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ORIGINAL ARTICLE

Effectiveness of a multimodal low–moderate intensity exercise rehabilitation program for stroke survivors

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Abstract
Introduction: The amount of people who survive a stroke is increasing annually. Persons with stroke suffer neurological deficits and a physical deconditioning that compromise walking ability, basic activities of daily living and health-related quality of life (HRQoL). The aim of the study was to determine the effects of a 12-week multimodal low–moderate intensity exercise rehabilitation program on walking speed, walking endurance and adherence to physical activity.
Material and methods: An observational repeated-measures design was used. The intervention consisted of 24 sessions of 1 hour per session two alternative days a week. A total of 31 participants were recruited and were evaluated at baseline, post-intervention and at six months follow up.
Results: Twenty-five participants completed the rehabilitation program. Significant improvements were found at the end of the intervention and those were maintained at six months on walking speed (10MWT $*p \leq 0.004$), walking endurance (6MWT $**p \leq 0.000$) and adherence (walking min/day $**p \leq 0.000$). Participants reported an overall satisfaction with the rehabilitation program of 94%: fitness, walking capacity, balance, accomplished expectations, satisfaction with the rehabilitation program, satisfaction with self-efficacy, learned strategies to improve QoL, adequate timing and would recommend the low–moderate intensity exercise rehabilitation program.
Conclusions: Promoting low–moderate intensity physical activity may be an interesting rehabilitation strategy for stroke survivors.

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PALABRAS CLAVE
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Efectividad de un programa de rehabilitación basado en ejercicio multimodal de intensidad moderada-baja para supervivientes de ictus

Resumen
Introducción: la cantidad de personas que sobreviven a un accidente cerebrovascular aumenta cada año. Las personas con ictus sufren déficits neurológicos y un desacondicionamiento físico que compromete la capacidad para caminar, las actividades básicas de la vida diaria y la calidad de vida relacionada con la salud (CdVRS). El objetivo de este estudio fue determinar los efectos de un programa de rehabilitación multimodal de 12 semanas de duración, basado en ejercicios de intensidad baja- moderada, en la velocidad de deambulación, la resistencia al caminar y la adherencia a la actividad física.
Material y métodos: estudio observacional de medidas repetidas. La intervención consistió en 24 sesiones de 1 hora de duración dos días alternos por semana. Se reclutó un total de 31 participantes que se evaluaron al inicio, después de la intervención y a los seis meses.
Resultados: veinticinco participantes completaron el programa de rehabilitación. Al final de la intervención se detectaron mejoras significativas de la velocidad de deambulación (10MWT $p \leq 0.004^{*}$), resistencia al caminar (6MWT $p \leq 0.000^{**}$) y adherencia (minutos de caminata/día $p \leq 0.000^{**}$). Estos resultados se mantuvieron a los seis meses. Los participantes manifestaron una satisfacción general con el programa de rehabilitación del 94% en relación a los siguientes ítems: condición física, capacidad para caminar, equilibrio, expectativas cumplidas, satisfacción con el programa, satisfacción con la autoeficacia, estrategias aprendidas para mejorar la calidad de vida, momento adecuado para participar en el programa y lo recomendarían a terceras personas.
Conclusiones: Promover la actividad física de intensidad baja-moderada puede ser una estrategia de rehabilitación interesante para los supervivientes de ictus.

Introduction

Global stroke epidemiology is changing rapidly. Although rates of stroke mortality have decreased worldwide in the past two decades, the absolute numbers of stroke survivors, referred as people who are living with the consequences of stroke are increasing. Over the 1990–2013 period, there was a significant increase in the absolute number of disability-adjusted life-years (DALYs) due to ischemic and hemorrhagic stroke.[1] The burden of stroke is high and is likely to increase in future decades as a result of aging of population. Physical inactivity is a major risk factor for cardiovascular disease (CVD) and stroke.[2] After a stroke it is recommended the promotion of lifestyle changes and the participation in exercise programs should be encouraged.[3] The guidelines recommend that adults get at least 150 min of moderate-intensity, such as brisk walking, or 75 min of vigorous-intensity aerobic activity (or an equivalent combination) per week and perform muscle strengthening activities at least 2 days per week.[4] It is known that High Intensity Training (HIT) has significant effects in stroke recovery.[5] However, HIT could favor the risk of cardiovascular failure, falls and long term loss of adherence. It has been described beneficial associations between low intensity physical activity (PA) and health benefits such as CVD risk factors.[6,7] It also has been described remarkable effects on reducing disease symptoms with low–moderate intensity therapeutic exercise[8] In this context low to moderate intensity exercise training is considered as a sustainable and beneficial rehabilitation strategy for being safe.[9]

Additional benefits occur with more intense exercises as HIT, but the marginal benefit is less than that observed with increases in PA at lower levels, as low to moderate-intensity continuous training (for example, changing from not doing exercises to walking 10 min/day).[10] Benefits from PA are seen for all ages and groups, including older adults, and people with disabilities and chronic conditions.[11,12] PA reduces premature mortality, improves risk factors for cardiovascular disease (CVD) (such as high blood pressure and high cholesterol), and reduces the likelihood of diseases related to CVD, including stroke, coronary heart disease (CHD), type 2 diabetes mellitus (DM), and sudden heart attacks.[10] After stroke, a progressive aerobic deconditioning occurs that difficult the recovering of walking ability and basic activities of daily living (ADLs) and which worsens cardiovascular (CV) risk and quality of life (QoL).[13] Although PA is beneficial in stroke recovery, stroke survivors often do not receive PA recommendations after hospital discharge.[2] Potential approaches to improve this situation include outpatient structured rehabilitation exercise programs that include walking training[14] and endurance training.[15] Numerous studies have demonstrated the efficacy of aerobic exercise[16] and resistance training (RT).[17] It has been suggested that RT in stroke survivors can improve muscle resistance but may be it does not turn into a functional improvement.[2] Therefore, there is strong evidence for exercise rehabilitation interventions favoring repetitive specific task-oriented training targeted on muscles that participate in a functional movement with deficit (e.g., to perform sit-to-stand transfer or stair climbing); muscular changes are activated with the performed task.[18] There are few data on the long term effects of multimodal programs that incorporate aerobic exercise, complemented by task-oriented training and neuromotor training (including balance and tonic postural activities, flexibility, dynamic and static stretching and breathing), at low–moderate intensity. Therefore, the purpose of this study is to investigate the impact of a multimodal low–moderate intensity exercise rehabilitation program (LIERP) tailored to stroke survivors on walking speed and walking ability.

Material and methods

We conducted an observational study with a repeated measures design to evaluate changes on walking speed and walking ability after a multimodal low-intensity exercise rehabilitation program. Assessments were performed at baseline, post-intervention and at 6-month follow-up. To calculate simple size, according to the literature review, the change in the main outcome was determined of 0.175 m/s[19]; considering a 95% confidence interval (CI) the sample required was of 29 participants (20% lost adjusted). Thirty-one participants were recruited from Hospital-Consorci Sanitari de Terrassa (Barcelona, Spain) over a period of one year. All of them had suffered a stroke and had completed a conventional rehabilitation program.

Inclusion criteria were: diagnosis of ischemic or hemorrhagic stroke; both genders; age $\geq$18; Functional Ambulation Classification (FAC) $\geq$3; Barthel Index $\geq$45. Exclusion criteria were: cognitive impairment (Mini Mental State Examination $\leq$24); unstable cardiovascular disease (acute heart failure, recent myocardial infarction, unstable angina and uncontrolled arrhythmias)[20,21]; alcohol or other toxic substances abuse and decompensated psychiatric disorders that prevented from following a group session.

Before the enrolment, participants underwent a medical examination to ensure that there were no circumstances that prevented their participation in the program, following the recommendations of the American College of Sports Medicine (ACSM) for patients with cardiovascular disease[22] and the guidelines of the American Heart Association for stroke survivors.[20]

All experimental procedures were conducted according to the Declaration of Helsinki.[23] The study was approved by the Ethics and Clinical Research Committee of Hospital-Consorci Sanitari de Terrassa. All participants provided written informed consent for the study.

Outcome measures

Gait speed

Gait speed was measured with the ten meter walking test (10MWT). The test was standardized according to the Locomotor Experience Applied Post-stroke Guidelines.[24] Participants were given a 2-m warm-up distance for walking, preceding the 10-m distance, and 2 m beyond the 10 m. The time that takes to walk 10 m at a comfortable pace and at their maximum speed were registered. Each measure was repeated twice and the average of the two distances was calculated in m/sec. Gait speed measures were found to be highly reliable and with a high test–retest reliability.[25]

Walking endurance

The six-minute walking test (6MWT) was originally developed and validated as a submaximal oxygen consumption test for individuals with cardiac or pulmonary disease.[26] It has been considered as a measure of peak aerobic fitness.[27] The 6MWT is an assessment of the distance walked over a period of 6 min and is also considered a clinically useful measure of walking ability poststroke.[28] It was performed over a 25 m-straight walkway. Heart rate (HR), oxygen saturation and blood pressure were measured sited before and after the test. The test was standardized according to the American Thoracic Society Guidelines.[29] The clinometric properties of the 6MWT in individuals post-stroke, has been examined by various authors. In community dwelling subjects with chronic stroke was reported to be highly reliable and with a high test-retest reliability.[30,31]

Adherence to physical activity

The adherence to the LIERP was reported by registering the walking time and the sitting time. The register was done by IPAQ Questionnaire.[32]

Participants' self-reported satisfaction

After the intervention participants were administered an ad-hoc self-reported satisfaction questionnaire. The objective was to assess their satisfaction with the LIERP in relationship with the benefits obtained (improvement of physical fitness, walking capacity, balance, expectations and self-efficacy).

Procedure

Following the American College of Sports Medicine (ACSM) approach,[33] our intervention is categorized as a multimodal, as combines aerobic, resistance and neuromotor exercises such as: (1) aerobic – including brisk walking, stair step exercise and, autonomous outdoors walking/hiking; (2) resistance – including task-oriented training against resistance provided by the body weight (gravity's resistance) and (3) neuromotor – including tonic postural activities, flexibility, dynamic and static stretching and breathing. The LIERP was conducted at Hospital-Consorci Sanitari de Terrassa (Barcelona) and delivered as a supervised multimodal program at the Rehabilitation Unit. It consisted of a 12-week intervention of two alternate days a week, in sessions of 1 hour (24 sessions in total). Participants exercised 120 min/week, as has been recommended for low to moderate intensity in healthy adults.[33] The intervention was performed in groups of 4–6 participants with a physical therapist who guided the session.

The multimodal program was adapted to the characteristics and capacity of each participant. It consisted of four workstations:

1. Warm up and aerobic exercise (25 min): stationary bicycle, walking as fast as possible on a circuit with obstacles, ramps, stairs and irregular ground.
2. Resistance training and task-oriented exercises (15 min) to strengthen muscular groups that participate in different tasks, performed in 8 repetition series:
   (1) Steps: short bouts of stair climbing to train the task of climbing stairs.
   (2) Sit-to-stand: to train the task of sitting down and getting up from a chair.
   (3) Balance on tiptoe: to train the propulsion phase of gait.
3. Neuromuscular exercises (20 min):
   (1) Balance and tonic postural activities (on the floor and on unstable ground planes).
   (2) Stretching exercises.
   (3) Furthermore, participants received indications on progressive daily ambulation to achieve a high rate adherence. The aim was to reach the levels of physical activity recommended by the World Health Organization (WHO)[4] of 150 m/week of moderate physical activity.

To calculate the intensity of exercise, we estimated the maximum heart rate (MHR) with the 220-age equation. Based on the recommendations of the ACSM[21] and the American Heart Association (AHA),[20] for older adults and stroke survivors participants, they were trained to work at a low–moderate intensity. To ensure the optimal control of HR during workouts participants were monitored at the target heart rate zone (50–60% MHR). Monitoring was used as a feedback for a learning process toward self-regulation. Participants were also trained to use the Borg scale of perceived exertion.[34] The objective was to achieve patients' self-regulation of their own exertion level and effort, especially in those taking beta-blockers, thyroid hormone or with a pacemaker. Participants were trained at an intensity of 6–7/10 in the Borg's scale with a self-perceived effort of ''difficult-hard'' and rest periods as needed. The physiotherapist asked regularly how intense was the effort for the participant. This measure has been used in patients who have suffered myocardial infarction at the beginning of a cardiac rehabilitation program.[35,36] The objective was to achieve self-efficacy in the ambulation program at home and, therefore, adherence to the rehabilitation program.

At the end of the intervention, participants filled in a satisfaction questionnaire. After the intervention and until the six-month follow-up, participants were contacted by phone monthly to promote adherence to the LIERP and to the progressive daily ambulation program. The aim was to solve any problem or question that might arise.

Statistical analysis

The Statistical Package for the Social Sciences (SPSS) version 21.0 (SPSS Inc, Chicago, IL, USA) was used for data analysis. Participants' demographic, clinical and functional data were analyzed using descriptive statistics: quantitative variables with the mean, SD and range (minimum–maximum); frequencies and percentages were used to define qualitative and dichotomous variables. A repeated-measures ANOVA was carried out on the data. Assumptions of normality, homogeneity of variance and sphericity were met with Kolmogorov–Smirnov test. The confidence interval (CI) was set at 95%. A p-value <0.05 was considered statistically significant. The effect size was estimated using Cohen's d for quantitative variables as follows: values up to $\leq$0.2 small, 0.5–0.8 medium and >0.8 large.[37]

Results

Characteristics of participants

A total of 31 participants were enrolled. Five participants withdrew (one underwent eye surgery and four due to transportation difficulties). Twenty-six participants completed the intervention but one participant was excluded due to the diagnosis of a neurodegenerative disease. Adherence rate during the rehabilitation program was of 95.67% of the sessions. Twenty five participants were assessed at the end of the intervention. Twenty participants completed the three assessments. Five participants dropped out (two had medical problems and were admitted to hospital, one was not interested and two were not located). No adverse effects were observed during the intervention. Sociodemographic data of participants were as follows: the mean age was of 66 ($\pm$11); there were 19 (76%) males and 6 (24%) females; 22 (88%) had suffered ischemic stroke and 3 (12%) hemorrhagic stroke.

Outcome variables

Table 1 shows the effects of the multimodal exercise rehabilitation program on outcome measures. Statistically significant improvements were observed in all variables.

Gait speed

Comfortable gait speed, assessed with the 10MWT significantly improved at the end of the intervention and was maintained six months later, with an increase of 0.16 m/s at the end of the intervention and 0.23 m/s at 6-month follow-up (* $p \leq .05$).

Improvements in fast gait speed (** $p \leq .001$) were found at the end of the intervention and were retained six months later: with an increase of 0.40 m/s at the end of the intervention and 0.44 m/s at 6-month follow-up.

Cohen's d effect size found in comfortable and fast walking speed between pre- and post-intervention was of medium size. At six-month follow-up, the effect was large at comfortable speed and medium at fast speed.

Walking endurance

Walking endurance measured with the 6MWT significantly increased (** $p \leq .001$) at the end of the intervention and was maintained six months later: with an increase in walking distance of 59.8 m at the end of the intervention and of 43.5 m six months later. Cohen's d effect size was large post intervention and medium at six months.

Table 1 Effects or the multimodal exercise rehabilitation program.

Mean (SD) Percent	Baseline	Post-intervention	Follow-up	*p*	Cohen's *d*	
N	25	25	20		B-P	B-R
Walking speed						
m/seccomfor	0.83 (.24)	0.99 (.18)	1.06 (.23)	0.004*	0.75	0.97
m/secfast	1.10 (.39)	1.50 (.64)	1.54 (.86)	0.000**	0.75	0.65
Walking endurance						
6MWT (m)	315.75 (64.40)	373.55 (68.30)	359.25 (91.31)	0.000**	0.87	0.55
Adherence PA						
Walking min/day	42.16 (±30.38)	76.03 (±39.04)	49.72 (±35.44)	0.000**	0.96	0.22
Sitting min/day	318.95 (±130.98)	223.50 (±122.52)	292.50 (±170.78)	0.003*	−0.75	−0.17

m/secconfor: meters/second at comfortable walking speed; m/secfast: meters/second at fastest speed; m: meters; min: minutes; PA: physical activity.
Test: repeated measures ANOVA; significant difference $*p \leq 0.05$;$**p \leq 0.001$; Cohen's *d*, B-P: baseline-post-intervention; B-R: baseline-retention.

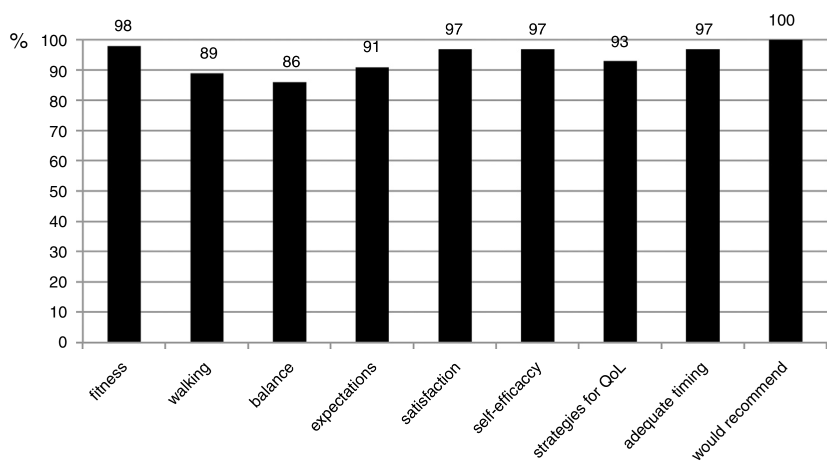

Figure 1 Participants self-reported satisfaction.

Adherence to physical activity

Adherence to physical activity was evaluated by IPAQ questionnaire. At the beginning of the intervention participants had a sedentary lifestyle: 28% of the participants along the day, only walked indoors, remained sitting at home or resting in bed. The remaining 78% walked outdoors only short distances at low energy expenditure intensity. At the end of the intervention the situation improved: all participants walked outdoors 30 min/day at least, with an overall increase of 80% of walking min/day. Six month later there was a trend toward sedentary lifestyle with an overall a decrease of walking time in relation to the beginning of the intervention. Cohen's *d* effect size in walking time was large post intervention and low at six months. Cohen's effect size in sitting time was negative because it refers to the reduction of sitting time and this indicates the positive effect of the intervention.

Participants' self-reported satisfaction

Participants reported an overall satisfaction with the LIERP of 94% (fitness, walking capacity, balance, accomplished expectations, satisfaction with the rehabilitation program, satisfaction with self-efficacy, learned strategies to improve QoL, adequate timing and would recommend the LIERP) (Fig. 1).

Discussion

The main finding of this study is that application of the LIERP in the subacute and chronic phase of stroke is associated with statistically significant and clinically meaningful increase in walking speed and walking distance. As suggested by Ivey and Macko,[13] stroke survivors suffer a severe degradation of physical condition and low improvements of fitness could notably improve walking endurance. An increase in gait speed in the 10MWT of 0.175 m/s or greater, in people with stroke undergoing outpatient rehabilitation, has been estimated as a meaningful improvement in walking ability.[19] A change in walking distance of 30.1 m has been considered a clinically important difference in the 6MWT.[38] This coincides with the results obtained in this study: the increase in walking speed and walking distance at the end of the intervention allows participants a functional outdoors ambulation. At the beginning of the intervention, participants had a sedentary lifestyle, at most participating in low energy expenditure activities such as walking outdoors small distances at a low gait speed. At the end of the intervention, all participants were able to walk independently outdoors longer distances at a faster gait speed. These results, besides, are maintained at six month follow up indicating a good adherence to the program. The results suggest that high adherence rates achieved in the LIERP program may have led to better walking speed and walking endurance outcomes. These findings justify the importance to consider the most prominent predictors of exercise adherence. This issue is especially important among the elderly suffering stroke where the lowest adherence is registered. Our study coincides with the recommendations of the US Department of Health Services that suggests that increasing physical activity at lower intensity levels (changing from nothing to walking 10 min/day is beneficial).[10] The low–moderate intensity of the program could have facilitated participants' engagement to the ambulation program at home, the reduction of the inactivity and overall satisfaction with the program. As concluded English it is important to reduce sitting time in order to reduce cardiovascular risk and improve stroke's recovery.[39] Therefore, at six month follow-up it is observed a trend toward a reduction of walking time comparable to similar studies.[40] It has been reported that persons with disabilities have lower QoL due to physical weakness and immobility and that regular exercise facilitates a better QoL.[41] Therefore, it is important to establish strategies to promote physical activity in persons with disabilities such as stroke survivors. In particular, it would be very meaningful to establish a promotion strategy for these people who are not yet feeling the need for physical activity. The LIERP is a multimodal rehabilitation intervention aimed to promote a healthy lifestyle as a secondary prevention for stroke survivors in chronic phase. The innovation of this study is that it demonstrates that low–moderate intensity physical activity improves functional capacity of stroke survivors. It is targeted to different aspects of physical condition: aerobic, task-oriented strengthening muscles involved in impaired function (sitting and standing up, climbing stairs and propulsion phase of gait) and balance in order to promote a relearning of the impaired function and transfer gains to activities of daily living. Considering physical inactivity and functional decrease after stroke,[42] the modality of multimodal low–moderate intensity exercise program facilitates long term adherence, reducing sedentary lifestyle and acting as secondary prevention of stroke. In spite the fact that at six months there was a trend toward decreasing walking time, we believe that the low–moderate intensity allows personalize the intensity of exercises to fit the individual needs of the participants and promote long term adherence. This coincides with other authors who conclude that it is possible to improve recovery using multimodal interventions in chronic phase after a stroke.[43] This is a wide-range exercise protocol aimed at improving upright physical mobility in people with stroke. Besides, is a very efficient group intervention in terms of personnel resources involving only one therapist who led a session with 4–6 participants.

The main limitation of the present study is the lack of a control group, as improvements at the end of the intervention could be partially due to a spontaneous recovery. For further studies, randomized trials would be required to confirm the benefits of multimodal low–moderate intensity exercise rehabilitation programs.

The sample is small due to the difficulty of recruiting participants, as they had transport difficulties to come to the rehabilitation unit on their own. This may reduce the generalizability of results. Given the difficulty of recruiting larger samples in a single center, it would be interesting for future research to conduct multicenter randomized trials and to explore the effects of multimodal exercise rehabilitation programs on QoL.

Conclusion

Physical activity is an important component of the rehabilitation process. Physical exercise of low–moderate intensity is associated with enhanced gait speed, walking endurance and adherence to physical activity. Exercise programs for community people who have suffered stroke and self-managed rehabilitation strategies should be implemented to maintain the gains made in rehabilitation programs and adherence to exercise programs.

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Conflict of interests

Authors declare that they do not have any conflict of interests.

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