

Supplementary material

Autonomic Conditioning Therapy for Post-Acute COVID-19 Syndrome (ACT for PACS)

The physical therapy program was conducted in three primary phases each with two subphases (Ia, Ib, IIa, IIb, and III). In Phase Ia of the protocol, a visual analog scale of chief complaint symptoms and vital signs (heart rate, pulse oximetry, blood pressure) were completed at the start of sessions to establish a baseline. Patients began in Phase Ia of the program with completion of supine exercise. Four specific exercises were completed including active range of motion open chain knee flexion heel slides, active range of motion open chain hip abduction, active range of motion concentric quadriceps activation via straight leg raise, concentric closed chain hip extension bridges. Each exercise was performed bilaterally over a 30 second interval. Time intervals were selected to allow patients to perform exercises at a self selected speed and repetition to meet standardized RPE metrics. Patients were encouraged to perform each exercise at a rate of perceived exertion of 2/10 on a modified Borg scale.

Recovery breathwork exercises including 4 second inhalation/6 second exhalation nasal breathing was implemented as a “recovery breathing” rest break between each set of exercise. Each rest break was less than 5 minutes and completed in the supine position. Progression to the next phase of the ACT for PACS program was dependent on the patient’s ability to tolerate intervention without requiring to stop the protocol over the course of 1 week. Should patients report greater than a 3 point change on the VAS of their chief complaint symptom, require greater than 5 minutes of rest, request to stop, or if the physical therapist deemed continuing inappropriate, the therapy session was stopped (defined as a “stop protocol”).

Following symptom tolerance in Phase IA, patients progressed to Phase IB. In Phase IB, patients progressed from supine based exercise to upright exercise. Phase IB introduced isometric exercise in the upright position as seated hip adduction ball squeeze, seated active range of motion hip flexion marches, seated concentric quadriceps long arc quadriceps (LAQ), sidelying hip abduction clamshells, and modified (high kneeling) plank. Additionally, patients continued with straight leg raise, bridge from phase IA. Exercises were performed at an intensity of 2 sets of 10 repetitions each. For the plank exercise, patients completed 2 sets of 10 second holds. The established “stop protocol” criteria from Phase IA was continued in phase IB.

In Phase IIA and IIB of the protocol, patients progressed to the initiation of submaximal aerobic exercise through overground walking intervals. Heart rate, pulse oximetry, chief complaint VAS were established at the start of the session. Patients progressed in Phase IIA through four stages of overground ambulation interval progressions, with each lasting 1 week. Intensity of intervention progressed weekly with patients performing 5, 1 minute intervals in week 1 progressing to 5, 90

second intervals in week 4. The goal of Phase IIA aerobic load was to complete 6 minutes of total aerobic training time with the goal of symptom stabilized completion of a 6 minute walk test (6MWT) at the end of week 4. In Phase IIB of the ACT for PACS program, patients continued to progress through submaximal aerobic training over the course of 4 additional weeks with progression of 3, 2 minute intervals in week 1 of Phase IIB through completion of 6, 2 minute intervals in week 4 of Phase IIB. The goal of Phase IIB aerobic load was to complete 12 minutes total aerobic training time in a session with the goal of initiating a submaximal aerobic exercise test to begin Phase III of the ACT for PACS

Prior to beginning Phase III of the ACT for PACS program, patients completed a submaximal aerobic exercise test. Using the YMCA protocol, age predicted heart rate max and subsequent work intensity were extrapolated. Following completion of the graded aerobic exercise test, patients began Phase III of the ACT for PACS based on the established Levine protocol. Developed by Fu and Levine (1. Fu Q, Levine BD. Exercise and non-pharmacological treatment of POTS. *Auton Neurosci Basic Clin.* 2018;215:20-27. doi:10.1016/j.autneu.2018.07.001), the Levine protocol proposes a progressive and graded aerobic exercise training program completed over the course of three months. Three training zones are derived from the established age predicted heart rate maximum- base pace at 75% age predicted heart rate maximum and a rate of perceived exertion of 13-16 on the Borg RPE scale, "maximum steady state" or RPE of 16-18, and "recovery pace" with reported RPE of 6-12. Early in training, patients completed three sessions per week on a recumbent bike for approximately 25-30 minutes per session. Early sessions include intervals of base pace and recovery pace exertions. As patients progress through the approach, maximum steady state intervals are introduced and the duration of intervals is increased. Baseline, midpoint, and end of session heart rate, pulse oximetry, and chief complaint visual analog scale data were collected. Patients completed 6 weeks of the Phase III/Levine Protocol before completion of the ACT for PACS program. Subsequently, patients are encouraged to continue aerobic training consistent with the guidelines of the Levine protocol beyond discharge from therapy in order to maximize gains, maintain symptom stability, and promote exercise tolerance and the benefits of aerobic training.