The Accelerated Recovery Performance (ARP) Trainer as a Method for Improving Rehabilitation Following ACL Reconstruction

+[1]Richardson, AB; [1]Tokumura, S; [2]Brusovanik, G; [2]Brown, DJ, [1]Chun, K; [1]Kikuchi, C; [1]O'Carroll, D; [1]Noh, T; [1]Burdick, D; [2]Kan, DM
[1]John A. Burns School of Medicine University of Hawaii, Honolulu, Hi [2]University of Hawaii Orthopaedic Residency Program, Honolulu, Hawaii

Introduction

Atrophy of the quadriceps femoris muscle following anterior cruciate ligament (ACL) reconstruction surgery is a well documented phenomenon [1, 2, 3]. The quadriceps serves as the primary stabilizer of the knee joint during translation; thus atrophy of this muscle group greatly impedes recovery following ACL reconstruction. Despite recent advancements in post-operative physical therapy; persistent quadriceps weakness and decreased cross sectional area at protracted post-operative time periods has been noted [1].

The adjunctive use of electrical stimulation has been suggested to lead to improved muscle strength and size in the post-operative period [4,5]. It has been noted specifically that rehabilitation of the quadriceps femoris following ACL surgery with the use of electrical stimulation alone is more effective than volitional exercises alone at improving gait, thigh girth, and isometric torque production about the knee [6].

The Accelerated Recovery Performance (ARP) Trainer is a high-frequency electrical-stimulation device that is used primarily in the rehabilitation of musculoskeletal injuries in athletes. Per the manufacturer, the ARP trainer, coupled with simultaneous use of a specific regimen of isometric exercises, has been purported to be capable of significantly improving muscle recovery after injury. To our knowledge, validation of the ARP trainer's ability to improve post-operational size and strength of quadriceps femoris muscle group following ACL reconstruction has not been previously performed. Therefore, the purpose of this study was to act as a pilot study to investigate the effects of the ARP trainer protocol on the rehabilitation of the quadriceps femoris after ACL reconstructive surgery.

Methods

Twenty-five patients with an isolated ACL injury and subsequent surgical reconstruction were included in this study, 14 in the experimental cohort and 11 in the control cohort. Both arms of the study received 6 weeks of traditional standard of care post-operative physical therapy prior to enrollment in the study. Once enrolled, each patient received an additional 16 sessions of physical therapy over a 6-week period. The control cohort received 6 weeks of traditional post-operative rehabilitation exercises and physical therapy. The investigational cohort received 6 weeks of the ARP trainer rehabilitation protocol.

The ARP trainer rehabilitation protocol consisted of two exercise routines utilizing a series of isometric exercises in conjunction with electromyostimulation from the ARP trainer. Two electrodes were placed over quadriceps muscle group, superiorly over the proximal muscle belly of the rectus femoris and inferiorly the distal muscle belly of the vastus medialis. The intensity of the ARP trainer was progressively increased to maximum tolerable power; determined be the patients' threshold of discomfort. Exercise routine 1 consisted of two rounds of the exercises, the first round the patient maintained position using a steady work technique (holding position while resisting gravity) and in the second round using a fast pulsation technique (repeated alternation between flexion/relaxation of the quadriceps at high frequency). The patient maintained position until failure occurred, repeating the process, after a brief period of rest, until 3 min of total work was performed. Routine 2 consisted of one round of exercises in which the patient of 10 seconds of fast pulses followed by 10 seconds of steady work. These repetitions were repeated for a total of 5 sets for each exercise.

Pre and post treatment leg circumferences served as the primary outcome measurement. The average percent difference gains of the involved limb were measured for both cohorts at 5 cm, 10 cm, 15 cm, and 20 cm above the superior patella respectively. Data was then analyzed initially with a normality test to validate the data. If the data was validated, statistical analysis proceeded with a t-test; otherwise, a Mann-Whitney Rank Sum test was utilized. Statistical significance was measured at $p < 0.05$.

Results

Figure 1 illustrates the circumference gains at the designated sites for the experimental and control cohorts. The experimental ARP cohort showed a 326% overall mean thigh circumferential gain than the control cohort. The ARP cohort had an overall mean thigh circumferential gain of 12.293 cm (SD 2.826). The control cohort had an overall mean thigh circumferential gain of 4.009 cm (SD 2.141). A statistically significant difference of 8.384 cm ($P < 0.001$) or a difference of 2.07 cm at each measured point. Thus ARP cohort had a gain ratio of 3.06:1 when compared to the control cohort.

The mean gain at 5 cm showed a statistically significant difference of 1.928 cm ($P < 0.001$). The ARP group gained an average of 2.864 cm (SD 0.719). The control group gained an average of 0.936 cm (SD 0.622).

The median gain at 10 cm showed a statistically significant difference of 1.950. Mann-Whitney U statistic value = 154.000/T value of 66.000 ($P< 0.001$). The ARP group had a median gain of 2.950 cm. The control group had a median gain of 1.000 cm.

The mean gain at 15 cm showed a statistically significant difference of 2.152 cm ($P < 0.001$).

The ARP group was 3.143 cm (SD 0.903). The control group had a mean gain of 0.991 cm (SD 0.607).

The mean gain at 20 cm showed a statistically significant difference of 1.669 cm ($P < 0.001$)

The ARP group had a mean gain 2.914 cm (SD 0.656). The control group had a mean gain of 1.245 cm (SD 0.886).

The average percent gains at each measured site for the experimental and control cohorts was also calculated. The ARP group showed an average percent growth difference of 7.38% (5cm), 8.29%, (10cm), 6.96% (15cm), and 5.95% (20cm) respectively. The control group showed an average percent difference of 2.38% (5cm), 2.10% (10 cm), 2.18% (15 cm), and 2.50% (20 cm) respectively.

Conclusion

This was the first study to investigate the potential of the ARP Trainer as an adjunct to physical therapy in order to achieve superior size and strength of the quadriceps femoris muscle group. We conclude that the ARP trainer rehabilitation protocol significantly improves the rehabilitation of the quadriceps femoris in the post-operative period. The average gain in thigh girth at each position of the quadriceps was 326% greater for ARP training protocols versus standard functional training.

References:

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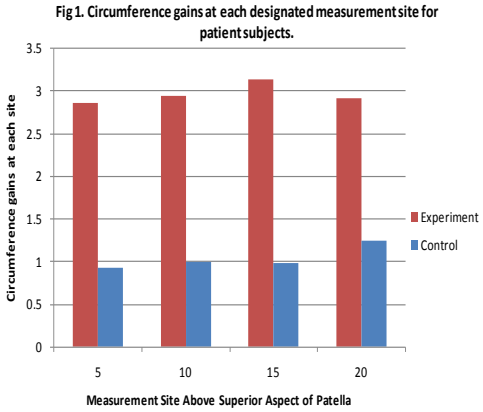

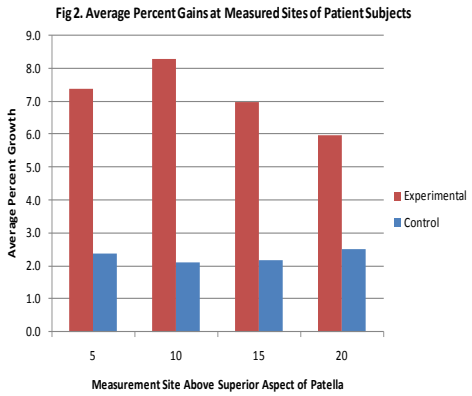

Discussion from Poster:

- There are conflicting results regarding the efficacy of current approaches to early intensive PT, as persistent weakness and disuse atrophy of the QF has been a consistent finding in both retrospective and prospective studies of outcome after reconstruction of the ACL [4,13,14,15,16,17].

- Different physiologic mechanisms have been proposed for this phenomenon, with recent studies supporting a theory of central nervous system (CNS) inhibition after joint damage indicating that stress voluntary quadriceps exercise alone may not result in a complete recovery of QF strength [19]

- Many studies have used ES successfully to target the proposed central mechanism of inhibition illustrating the efficacy of direct activation and recruitment of centrally inhibited motor neurons in order to produce significantly improved strength gains [18, 24]

- While conflicting results exist regarding the efficacy of ES on prevention of disuse atrophy, our results show a dramatic difference in the degree of disuse atrophy and thigh circumference for each measurement point recorded as well in the overall thigh growth between the two groups. Previous reports on ES have not been able to produce an equivalent difference in gain as produced by our study, which is a 300%.

Conclusions:

- ES can be used to activate muscle fibers at frequencies far greater than the critical fusion frequency (the minimum firing rate that produces a tetanic response) and the normal firing rate for QF fibers. The use of ES could bypass the effects of reflex inhibition of the QF post-ACL reconstruction leading to greater increases in muscle mass and functional strength. Our results indicate that the addition of the DC ES provided by the ARP machine resulted in a significant difference in circumferential gains between the experimental and control cohorts.

- These findings demonstrate that there is an advantage in the use of the ARP protocol to restore strength of the QF and retard disuse atrophy following ACL repair and that the ARP protocol is a modality that should be further studied. The use of ARP for high performance athletes as well as determined and dedicated individuals has been shown to be a successful adjunctive therapy that will improve QF post-operative outcomes following ACL repair.

Limitations:

- The use of measured thigh circumference as our end-point of to assess the efficacy of therapy rather than use of modalities such as CT made it impossible to assess the QF tissue distribution, and thus we were unable to confirm the tissue type of the gains appreciated in our subjects [35,38].

- Our study was also limited by our small sample size. This was mainly due to the fact that this was a single-center study completed within 8 months; 5 patients were lost to follow up due to the difficulty of the protocol

- Our study was randomized, but not blinded to either the patients or the administrators. This may have affected the voluntary effort of patients in both groups, but was unavoidable due to logistics of our protocol administration.

- There was also no control for exercise of patients outside of the study.

- Further trials with greater sample size, control for patient selection, questionnaires regarding physical activity outside of rehabilitation protocol, and assessments including pre- and post-test strength testing of both extremities and pre- and post-test imaging assessment should be pursued.