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ORIGINAL REPORT

EFFECT OF RESISTANCE TRAINING THROUGH IN-PERSON AND TELECONFERENCING SESSIONS IN REHABILITATION OF ACUTE STROKE PATIENTS

Nikolaos KINTRILIS[1], Antonis KONTAXAKIS[2] and Anastasios PHILIPPOU[1]

From the [1]Department of Physiology, Medical School, National and Kapodistrian University of Athens, Athens, Greece and [2]Physical and Rehabilitation Medicine Department, 414 Military Hospital of Special Diseases, Penteli, Greece

***Objective*: To determine whether application of a strength training regimen yields measurable results on stroke survivors and compare different methods for the proposed intervention.**
***Design, Patients and Methods*: Ninety stroke patients were recruited from the neurological clinic of a local third-level clinic. Sixty patients participated in a strength training regimen with trainings taking place 3 times a week for 12 weeks with the use of resistance bands. Thirty of these patients were given face-to-face sessions and 30 patients were given trainings through an on-line platform. The last 30 patients who comprised the control group only followed usual care after the stroke.**
***Results*: The applied strength regimen had a statistically significant effect on Visual Analog Scale scores of stroke patients who received it ($p = 0.009$), as well as in the teleconferencing group ($p = 0.004$). The measured arteriovenous oxygen difference was elevated for stroke patients who received the intervention as a whole ($p = 0.007$). Patients who were trained in person and the ones who were trained via teleconferencing yielded similar results as evaluated through the VAS index.**
***Discussion and Conclusion*: Administration of strength training 3 times weekly for 12 weeks to stroke patients yielded measurable results in terms of general function and quality of life.**

Key words: stroke; rehabilitation; anaerobic/strength training; resistance bands; telemedicine; telerehabilitation.

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Correspondence address: Nikolaos Kintrilis, Department of Physiology, School of Medicine, National and Kapodistrian University of Athens, Mikras Asias 75, GR-115 27 Athens, Greece. E-mail: nikoskint@hotmail.com

LAY ABSTRACT

The present article examines how anaerobic exercise can be implemented in rehabilitation regimens of patients recovering from a stroke and ways through which it can be delivered to patients. Results of the study suggest that patients can benefit from anaerobic training, whether this is delivered in person or through telemedicine techniques.

Stroke is an acute disease, unique in the way that survivors commonly suffer from persistent disabilities, which critically affect their everyday life and general level of function. Post-stroke health implications include a plethora of cardiovascular, respiratory, cognitive and mobility manifestations. Symptoms include but are not limited to negative effects on balance and coordination, walking, upper and lower limb function, and performance of daily activities (1). According to the World Stroke Organisation (WSO) fact sheet from last year, stroke does not only remain the second-leading cause of death worldwide but also the third-leading cause of death and disability combined, with substantial increases in incidence, mortality and disability-adjusted life-years (DALYs) lost in the last 3 decades (2). According to the existing medical literature, especially randomized control trials (RCTs), post-stroke rehabilitation interventions are currently established as a mainstay of treatment to aid improvement of general function and physical condition and reduce complications. At the same time, application of such interventions can aid toward the direction of reduced financial burden of acute stoke, both by reducing length of stay in the hospital and by minimizing DALYs lost from the disease (3–7). Key priority in the setting of stroke rehabilitation services is the formation of a personalized approach for each patient, driven by a multidisciplinary team of professionals with clinical expertise in the field, including attending physician and nurses, physiotherapists and occupational therapists, speech therapists, psychologists and social workers (8–10).

The goal of recovery in stroke rehabilitation is to enhance the patients' functional, cognitive and mobility status in order to achieve a level of everyday life similar to the one before the disease (11). Aerobic exercise is defined by the American College of Sports Medicine (ACSM) as "any activity that uses large muscle groups, can be maintained continuously and is rhythmic in nature" (12). Aerobic exercise is recommended in the American Heart Association/American Stroke Association (AHA/ASA) Guidelines as a part of post-stroke rehabilitation training regimens. At the same time, aerobic exercise seems to improve cognitive and executive function among stroke patients. Current recommendations suggest that aerobic trainings are executed on most days of the week for a minimum of 8 weeks after the incident, at an intensity which is gradually greater (13–15). Anaerobic, strength or resistance exercise is defined by the ACSM as "short, intense physical activity that is fuelled by energy sources within the contracting muscles". There is a paucity of data in the current medical literature regarding the incorporation of strength training as a mode of exercise within effective stroke rehabilitation programs (16). However, strength training has been shown to aid the process of functional, psychological and social recovery, which in turn leads to overall improvements in the quality of life of affected patients. It is therefore vital that both exercise modalities be included in the context of stroke rehabilitation programs (17, 18).

Home-based rehabilitation programs have been applied during the last decade as a means of reaching out to stroke survivors with limited access to rehabilitation services due to geographic, financial or mobility limitations. Promising results have been demonstrated in the context of patient satisfaction as well as cost effectiveness of such interventions (19). Telemedicine and telerehabilitation platforms have seen important improvements in the last years owing to the challenges posed by the coronavirus pandemic. Electronic devices and virtual reality tools have been shown to yield positive results when it comes to stroke rehabilitation at a home setting, a field in which we aim to contribute with this study (20–22).

METHODS

Patients

Ninety acute stroke patients (male sex: 52.2%) were recruited for the needs of this study from the neurological clinic of a third-level greek clinic. For the purposes of this study, acute stroke patients were defined as individuals being hospitalized for symptoms of symptomatic neurological dysfunction with evidence of acute infarction or hemorrhage on imaging examinations. Patients were excluded from this study if any of the following conditions were present:

- pre-existing neurological conditions that could also affect the patient's quality of life (e.g. multiple sclerosis, dementia, Parkinson's disease, etc.)
- comorbidities that could also affect the patient's quality of life, whether they occurred before or after the stroke (e.g. uncompensated cardiovascular disease, musculoskeletal disease)
- comorbidities uncontrolled through pharmacologic treatment (e.g. uncontrolled diabetes mellitus, uncontrolled hypertension)
- language or communication barriers
- inability to follow directions or to participate in the exercises (e.g. visual problems, dementia)

Patients who fulfilled the eligibility criteria of this study were assigned into 3 categories, 2 study groups and 1 control group. More specifically, 30 patients were assigned to study group 1 (G1) and followed a strength resistance training program with in-person sessions, 30 patients were assigned to study group 2 (G2) and followed a strength resistance training program via telecommunication, and the remaining 30 patients comprised the control group (G3) and only received traditional post-stroke care. For the needs of the telerehabilitation, an online telecommunication platform (Skype version 8, Skype Technologies, Microsoft, US) was used. Patients were assigned at random in the 3 groups and confidentiality was assured by giving a unique number to each patient for the study needs. The researcher who randomized the patients did not have access to patients' names, only to the individual numbers.

Examination of the parameters included as dependent variables in the study took place at 2 time points for each participant, once on discharge day and once 3 months after discharge. Testing on discharge day was performed at the hospital and testing at the second stage took place at each individual's environment, usually their residence. During the initial assessment, after confirmation of participation eligibility, each patient was informed about the study, explained the concept and provided written consent for participation. The researcher who performed the testing for each patient remained blind to allocation and did not know in which group they belonged. Demographic data, full personal medical history as well as documentation of the examined parameters was taken. Each patient was invited for a second examination 3 months after initial evaluation and the procedure was repeated.

Parameters examined

- Quality of Life Assessment: The greek version of the EuroQol – 5 Dimension (EQ-5D) questionnaire was adopted. The EQ-5D descriptive questionnaire is a quality-of-life measure with 1 question for each of the 5 dimensions that include mobility, self-care, usual activities, pain/discomfort, and anxiety/depression. This questionnaire also includes a Visual Analog Scale (VAS), where patients can report on their perceived health status with a grade ranging from 0 (worst possible health status) to 100 (best possible health status). The VAS score was the component of the questionnaire that was used for the purposes of this study. (23–25).
- Mobility Assessment: For evaluation of the patients' mobility status, the following tests were implemented.
  - **Timed Up and Go Test (TUG):** TUG is a functional test designed to assess mobility status among elderly or sick populations. The test records the time needed to rise from a chair, walk 10 feet (3 m), turn and sit on the chair again (26, 27).

- **Berg Balance Scale (BBS):** BBS is a widely used functional test to assess a person's balance, based on execution of 14 predetermined simple tasks (28, 29).
- **Chair Stand Test (CST):** CST is a functional test to determine a person's leg strength and endurance. The participant, sitting in the middle of a chair, places his hands crossed on opposite shoulders and keeps feet flat on the floor. With a straight back, the patient rises to a full standing position and then returns to the seated position. The process is repeated for a duration of 30 s and the number of repetitions is documented (30, 31).
- **Six Minute Walk Test (6MWT):** 6MWT is an aerobic exercise test designed to assess aerobic capacity and endurance, where the distance covered in a 6-min duration is documented (32, 33).

- Cardiorespiratory Function Assessment: For evaluation of the patient's cardiorespiratory status, the arteriovenous oxygen difference (A-VO_2) was calculated. The measurement has been proven to increase progressively during exercise, indicating an increase in the oxygen extracted from the blood by muscle. According to the Fick principle, oxygen consumption (VO_2) is the product of cardiac output (CO) and the A-VO_2. In other words,

  VO_2 = CO x (A-VO_2) (34–36)

Intervention

Patients in G1 followed a strength training program that took place 3 times a week for a duration of 12 weeks. Each session included a warm up period of 3–5 min, followed by 8 exercises, each 1 performed for 12 repetitions. Another 3–5 min were devoted to cooldown, giving a total of about 30 min for each session. Training intensity was moderate, with a target heart rate between 50 and 70% of the patient's maximum heart rate (220 beats per minute minus the person's age) (37–39). A member of the research team with the capacity of a physical medicine and rehabilitation (PM&R) physician was present during the intervention and was giving face-to-face instructions for the duration of the study. Prior to initiation of the regimen for the first time, a demonstration of the equipment was performed, in order to assure proper handling by the individuals participating in the study.

For the needs of the strength training, a set of elastic resistance bands was used. The exercises performed by the participants included the following:

- Lower body exercises: leg extension – right leg, leg extension – left leg, seated abduction
- Upper body exercises: bicep curl – right arm, bicep curl – left arm, tricep extension – right arm, tricep extension – left arm
- Back exercise: seated row

Instructions on how to perform each exercise can be found online. The instructions were followed for each exercise and the setting was similar, with the exception of exercises where the patient had to lie down, which were performed on a mattress or bed (40).

Patients in G2 followed the exact protocol for strength training, with the only difference that an investigator was providing directions through an online communication platform as described previously. For patients who had difficulties establishing the video conference, the aid of a relative or caregiver was employed.

Patients in G3 did not participate in a strength training regimen and only received usual post-stroke care at home.

Data analysis

Comparison of numerical parameters was performed using ANOVA-test and the affected side distribution was compared via χ^2 test. Comparison of quality of life and significance of the difference were calculated via Mann–Whitney *U* test. For the purposes of the study, a significance level at $p=0.05$ was established. Individuals with missing data for any of the required fields were removed from the study. All statistical processing was carried out using the statistical package SPSS version 27 for Windows (IBM, Chicago, IL, USA).

RESULTS

General characteristics

Baseline characteristics of the study participants are depicted in Table I. There were no significant differences observed among the 3 groups regarding basic patient characteristics.

Effects of strength training

The effects of our intervention on the whole group who participated in the strength training sessions as well as each of G1, G2 and G3 are depicted in Table II. The applied strength regimen had a statistically significant effect on VAS scores of stroke patients ($p=0.009$), which was also proved for G2 ($p=0.044$). In G1 and G3 the effect was not statistically significant. TUG test times were also improved for stroke patients as a whole ($p=0.007$): an effect which remained statistically significant for G3 ($p=0.005$) but not for the 2 groups who conducted strength exercises. BBS and CST tests showed no statistically significant results after application of the strength regimen. The distance covered in the 6MWT was improved for stroke patients as a whole ($p=0.001$) as well as for patients in G3 who did not perform strength exercises ($p=0.004$). Finally, the measured arteriovenous oxygen difference (A-VO_2) was elevated for stroke patients as a whole ($p=0.007$) but not in each of the 3 separate patient groups.

Differences between patient groups

There were no significant differences observed between the group that received in-person and the group that received teleconferencing strength training. G1 and G2 yielded similar results as evaluated through the VAS index, the 4 functional tests and the A-VO_2. The VAS index and the A-VO_2 were similar when G1 vs G3 and G2 vs G3 were compared. In other words, the strength regimen followed by the participants of the study did not alter VAS scores and A-VO_2, regardless of the way through which it was administered. Regarding the functional tests, patients who followed an in-person strength training regimen scored lower than patients who only received standard care in 2 of them before (*p*-values for TUG, CST were 0.001 and 0.014, respectively) and 3 of them after the intervention (*p*- values

Table I. Baseline characteristics of the patients

	Total ($N=90$)	Group 1 ($n_1=30$)	Group 2 ($n_2=30$)	Group 3 ($n_3=30$)
Age, years	64.8±12.6	64.9±10.7	64.1±13.6	65.4±13.8
Male sex, *n* (%)	47 (52.2)	16 (53.3)	15 (50.0)	16 (53.3)
Height, m	1.64±0.72	1.65±0.79	1.64±0.75	1.64±0.63
Weight, kg	80.1±16.0	78.4±12.5	80.7±17.0	81.1±18.2
BMI, kg/m^2	29.7±6.2	28.6±3.9	30.4±7.2	30.2±7.1
Type of stroke, *n* (%)				
Ischemic	80 (88.9)	27 (90.0)	26 (86.7)	27 (90.0)
Hemorrhagic	10 (11.1)	3 (10.0)	4 (13.3)	3 (10.0)
Affected side, *n* (%)				
Dominant	47 (52.2)	18 (60.0)	13 (43.3)	16 (53.3)
Non-dominant	43 (47.8)	12 (40.0)	17 (56.7)	14 (46.7)

for BBS, CST, 6MWT were 0.021, 0.009 and 0.001, respectively). Patients who belonged in the teleconferencing group had no differences in functional tests before the intervention but also scored lower at CST and 6MWT tests (p -values were 0.009 and 0.005, respectively).

DISCUSSION

In this study we set out to explore how a strength training regimen applied at regular intervals for 12 weeks affected stroke patients' perception of life quality as well as general function. Two ways of administering the intervention were provided, through in-person training (G1) and through telecommunication (G2). The smaller patient groups that received each form of intervention were compared with each other, as well as with a third control group (G3), which only received standard post-stroke care. Session times for patient groups G1 and G2 were approximately 30 min and trainings were conducted 3 times a week for 12 weeks.

Our research indicated substantial changes in the perceived quality of life as measured by VAS scores as well as general function as evaluated through functional tests. More specifically, patients who followed the strength training regimen (regardless of the way through which this was administered) performed better after 12 weeks in all 4 functional tests, with scores for 2 of them (TUG and 6MWT) reaching the level of statistical significance. However, the control group (G3) performed better on some of the functional tests (TUG, CST before as well as BBS, CST, 6MWT after the intervention) than G1. The same result was found after the intervention for G3 versus the teleconferencing group (G2) for CST and 6MWT. Although this is a finding we did not anticipate, there is available literature suggesting that not all applied strength training regimens improve functionality, as well as not all strength gains from strength training in stroke patients can be transferred to gains in functional capacity (41, 42).

Regarding the way through which strength rehabilitation was administered, no statistically significant differences

Table II. Mean values and Standard deviations of physical health and general function for each patient group before (discharge day) and after completion of the intervention (3 months after discharge)

	All patients with intervention (G1 + G2)	Group 1 ($n_1=30$)	Group 2 ($n_2=30$)	Group 3 ($n_3=30$)	*p* G1 vs G2	*p* G1 vs G3
VAS, score (0–100)						
Before	58.1±22.2	58.1±15.3	54.6±25.2	61.6±25.2	0.518	0.521
After	65.9±17.5	63.7±17.2	66.2±17.8	67.9±18.1	0.577	0.360
p	0.009	0.187	0.044	0.268		
TUG, time (s)						
Before	19.3±2.8	18.2±2.3	19.6±3.5	20.1±2.0	0.067	0.001
After	18.3±2.4	18.1±2.3	18.3±2.4	18.4±2.5	0.743	0.562
p	0.007	0.848	0.089	0.005		
BBS, score (0–64)						
Before	38.3±10.5	39.9±8.6	39.1±11.8	36.0±11.1	0.765	0.136
After	38.6±6.9	37.4±7.5	38.7±6.6	39.7±6.9	0.489	0.021
p	0.836	0.240	0.872	0.126		
CST, repetitions						
Before	12.3±3.9	13.3±4.2	12.7±4.2	12.9±3.2	0.601	0.014
After	12.9±3.8	11.8±4.0	13.5±4.1	13.4±3.2	0.104	0.009
p	0.295	0.161	0.458	0.303		
6MWT, distance (m)						
Before	273.1±81.5	272.6±73.1	270.1±85.9	276.7±88.8	0.904	0.848
After	312.1±66.7	286.1±32.0	308.7±71.5	341.4±77.8	0.120	0.001
p	0.001	0.359	0.064	0.004		
(A-VO$_2$), mL/100 mL						
Before	4.7±0.9	4.7±0.9	4.7±0.9	4.7±0.9	0.899	0.989
After	5.0±0.9	5.0±0.9	5.0±0.9	5.0±0.9	1.00	1.00
p	0.007	0.112	0.155	0.114		

TUG: Timed Up and Go Test; BBS: Berg Balance Scale; CST: Chair Stand Test; 6MWT: Six Minute Walk Test; VAS: Visual Analogue Scale; A-VO$_2$: arteriovenous oxygen difference.

were observed between the 2 patient groups. Given that stroke patients usually represent a frail population, further research is guaranteed in order to evaluate the exact results of this type of intervention, as well as to establish guidelines for the variables of the training (5, 42, 43).

Although medical literature in the field of telerehabilitation is still scarce, recent systematic reviews substantiate the role of this form of rehabilitation delivery. Recent systematic reviews support that training delivered through telecommunication can yield comparable or even better results for selected groups of patients, something that is compatible with our finding of non-superiority for teleconferencing training in comparison to in-person application of the training regimen (44, 45). Furthermore, the recent coronavirus pandemic made it critical for telerehabilitation programs to be studied, developed and applied at a greater extent, as many recovered patients who remain infectious need to participate in therapeutic interventions. Findings of 2 systematic reviews support the feasibility and effectiveness of this method (46, 47).

Although the small size of the patient groups in this study may be considered a limitation, we believe it is sufficient for the purposes of our research given the experimental design used as well as the frequency of the exercise regimen applied. To the best of our knowledge this is the first study to include sessions 3 times a week for an extended period of time. This study wishes to help toward setting the basis for future research in the field of rehabilitation through strength training, especially through telecommunication methods.

In conclusion, 12 weeks of strength training sessions performed 3 times weekly yielded measurable results in acute stroke patients when it comes to subjective perception of well-being as well as general function measured through functional tests. No significant differences were revealed between groups who received the intervention through in-person training or via telecommunication. Both ways of administration showed a beneficial effect on quality of life in stroke patients. This study emphasizes the need for strength training rehabilitation schemes to be introduced as components of traditional physical therapy and rehabilitation programs in this population of patients. In addition, it lays the groundwork for telerehabilitation programs to be further researched and implemented as a means of providing targeted support to acute stroke patients after the treatment of their disease.

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This study was conducted according to the guidelines of the Declaration of Helsinki and approved by the Ethics Committee of the participating clinic. Written informed consent was obtained from all patients involved in the study.

The data that were processed to elicit the findings presented in this study are available upon request from the corresponding author.

The authors declare no conflict of interest.

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