spines (ASIS) with no perineal pressure. The GlideTrak$_{TM}$ is adjusted to each individual with un-weighting created by tightening the straps (0-100%) [36]. The amount of un-weighting was estimated with the subject standing on a scale during tightening of the seating system. When un-weighted 40-50% by the seating system, the knee was flexed @10-20˚ [47]. For this study, striding rather than jogging was encouraged (e.g., upright trunk, good hip extension, forefoot roll off, heel rise with knee flexion as the weight bearing limb moved into the swing phase with hip, knee and ankle flexion until heel strike to begin the stance phase again). If necessary, the physical therapist could assist in the swing phase. The GlideTrak$_{TM}$ frame/seating system was placed over a Star Trek treadmill www.StarTrek.com [48]. The participant could hold on to the GlideTrak frame or swing the arms. The objective was to glide between 3 and 5 mph on a treadmill slope of 10%. The GlideTrak$_{TM}$ and the GlideCycle are approved by the FDA for fitness and rehabilitation.

NuStep$_{TM}$ with Vasper Cooling and Compression (Figure 4).

Figure 4: NuStep$_{TM}$ with Vasper$_{TM}$ Cooling and Compression: Quality Assurance Study II.

The NuStep$_{TM}$ [49], is a recumbent cross trainer which combines lower and upper extremity reciprocal body movements for a full body workout for users of virtually all ability levels. It builds strength,

promotes independence, and invigorates users. It has user controlled step length and arm amplitude, low inertia startup, instant free coasting start and stop action for safety, a self-powered battery, quiet belt drive and a generator resistance range of 5-1400 watts. The seat swings out for easy transfer and there are leg stabilizers to keep the lower limb in neutral as needed. It is possible for the subject to use only the arms, only the legs or one arm or one leg if necessary due to pain, weakness or loss of motor control.

The Nu-Step$_{TM}$ is connected to a vasper (http://vasper.com/) cooling and compression unit [38,50,51]. This system cools both feet, the torso, the upper arms and the thighs (quadriceps and hamstrings) with an option for head cooling. Pressure is created by running cold water through the cuffs. For this quality assurance study, the pressure was adjusted primarily between 50-60 mmHg.

Intervention

In Study I, each participant performed high intensity gait training for 5 consecutive days, 40-45 minutes per session. Each subject trained to achieve a Heart Rate (HR) of 60- 80% of age appropriate maximum (220-patient age) with an exertion equivalent to 3 or greater on a scale of 0-10. Subjects on cardiac medications or with a pacemaker had to receive clearance from their MD to participate in high intensity exercise. Exertion was monitored rather than HR as an indication of aerobic training.

Each subject warmed up over ground prior to treadmill training (e.g., walking with ankle and arm weights [2-5#], stepping over objects, integrating large arm swings, high stepping, rhythmical stepping to music and general stretching). An oximeter was used to record oxygen saturation and heart rate prior to, during and immediately after intensive exercise. An assistant or a physical therapist provided guidance for aggressive high stepping and reciprocal arm swinging.

A consistent physical therapist helped each subject on/off the GlideTrak$_{TM}$ and adjusted the un-weighting. A consistent research assistant helped each subject on/off the Alter-G$_R$, zipped in the suit and calibrated the equipment. Each participant was un-weighted to approximately 50-60% of their body weight. On the Alter-G$_R$, the amount of un-weighting, suit size, height of the air bag, running speed and time were documented each day. During the first GlideTrak$_{TM}$ session, the subject stood on a normal scale while the therapist tightened the straps to achieve 20° of knee flexion and approximately 40-50% of un-weighting.

On both of the BWST systems, the subject warmed up for 3-5 minutes, walking 1.0-2.4 mph. The speed was slowly increased (4.5 to 7.0 mph) depending on subject conditioning and tolerance. The subjects exercised at high intensity for 30 minutes and then cooled down by walking slowly for 3-4 minutes. Each individual was asked to stretch the heel cords before dismounting from the treadmill.

For Study II, on the NuStep$_{TM}$-Vasper, each subject was scheduled to train for 10 sessions. Each session was 20 minutes of exercise (plus 5 minutes for set up and 5 minutes of post exercise cooling). One of two interval training programs was selected: "Super Six" or "Hummingbird". Each participant trained at the low or medium level depending on their pre existing level of fitness. The hummingbird protocol included a warm up of 7 minutes at level 4 followed with 7 sprint intervals at level 5 or 6 (three 30 second sprints and four 15 second) followed by recovery intervals of 60 seconds) at 3 or 4 and a cooling period of 90 second at level 3. The super six protocol included a warm up of 9 minutes at level 4, with 6 sprint intervals at level 6, each for 30 seconds, followed by a recovery or cooling phase for 60 seconds at level 4 and a final cooling of 60 seconds. The 20 minute workout protocol ended with @10 minutes of cooling on a cooling mat.

Study design and data analysis

Studies I and II were methodological, quality assurance studies based on a pre-post test design. Study I also included a cross over component. There was 3 month waiting period before training with the second BWST.

The primary mobility dependent variables included gait (10 Meter Walk, fast speed and Six Minute walk-endurance) and balance (FTSST and TUG). For each study, the primary dependent variables were summarized and described by mean (score or percentage), standard deviation and effect size [52]. The post-pre difference scores on the primary dependent variables were analyzed for significance using the nonparametric paired Wilcoxon test. Differences between the post-pre change scores for the different training groups were compared with the two sample Wilcoxon test ($p<0.0125$) [53].

For descriptive purposes, self reported signs and symptoms of PD and aging, ease, comfort, quality of the workout and likes and dislikes were monitored at the beginning and end of training. This data was summarized by frequency and qualitative summaries.

Results

Study l

One participant had difficulty achieving a comfortable adjustment of the seating system on the GlideTrak$_{TM}$ and decided not to participate. Two females and 9 males completed the study with no adverse events (Table 1).The average age was 69.1 years (±2.8). The participants had been diagnosed with PD for an average of 4.1 years (±3.0) and were considered between stages I and III on the Hoehn and Yahr scale. All participants were taking at least one medication for PD (with a mean of 3.7 medications (±1.4). All participants reported low levels of joint pain (back, hip, knee, ankle and shoulder), fatigue, tremor, freezing and problems of in-coordination at baseline. All participants were independent at home (self report with pre screening mean scores on the CAFÉ 40 greater than 50%) [40]. With the exception of two subjects who were taking cardiac medications to decrease heart rate, all subjects were able to jog or stride to bring their heart rate to between 60-80% of the estimated maximum for age (Table 2).

Table 2 summarizes the change in mobility and balance performance following the training on each piece of BWST equipment. During training on the Alter-G$_R$, participants made significant gains (12-19.8%) including large effect sizes (ranging from -1.04 to +2.01) on the 10 meter walk, the 6-minute walk and both balance tests. During GlideTrak$_{TM}$ training, there were gains (2.5% to 12.3%) and moderate effect sizes (-0.88 to+0.37) on the mobility and balance tests, but the gains were not statistically significant. In both groups, participants performed within age related norms for balance and gait speed [54-58]. After training, the gain scores on all primary dependent variables were significantly greater after AlterG$_R$ training compared to GlideTrak$_{TM}$ training ($p>0.0125$).

Table 3, summarizes the self reported changes in signs and symptoms pre and post training on both BWST systems. In general, the participants reported mild signs and symptoms (pain, incoordination, balance, fatigue, tremor, and freezing) pre, during

Participant	Gender	Age (years)	Onset PD (years)	Hoehn & Yahr I-III	Pacemaker	Target HR 70-80%	Un-Weighting	Training Speed (mph)
1	M	77.2	6	II	Yes	100-104	50%	AG 7.0 GT 6.0
2	M	70	5	II	No	105-124	50%	AG 6.5 GT 5.5
3	M	66.9	10	III	No	107-126	50%	AG 4.8 GT4.5
4	F	64	8	II	No	104-124	50%	AG 6.0 GT 6.5
5	M	64.1	3	III	No	109-124	50%	AG 4.7 GT 6.8
6	M	66.7	5	III	No	107-122	50%	AG 5.8 GT 7.0
7	F	57.5	2	II	No	113-126	40%	AG 6.0 GT 5.5
8	F	73.1	3	II	No	110-118	50%	AG 5.0 GT 7.0
9	M	61.3	3	II	No	111-128	50%	AG 4.5 GT 5.5
10	M	71.5	3	II	No	104-118	50%	AG 5.5 GT 6.5
11	M	75.6	12	III	Yes	108-116	50%	AG 4.5 GT 5.5

Table 1: Description of Participants: Quality Assurance Study I.

AG = AlterG$_R$ GT = GlideTrak$_{TM}$

*Pacemaker limited maximum heart rate

**Target heart rate set at 70-80% of maximum based on age [(220-age] x 70 % - [220-age] x 80 %)

***Speed of jogging/striding set by participant and therapist to achieve maximum heart rate

Note: Eleven participants completed the quality assurance study I. Seventy three percent of the participants were males. The participants had a mean age of 69.4 years of age with a diagnosis of mild to moderate PD for an average of 4.1 years. All were un-weighted to @ 50% of body weight to enable jogging/striding with reduced ground reaction forces. All but two participants achieved exercise heart rate. The two who did not achieve the desired heart rate were participants with pacemakers.

	Gait Speed (m/sec)	6-minute walk (m)	TUG* (sec)	FTSTS** (sec)
AlterG$_R$ Group				
Pre Score Mean (SD)	1.84 (0.23)	419.1(84.6)	6.86 (1.31)	9.76 (2.05)
Post Score Mean (SD)	2.06 (0.43)	501.3(85.9)	6.46 (1.52)	8.11 (1.29)
Difference Score	0.22 (0.36)	82.2(40.95)	- 0.39 (1.24)	-1.65 (1.58)
% Difference Score	12.00%	19.80%	-5.70%	-16.90%
Effect Size	0.61	2.01	-0.31	-1.04
Paired Wilcoxon p<0.025; Sum of Ranks: < 10 or > 45	Sum of ranks=6 Significant	Sum of ranks= 7 Significant	Sum of ranks =6 Significant	Sum of ranks =7 Significant
GlideTrak$_{TM}$ Group				
Pre Score Mean (SD)	1.94 (0.32)	460.2(87.8)	6.53 (0.93)	9.06 (1.75)
Post Score Mean (SD)	2.08 (0.57)	486.5(77.5)	6.36 (1.48)	7.94 (1.87)
Difference	0.13 (0.44)	26.5(72.1)	-0.16 (0.82)	-1.12 (1.27)
% Difference Score	6.70%	5.70%	-2.50%	-12.30%
Effect Size	0.3	0.37	-0.2	-0.88
Paired Wilcoxon p<0.05; Sum of Ranks: 10 or >45)	Sum of ranks=19 Not Significant	Sum of ranks=13.5 Not Significant	Sum of ranks=14 Not Significant	Sum of ranks=22 Not Significant
Alter-G compared to GlideTrak$_{TM}$				
Mean Difference	0.10 (0.65)	58.4 (80.8)	-0.25 (1.75)	-0.64(1.75)
Effect Size	0.14	0.72	-0.21	-0.36
Two Sample Wilcoxin (Significant<0.025); sum < 65 >115)	Sum=32.5 significant (AG>GT)	Sum= 43.0 significant (AG>GT)	Sum= 44.5 significant (AG>GT)	Sum= 17 significant (AG>GT)

Table 2: Change in Mobility and Balance by BWST Group (AlterG$_R$ and Glide Trak$_{TM}$): Quality of Assurance Study I.

Note: Effect sizes ranged from small to large (0.2 to 2.01) with significant gains post AlterG^R training (10 meter walk, six minute walk, timed up and go and five times sit to stand.

and post training). On a scale of 0-10 (0 referring to none or minimal signs/symptoms and 10 referring to severe signs and symptoms), mean scores varied from 0.6 to 2.7. The effect sizes were generally low (minimal change), but moderate reduction was self reported in freezing, arm pain and leg pain.

Over the week of training, there was a reduction in the severity of signs and symptoms experienced by the participants during training. On the AlterG$_R$, at the end of the week, 25% of the participants continued to report moderately severe discomfort, 37% reported moderate fatigue, and 12% reported severe freezing during training. On the GlideTrak$_{TM}$, there was also a reduction in the severity of signs and symptoms during training from the beginning to the end of the week of training. However, at the end of the week, during the training, 44% continued to report moderate discomfort, 25% reported

Group	Pain	Pain	Pain	Incoordination	Balance	Fatigue	Tremor	Freezing
	Back	Arms	Legs					
AlterG (AG)								
Pre	1.5 (1.5)	1.2 (2.1)	1.6 (23)	2.5 (2.8)	2.4 (3.0)	2.1 (1.4)	1.7 (1.8)	0.9 (1.7)
Post	1.6 (1.5)	1.1 (1.8)	1.6 (1.9)	2.4 (1.9)	2.5 (2.0)	2.6 (2.1)	1.3 (1.6)	0.9 (1.6)
Difference	0.7 (2.1)	-0.4 (0.7)	-0.7 (1.6)	-0.4 (2.5)	0.1 (2.3)	0.45 (1.6)	-0.6 (1.2)	-0.4 (1.3)
Effect Size	0.33	-0.57	-0.44	-0.16	0.04	0.28	-0.5	-0.31
GlideTrak (Gk)								
Pre	1.2 (1.5)	0.6 (1.3)	0.5 (0.8)	2.9 (2.7)	3.0 (2.6)	2.2 (1.5)	1.5 (1.5)	0.6 (1.2)
Post	1.2 (1.4)	0.8 (0.8)	1.3 (1.4)	2.5 (2.5)	2.4 (2.2)	2.7 (2.1)	1.0 (1.3)	0.9 (1.6)
Difference	0.03 (1.1)	-0.2 (1.6)	0.14 (1.5)	-0.4 (1.7)	-0.5 (2.1)	0.5 (1.8)	-0.6 (1.1)	0.01 (1.5)
Effect Size	0.03	-0.13	0.09	-0.24	-0.24	0.28	-0.55	0.01

Table 3: Change in Self Reported Signs and Symptoms Pre and Post Training: Study I.

Difference scores: 0= no problems or no signs and symptoms; 10 = severe signs and symptoms; Negative change is improvement

Note: The participants reported mild signs and symptoms with minimal change before and after training except for tremor where there was a moderate reduction in both groups and a moderate reduction of arm and leg pain after training on the AlterG$_R$.

moderate to severe fatigue and 12% reported moderate pain, tremor and freezing while training on the GlideTrak$_{TM}$.

Table 4, summarizes the participants' subjective "likes" and "dislikes" about the technology. On the AlterG$_R$, the subjects liked the feeling of a "good workout especially "without the fear of falling". On the other hand, the participants disliked putting on the shorts and the feeling of bladder fullness or urgency when un-weighted to 50% of their body weight. On the GlideTrak$_{TM}$, the subjects liked the feeling of standing tall, stretching the legs into a long stride, getting a good work out, challenging their balance, making a good heel strike and taking a long stride. However, the participants had trouble achieving a comfortable adjustment relative to the pelvic seating system.

Table 5 and Figure 4, summarize the participants evaluation of the training characteristics of the AlterG$_R$ and the GlideTrak$_{TM}$. The AlterG$_R$ was easier to set up and adjust to comfort compared to the GlideTrak$_{TM}$ and participants experienced a better work out. At home, 36% would prefer to use the GlideTrak$_{TM}$ and 64% would prefer to work out on the AlterG$_R$. The participants would recommend both pieces of equipment to their friends and to their neighborhood fitness center. However, if only one piece of equipment could be purchased, 82% would recommend the AlterG$_R$.

Study II

One of the 10 participants recruited was unable to complete the study as a consequence of a herniated disc experienced while doing housework at home. Two females and 7 males completed the study. The average age was 68.3 years (±3.0 SD) with a diagnosis of PD for an average of 6.4 years (±6.1 SD). All were taking medications for PD (a mean of 3.4 [±0.9 SD] different medications) (Table 6).

All but two participants achieved 60-80% of their maximum heart rate during training on the NuStep$_{TM}$-Vasper. Participants 2 and 5 were taking medications to control heart rate. The mean wattage achieved from the workout varied by the intensity of the protocol and work out selected. One subject flared an old ankle injury, but reinserted his orthotic in his shoes, wore an ankle support during training and completed the study with no further ankle pain. Another participant was jogging to catch a shuttle and experienced a tear of the vastus medialus. He was able to complete the quality assurance study. Peak sprinting wattage over the 10 sessions increased for 6 participants and decreased for 3 participants (Table 6).

The participants significantly ($p<0.025$) increased gait speed (1.73 to 2.01 m/sec), endurance (440 to 471 meters) and balance performance (Table 7). Post training, the participants performed within age expected norms on the two balance tests, with a significant reduction in performance time (performed the tests 3 to 4 seconds faster; $p<0.025$). Effect sizes ranged from 0.39 to 0.82.

Descriptively, self rated signs and symptoms changed from 1.2 to 11.8% from baseline to immediately post exercise. The effect sizes ranged from small to moderate (.04-.55). Pain levels were low (between 1 and 2 on a scale of 1-10), increasing slightly from a mean of 1.49 to 1.61. Problems with freezing and sleeping increased slightly (3.56% and 4.3%) respectively. However resilience increased 10.9% and fatigue decreased 1.2%.

Over the month of NuStep$_{TM}$-Vasper training, participants reported a decrease in pain in both ankles, but 11-22% of the participants reported continued neck, low back or knee pain during training. Moderate pain persisted during intense training on the NuStep$_{TM}$-Vasper from the initiation to the end of the training sessions. However, overall self reported signs and symptoms were in the mild range, with self reported symptoms of pain, sleeping, fatigue and freezing slightly improved (gains of 1.2-11.8%) with a moderate gain in resilience (effect size 0.55) (Table 8). A decrease in the mean % scores on fatigue and freezing represented improvement. An increase in the % scores on resilience and sleep represented improvement.

Eight of the nine participants in Study II trained on the NuStep$_{TM}$/Vasper as well as the AlterG$_R$. Table 9 summarizes the likes and dislikes as reported by the participants who trained on both pieces of technology. In general, the participants liked training on both the NuStep$_{TM}$-Vasper and the AlterG$_R$. Very few participants expressed dislikes about the NuStep$_{TM}$-Vasper. The dislikes reported about the AlterG$_R$ related to putting on the shorts and a preference to run over ground rather than run on a treadmill. After training on the AlterG$_R$, 62% of the participants reported an increase in energy level and 75% reported an improvement in balance and gait safety. After training on the NuStep$_{TM}$-Vasper, 100% of the participants reported increased energy and 44% reported improved balance, gait safety and reduction in muscle tension.

Liked	Disliked	General Comments
Alter-G$_R$		
Freedom of running without fear of falling Weightless exercise and comfortable Easy to set up and use; Easy to get a good workout I like the ability to run with ease while still pushing my limits Gives me a glance back to my days as a runner but lost when diagnosed with PD	Cumbersome to get into the equipment but easy to use Feeling like my bladder was full even though I went to the restroom before the session Putting on the neoprene shorts	Easy to maintain balance Good workout Good body support and secure feeling while exercising
GlideTrak$_{TM}$		
Feel I could stretch my legs I could stride as if running in a dream Felt I had a more erect posture after the workout	Never achieved anything close to comfortable Back, hips, pelvis, tops of thighs felt a lot of pressure Difficult to set up Pelvic support was uncomfortable	If I could get comfortable, I think this could be a good challenge for my balance and a good workout More demanding in terms of balance Had the perception my feet did not have contact with the treadmill as much as on the AlterG^R

Table 4: Subjective Comments about the Exercise Technology Post Training: Quality Assurance Study I.

Note: All participants had positive comments about both pieces of equipment but still felt some discomfort with the un-weighting to 50%.

Characteristics of Work Out	Alter-G$_R$	Glide Trak$_{TM}$
Ease of set up	7.8 (2.0)	5.6 (2.7)
Ease of making adjustments	8.5 (1.2)	4.8 (2.2)
Comfort during workout	8.3 (0.9)	4.9 (2.7)
Quality of work out	8.9 (0.9)	7.7 (2.5)
Ability to heel strike	7.9 (1.4)	8.4 (1.2)
Length of stride	8.0 (1.3)	8.3 (1.1)
Post exercise soreness	8.9 (0.9)	7.7 (1.6)
Preference for Equipment		
Want to purchase for home use	64%	36%
If cost =, preference to purchase for home	82%	18%
Recommend for a community fitness Center	82%	18%*

Table 5: Participant Perceptions of Equipment Characteristics and the Work out: Quality Assurance Study I.

*45% of the participants wanted to recommend both the Glide Trak$_{TM}$ and AlterG$_R$.

Note: Participants were the most critical of the ease of set up, making adjustments and comfort during the workout on the GlideTrak$_{TM}$ but positive of the ability to work on improve gait parameters of heel strike and step length. The participants were the most satisfied with the quality of the work out on the AlterG^R and the lack of post exercise soreness.

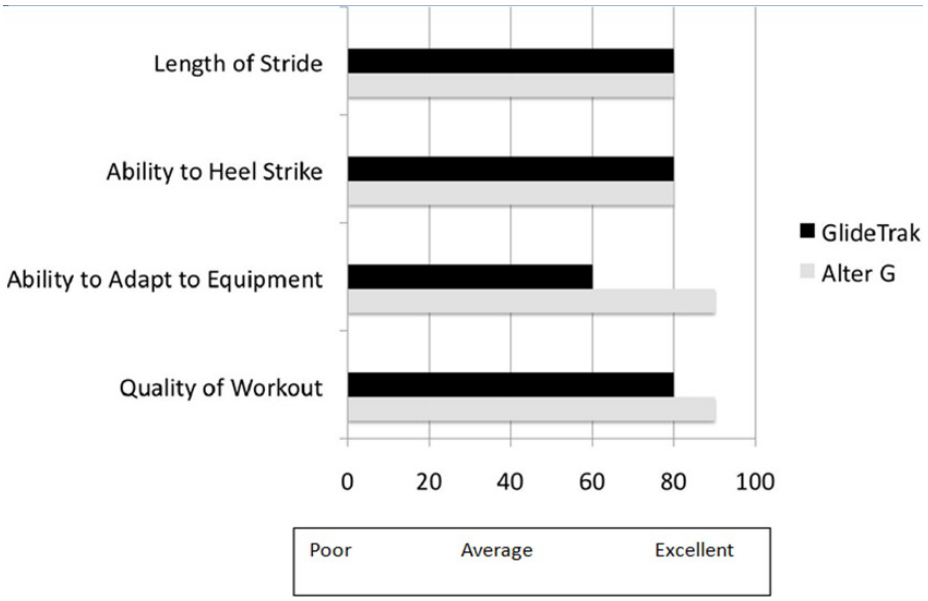

Figure 5: Quality Assurance Study I: Participant Rating of Equipment Characteristics to Facilitate Mobility.

Participants	Gender	Age in years	Onset of PD (Years)	Hoehn and Yahr	Peak Watts Beginning/End	Target Aerobic HR 70-80%	Exercise HR	Sprint Level Beginning/End
1	M	65	11	II	295/416	108-124	136	8/6
2	M	71	3	II	159/329	104-120	100	4/6
3	F	73	3	II	159/297	103-118	115	2/5
4	F	68	2	II	433/391	106-122	118	6/6
5	M	67	20	III	200/278	108-122	93	4/6
6	M	71	3	II	269/176	104-122	100	6/6
7	M	65	3	III	119/107	108-124	102	3/ 4
8	F	70	10	III	81/42	105-120	116	2/4
9	M	65	3	III	132/338	108-124	112	3/4

Table 6: Description of Participants: Quality Assurance Study II.

Note: The average age of the participants was 68.3 years, diagnosed with PD for an average of 12.4 years. There were 3 females. All of the participants exercised within 70-80% of maximum heart rate except participants 2 and 5 who were on medications to control heart rate. Five of the 9 participants were working out at a higher wattage and 5 were sprinting at a higher resistance level after 10 sessions of aerobic training.

	10 Meter Walk Speed (m/s)	6 Minute Walk Distance (m)	Timed Up and Go (s)	5 Times Sit to Stand (s)
Vasper$_{TM}$ with NuStep				
Pre Score Mean (SD)	1.73 (0.36)	439.9 (126.3)	14.6 (23.6)	12.5 (8.7)
Post Score Mean (SD)	2.01 (0.40)	470.7 (135.4)	10.4 (13.1)	9.6 (2.8)
Difference Score (SD)	0.28 (0.34)	30.8 (54.4)	-4.1 (10.6)	- 2.9 (6.5)
% Difference Score	16.4%	7.0%	-23.0%	-28.3%
Effect Size	0.82	0.57	-0.39	- 0.45
Significance < 2 or> 26	Sum of ranks =7 p<0.05 Sign	Sum of ranks =6 p<0.05 Sign	Sum of ranks=6 p<0.05 Sign	Sum of ranks= 7 p<0.05 Sign

Table 7: Summary of Mobility and Balance Gains Post Aerobic Training on Vasper$_{TM}$: Quality Assurance Study II.

Note: There were significant gains on all of the quantitative measures of mobility and balance following aerobic training on the Vasper$_{TM}$.

	(A) Pain*	(B)Freezing (%)**	(C)Resilience (%)**	(D) Fatigue (%)**	(E) Sleep (%)**
Pre Score Mean (SD)	1.49 (1.35)	30.2 (22.4)%	77.2 (12.0)	43.4 (18.8)	70.1 (15.5)
Post Score Mean (SD)	1.61 (1.45)	33.7 (23.4)	85.8 (8.8)	42.8 (18.6)	67.1 (18.2)
Difference Score (SD)	0.12 (1.36)	3.56 (11.6)	8.5 (15.4)	-0.54 (15.1)	-3.0 (7.0)
% Difference Score	8.3%	11.8%	10.9%	-1.2%	-4.3%
Effect Size	0.09	0.31	0.55	-0.04	-0.43

Table 8: Self rated resilience was self reported with moderate improvement and there were minimal effects on the other signs and symptoms.

*(A) Pain was recorded on a Visual Analog Scale from 0 (no pain)-10 (severe pain) for six sites (neck, low back, R and L knee, R and L ankle) with a decreased mean score representing improvement,

**(B-E) were reported as a percentage of the maximum score on standardized questionnaires: B) Freezing of Gait Questionnaire (FOG-Q); (C)The 14-Item Resilience Scale (RS-14); D) Fatigue Questionnaire; (E) Parkinson's Disease Sleep Scale.

Table 10, summarizes the participant's perception of the differences in equipment characteristics for the AlterG$_R$ and the NuStep$_{TM}$-Vasper. The participants indicated it was easier to use, get use to and achieve a good workout on the NuStep$_{TM}$-Vasper compared to the AlterG$_R$ and the participants felt they better feedback about performance and less post training soreness. On the other hand, the participants felt it was easy to make adjustment on both pieces of equipment but they felt there was better balance training on the AlterG$_R$. Seventy five percent of the participants preferred the NuStep$_{TM}$-Vasper over the AlterG$_R$ with 63% likely to recommend the NuStep$_{TM}$-Vasper to the fitness center over the AlterG$_R$.

On all equipment parameters as well as the workout characteristics, the participants wanted to work out with both pieces of equipment but generally rated the NuStep$_{TM}$-Vasper slightly higher than the AlterG$_R$.

The gains in mobility after training on the NuStep$_{TM}$-Vasper in Study II compared to the participants training on the AlterG$_R$ and the Glide Trak$_{TM}$ from Study I are summarized in table 11. The gains in gait speed, endurance and balance were significantly greater following training on the NuStep$_{TM}$-Vasper than training on the AlterG$_R$. However, the gains in gait speed and performance on the TUG were not significantly greater after training on the NuStep$_{TM}$-Vasper compared to the GlideTrak$_{TM}$.

Discussion

These quality assurance studies were carried out to improve the care delivered in a PT health and wellness center where new technology was integrated to enable patients with neuromusculoskeletal impairments to maintain fitness and wellness, the two QA studies confirmed patients with mild to moderate PD could safely train at aerobic levels on the AlterG$_R$, the GlideTrak$_{TM}$ and the NuStep$_{TM}$-Vasper

Liked	Disliked	General Comments
NuStep$_{TM}$/Vasper		
Excellent supplement to AlterG$_R$ Works all body pats - forces one to work hard as intervals promote working to the maximum Self competition I liked the ability to sprint and use intervals to challenge myself Consistency of high level of training	No negatives Nothing that I disliked "I did not feel the high level of improvement as I heard reported by others" "Foot pedal straps did not hold for me"	Good exercise w/o impact "Loved it " - great workout "I can compete against myself and feel muscle tone in my arms" I have noted improvement of my leg strength I enjoy the workout and often feel the burn in my muscles when working out, but not sore afterwards
AlterG$_R$		
Positive health benefits "I can run without fear of falling - lots of sweating" "I can run again" The weightless feeling is great Feel psychological benefits I can do other things simultaneously (e.g., practice ball throwing/catching) "By controlling weightlessness and speed, I can walk at a better pace."	Having to deal with putting on shorts and their leaks (2) Questions of hygiene with shorts Running on treadmill versus running outside Pain to get in and out of rubber suit I generally don't enjoy working out on treadmills, even with un-weighting.	At 50% un-weighting, I have a feeling of "really running" Excellent - no fear of falling "I used to be a runner and with the AlterG^R, I feel like a runner again" "I was a 3 hour marathoner in the past; having to give up running has been the biggest loss due to PD" "AlterG^R gives me some of the restored running experience."

Table 9: Participants Qualitative Comments on the Vasper$_{TM}$-Vasper and the AlterG$_R$: Quality Assurance Study II.

Characteristics of Equipment/Work out*	NuStep$_{TM}$-Vasper	AlterG$_R$
Ease of using equipment	8.2 (1.9)	5.8(3.2)
Comfort during training	8.1 (1.5)	7.3(2.2)
Ease of making adjustments	7.8 (1.6)	7.9(1.4)
Getting used to equipment	8.7 (1.0)	7.8(1.5)
Ability to achieve intense workout	8.7 (1.6)	7.5(2.9)
Good challenge to balance	7.0 (1.6)	8.4(1.5)
Minimal post exercise soreness	8.6 (0.9)	8.1(1.5)
Receiving feedback re performance	8.4 (1.3)	8.0(1.4)
Recommendations/Preferences**		
Preference for using Vasper$_{TM}$ versus AlterG$_R$	75%	25%
Would purchase Vasper$_{TM}$ versus AlterG$_R$ for home use	75%	25%
If fitness center could only purchase one new piece of equipment, which would you recommend?	63%	37%

Table 10: Participant Evaluation of Equipment Characteristics and Workout on the NuStep$_{TM}$-Vasper Compared to the AlterG$_R$: Quality Assurance Study II.

*Rated on a scale of 0-10 with a 0 = difficult, poor and 10 = easy, excellent

**Proportion of participants indicating yes. Eight participants in Study II worked on the AlterG$_R$.

Note: Eight of 9 participants would like to use NuStep$_{TM}$-Vasper at home, recommend it to their friends and to community fitness centers.

Comparison by Training Groups	10 Meter Walk Speed (m/s)	6 Minute Walk Distance (m)	Timed Up and Go (s)	5 Times Sit to Stand (s)
NuStep$_{TM}$-Vasper and AlterG$_R$				
Mean Difference	0.50 (0.66)	-45.8 (62.2)	-4.10 (10.41)	-1.38 (5.62)
Effect Size	0.76	-0.74	-0.39	-0.25
Significance <8 or >37	Sum of ranks = 73; p<0.05 Sign NV>AG	Sum of ranks = 52.5; p<0.05 Sign AG>NV	Sum of ranks = 83; p<0.05 AG>NV	Sum of ranks = 63.5; p<0.05 Sign AG>NV
NuStep$_{TM}$-Vasper and GlideTrak$_{TM}$				
Mean Difference	0.12 (0.51)	8.4 (122.6)	-4.04 (10.29)	-2.28 (6.65)
Effect Size	0.23	0.07	-0.39	-0.34
Significance < 65 or >115	Sum of ranks = 70; p>0.05 NS	Sum of ranks = 53; p<0.05 Sign NV>GT	Sum of ranks = 65; p>0.05 NS	Sum of ranks = 62; p<0.05 Sign NV>GT

Table 11: Change in Mobility and Balance post Aerobic Training on the NuStep$_{TM}$-Vasper, AlterG$_R$ and the GlideTrak$_{TM}$: Quality Assurance Studies I and II.

Note: Compared with the AlterG$_R$, the quantitative gains in gait speed were greater post training on the NuStep$_{TM}$-Vasper but the gains in endurance and balance were greater post training on the AlterG$_R$. The gains in endurance and FTSTS achieved post training on the NuStep-Vasper$_{TM}$ were significantly greater than the gains achieved post training on the GlideTrak$_{TM}$.

cooling and compression. Following aerobic training, the participants significantly improved mobility (speed and endurance) and balance. Although the aerobic training was associated with mild to moderate training discomfort (urinary urgency on the Alter-G$_R$, uncomfortable pelvic support on the GlideTrak$_{TM}$ and some joint pains on the NuStep$_{TM}$-Vasper, the signs and symptoms associated with aging and

PD (e.g., pain) remained in the mild range. The participants reported they would like to have rehabilitation technology to use at home and in their community fitness center with a preference for the AlterG$_R$ over the GlideTrak$_{TM}$ and a preference for the NuStep$_{TM}$-Vasper over the AlterG$_R$.

Following these two QA studies, protocols for integrating rehabilitation technology into the clinic were more clearly defined. To facilitate improvement in walking speed, endurance and balance while minimizing the ground reaction forces on the lower limbs [31,35], the therapist could select either the AlterG$_R$ or the GlideTrak$_{TM}$. A more complete history on urological problems was added to the medical history to minimize urinary complaints specifically on the AlterG$_R$. All patients are asked to stop by the rest room before training on the AlterG$_R$ and each therapist discussed the potential feelings of urgency with each patient before training on the AlterG$_R$, particularly when planning to unweight up to 50% of body weight. Patients with a history of occasional incontinence are now asked to purchase their own training shorts for purpose of cleanliness and those with severe incontinence are asked to train on the NuStep$_{TM}$-Vasper or the GlideTrak$_{TM}$ instead of the AlterG$_R$. The therapist also educates patients about short bouts of progressive training to achieve comfortable support on the GlideTrak$_{TM}$. Before training, on the NuStep$_{TM}$-Vasper, the therapist inquires about neck, back or knee pain. Where necessary, the patient may be asked to wear a back or knee support during training.

Following quality assurance Study I, participant enthusiasm for rigorous, technological assisted aerobic exercise led to the creation of an intense aerobic exercise class (90 minutes) for patients with mild to moderate PD. In this class, over ground gait, balance, strengthening and coordination training are complemented with interval type aerobic training on the NuStep$_{TM}$-Vasper, the AlterG$_R$ or the GlideTrak$_{TM}$. Seven of the 9 subjects participating in QA Study II joined this PD Exercise group.

While all participants noted some discomfort with intense aerobic exercise, the discomfort with un-weighting was more bothersome on the GlideTrak$_{TM}$ than the AlterG$_R$. Although the participants were set up by the same therapist, a therapist who used the GlideTrak$_{TM}$ and the AlterG$_R$ regularly, the pelvic support was still not considered comfortable by some participants. To accommodate this adjustment, individuals start with a short training session (e.g., 5-10 minutes), with a slow increase to a session of 30-40 minutes. In addition, some individuals have elected to use the GlideTrak$_{TM}$ overground rather than over a treadmill. There is a bicycle model available for use outside (GlideCycle).

On the TUG, individual participants had variable performance. In Study I, the participants performed at a level similar to young controls (7.36±0.945 sec) suggesting maintenance was a more reasonable expectation than improvement [45,55,56]. In Study II, at baseline, performance was not as good as age expected norms. After training, participants significantly improved the TUG scores, performing better than the norms for individuals at risk for falling (18.14±4.6 sec) or individuals with an average age of 62.7 years (norm of 16.8 sec [±6.8]). A reduction of 2.3 seconds is considered a minimally significant improvement [55,56]. Also, initial performance on the FTSST was below normative values for the participants in Study II [56]. As in Study I, post training, mean scores were actually better than age matched normative performance. This was interesting given the aerobic workout was done in a sitting position on the NuStep$_{TM}$-Vasper.

One unique difference in the outcomes between the different technologically assisted aerobic exercise protocols related to energy level and resilience. More than 75% of the subjects experienced an increase in energy and resilience after training on the NuStep$_{TM}$-Vasper. To determine if this is a predictable outcome related to the features of the compression and cooling, additional research studies are needed. In terms of gait speed, the participants recruited for this QA study were independent in activities of daily living and active in the community. Their average gait speed fell into the community level of performance (>0.8 m/sec) [57-59].

A variety of community exercise programs have been established for patients with PD (tandem biking, "Delay the Disease" [Zid], Tango, Mark West Dance for PD, PWR!Moves^{TM}, Rocksteady Boxing, Tai Chi) [60-65]. Our quality assurance studies reinforce the benefits of specific, short term aerobic exercise protocols using different rehabilitation technologies to improve mobility and balance without exacerbating signs and symptoms of PD (e.g., pain). However, longitudinal studies with a large heterogeneous group of participants with PD would be needed to clarify if exercise (intense, aerobic or moderate) is neuroprotective for PD.

With physical inactivity as a primary health problem in the elderly [14,60-68], exercise must be a standard part of health care services not only for those that are aging but also for those with impairments associated with chronic neurological disease like PD. To enhance opportunities for physiological and neuromusculoskeletal change, exercise protocols should follow the principles of "overload" (e.g., speed, performance time, frequency, progressive difficulty) with adaptation to individual signs and symptoms and individual preferences [66,67]. Unfortunately, the effects of exercise are transient unless continued [68-70] wireless monitoring of mobility (e.g., pedometer, sleep, medication management) with occasional face to face visits for a review of exercises, may help with compliance along with the convenience of the fitness center location, efficiency of performance, time of day, safety, potential group support and positive feedback [70-71].

Study limitations

There were some limitations in these two methodological quality assurance studies. A small number of participants were included. The training period was short (daily for a week or twice a week up to 5 weeks for a total of 200 minutes) and the follow up was immediately post training without a longitudinal follow up. The findings can only be generalized to independent patients with mild to moderate PD (Hoehn and Yahr I-III) who are cognitively intact, independent at home and were functional community ambulators. The speed of fast walking of the participants was comparable to healthy age matched controls of 60-69 years (2.05 m/sec for males and 1.87 m/sec for females) [57-58]. However, on the six minute walk, the endurance was approximately 10% below age matched norms (60-79 years) [54]. This was potentially procedural given the six minute walk was performed in a space requiring participants to turn every 10 meters rather than the standard 30 meters. Given, patients with PD commonly have difficulty with turning; the increased number of turns could potentially explain the decreased distance walked.

These quality assurance studies have several potential confounding variables. All of the participants had previous training on the AlterG$_R$ but none had trained on the NuStep$_{TM}$-Vasper nor the GlideTrak$_{TM}$. However, this was not associated with a consistent preference for the

AlterG$_R$ over the other two pieces of equipment. In QA Study I, a cross over repeated measures study design lends itself to the possibility of residual training effects even when the order of training is randomized and separated by 3 months. Finally, some of the self report questionnaires regarding feedback about the technology and change in signs and symptoms were based on ordinal scores (0-10) and not based on standardized measurement instruments.

Falls were not measured as outcomes in these studies. The subjective reporting of falls as an outcome variable is usually based on self report. Unfortunately, when the information is collected from the subject after one to three months, the information is even more unreliable and generally only remembered when a fall was associated with an injury. In this particular population, the majority of the patients were Hoehn and Yahr I and II. Of the 20 participants who completed QA I and II, 17 were not fallers. However, there was one patient in Study I (Hoehn and Yahr III) and one patient in Study II (Hoehn and Yahr III) who were regular, daily fallers (2-3x/day). This had been their history for at least a year, yet they were still living independently. During the study period, the two participants continued to have falls but were either falling approximately every other day and the falls were not associated with a serious injury. In a controlled randomized trial, falls should be tracked carefully.

Objective posturography data was not gathered in these preliminary, unfunded quality assurance studies to assure the safety of incorporating new technology into a Health and Wellness Center. The time based clinical tests of balance (TUG and FTSST) can be used to inexpensively and objectively monitor improved balance performance and predict individuals at risk for falls [44]. However, in a controlled randomized clinical trial, objective posturography as well as more detailed kinematics of gait and balance tests would potentially increase the sensitivity of measuring improvement in outcomes in patients with PD following controlled intervention strategies.

Conclusion

Novel rehabilitation technologies such as un-weighting systems (e.g., the GlideTrak$_{TM}$, AlterG$_R$) and exercise under conditions of compression and cooling (NuStep$_{TM}$-Vasper) enable individuals with mild to moderate PD to safely exercise at aerobic levels. Post training, participants improved mobility and balance without exacerbating motor and non-motor signs and symptoms of aging and PD. Participants admitted there was some discomfort during the training, but perceived improvement in energy and resilience. New rehabilitation technology is more expensive than traditional fitness equipment; however with the increasing population of elders, it is important to create safe opportunities for all individuals to exercise aerobically, even those with neurological impairments associated with chronic disease such as PD. As the benefits of technologically enhanced aerobic exercise are documented and the demand for the technology increases, the cost of this technology should become more reasonable in price and more accessible in community sites.

Summary of Key Points

QA study I

Integrating bodyweight supported technology by AlterG$_R$ and GlideTrak$_{TM}$, individuals with mild to moderate PD

- Can achieve aerobic levels of training by jogging/running (HR$_{60\text{-}80\%}$ of maximum).
- Can improve mobility and balance without exacerbation of pain, in coordination, fatigue, tremor or freezing.
- May be associated with discomfort during training (e.g., pelvic discomfort relative to the pelvic support on the GlideTrak$_{TM}$ and urinary urgency in the AlterG$_R$ when un-weighted by 50%.
- Find it easier to adjust the AlterG$_R$ than the GlideTrak$_{TM}$.
- Recommend that community fitness centers integrate new rehabilitation technology to enable individuals with impairments to safely exercise aerobically.

QA study II

Participants with mild to moderate PD, can achieve aerobic levels of training doing reciprocal leg and arm movements under conditions of cooling and compression by NuStep$_{TM}$-Vasper Following 10 sessions of aerobic training on a reciprocal recumbent trainer under conditions of cooling and compression with NuStep$_{TM}$-Vasper, participants:

- Made significant gains in mobility, balance and resilience without exacerbating musculoskeletal pain, freezing or fatigue.
- Who trained on the AlterG$_R$ and the NuStep$_{TM}$-Vasper reported the NuStep$_{TM}$-Vasper to be easier to adjust, more comfortable to use and provided the opportunity for a more intense workout.
- Would recommend training on the Vasper$_{TM}$ to their friends and for purchase by community fitness centers.

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