Title

Remote Rehabilitation: A Field-Based Feasibility Study of an mHealth Resistance Exercise Band.

Authors

Petersen, Curtis L
Minor, Colin M
Mohieldin, Suehayla
et al.

Publication Date

2020-12-01

DOI

10.1145/3384420.3431773

Peer reviewed

HHS Public Access

Author manuscript

IEEE Int Conf Connect Health Appl Syst Eng Technol. Author manuscript; available in PMC 2021 December 01.

Published in final edited form as:

IEEE Int Conf Connect Health Appl Syst Eng Technol. 2020 December ; 2020: 5–6.

Remote Rehabilitation: A Field-Based Feasibility Study of an mHealth Resistance Exercise Band

Curtis L. Petersen,
Geisel School of Medicine, Dartmouth College, Hanover, USA

Colin M. Minor,
Thayer School of Engineering, Dartmouth College, Hanover, USA

Suehayla Mohieldin,
Thayer School of Engineering, Dartmouth College, Hanover, USA

Linda G. Park,
Department of Community Health Systems, University of California, San Francisco, USA

Ryan J. Halter,
Thayer School of Engeering, Dartmouth College, Hanover, USA

John A. Batsis
Department of Medicine, University of North Carolina, Chapel Hill, USA

Abstract

Sarcopenia is the age-related loss of muscle mass and strength that is associated with adverse health outcomes. Resistance-based exercises are effective for mitigation and enhancement of strength; however, adherence is low and challenging to measure when patients are at home. In a single-arm, pilot study of seven older adults, we conducted a field-based usability study evaluating the feasibility and acceptability of using a system consisting of a Bluetooth-connected resistance exercise band and tablet-based app which together we call BandPass in completing four different home-based exercises. The system measured a total of 147 exercises by participants with a mean duration of 94±66 seconds, completing an average of 30±20 repetitions. Though not all patients completed each exercise type, patients were positive about use: patient activation measure: 80.7±14; system usability scale: 6.9±2.9; and confidence in use: 7.7±2.7. The BandPass system demonstrated its ability to collect data on exercise type, force during an exercise, and duration of exercise when older adults use it for monitoring exercise at home.

Keywords

mHealth; remote medical sensing; sarcopenia; app; physical function; physical therapy

curtis.l.petersen.gr@dartmouth.edu .

1 Introduction

Sarcopenia is the loss of muscle mass and strength with aging and has been associated with increased risk of morbidity and mortality.[1] The etiology of sarcopenia is complex, yet resistance based exercises have been found to mitigate its development and progression by maintaining physical function.[2] Typically, these exercises are prescribed and conducted in-person so the therapist can monitor it.[3] Though there is clear efficacy for these treatment strategies, nearly 40% of patients do not adhere to these regimens at home decreasing the potential efficacy.[4] Currently there is no method to measure the extent of or even if an exercise was completed. Mobile health (mHealth) could provide adherence and feedback information to the patient and the clinician for exercises completed at home. Here, we test a previously developed Bluetooth-connected resistance exercise band and associated app - BandPass - in older adults to assess their usability, feasibility, and acceptability in the home setting.[5, 6].

2 Methods

2.1 Study Design, Population, and Data Collection

Adults aged ≥65 years were recruited through a primary care clinic at Dartmouth-Hitchcock (DH) in Lebanon, NH. Participants were given a BandPass, a Samsung Galaxy Tab A tablet with a custom app installed, and instructions on how to use both.[8, 9] Participants were shown how to complete each of the four exercises (arm-lift, bicep curl, seated row, and triceps extension) and asked to complete them once a week for a month. Dartmouth/DH Committee for the Protection of Human Subjects and IRB approved the study. For each participant, the following data were collected through BandPass: when each exercise occurred; the duration of each exercise; the force exerted during the exercise; the type of exercise selected; and the Borg scale of perceived exertion of the exercise. Data from BandPass system were stored in a NoSQL cloud database. Participants also completed: 1) patient activation measure (PAM) scaled 0-100; 2) system usability scale (SUS) 0-10; 3) confidence in use 0-10; and 4) Willingness to Pay (WTP) for the device and app ($0-10, $11-20, $21-30, $31-40, $41-50, >$50). These questionnaires were electronically delivered using RedCAP at 4 weeks after enrollment. In all, higher values indicate favorability.

2.2 Analysis

We calculated mean and standard deviations for each for PAM and SUS scores. For each exercise, we calculated the correlation, Pearson's r, between total repetitions, length exercising, and perceived exertion, each pairwise. We also examined the association between repetitions and perceived exertion through a linear mixed effects model, controlling for the exercise type and individual correlation. Data analysis in R v3.6.2.

3 Results

Seven participants (57% female), all white non-Hispanic, had a mean age 74±4 years. Three of the four exercises (arm-lift, bicep curl, and seated row) were completed by all participants. Over the study, the BandPass system collected force data on 147 exercises of the 112 expected: 36 (24%) arm-lift, 49 (33%) bicep curl, 36 (24%) seated row, and 26

(18%) triceps (Figure 1). Patients were positive about the system's use reporting moderately high scores in PAM: 80.7±14, SUS: 6.9±2.9, and confidence in use: 7.7±2.7. Patients would pay a median of $31-40 for the BandPass system. We found a large correlation between repetitions and length of exercise ($r=0.72$, $p<0.001$), and moderate correlation of each with Borg scale ($r=0.49$ [$p<0.001$], $r=0.54$ [$p<0.001$]). This positive relationship was maintained through a mixed effects model ($\beta=0.03$, $p<0.001$). Finally, we also found differences in the number of repetitions, and duration of exercises (Figure 1).

2 Discussion

Remote monitoring of rehabilitation exercises offers patients with sarcopenia and their providers a method to examine adherence and changes in strength. In this pilot study, we demonstrated that an mHealth connected resistance band can automatically collect and detect when exercises are completed, the force exerted during the exercise and subjective data about each exercise longitudinally. The PAM survey indicated that patients felt highly activated to take on self-management behaviors and make lifestyle changes. Participants were relatively confident in use. Together with moderate SUS, TAM, and willingness to pay, these results indicate that patients believe the system can help them yet it is unclear on how acceptable its use is or efficacy as a therapeutic tool, requiring further investigation. Together with moderate SUS, and willingness to pay, these results indicate that patients believe the system can help them yet it is unclear on how acceptable its use is or efficacy as a therapeutic tool, requiring further investigation. Older adults completed the four exercises at unequal proportions and one participant did not complete any triceps extension suggesting that they were either too easy, too difficult, or not equally understood. This information suggests a need to revise our instructions. Further, our ability to capture these differences in the data demonstrates it is an easily monitored component of the therapeutic plan. The positive association between perceived exertion, the number of repetitions, and length of the workout is of note. Participants were provided bands that may have been too 'easy' for them; hence, it is important to ascertain the need to graduate to a higher resistance band. This study is not without limitations. First, this study was interrupted by the spread of SARS-CoV-2 limiting the intended recruitment of ≥14. We are not able to determine if participation was impacted by the pandemic. Second, we deliberately did not assess the efficacy of its use in increasing muscle strength at this stage of prototype development. Third, the participants in this study do not represent the broader United States population and future work will recruit a larger diverse cohort. Overall, data on all exercises, from all designed sources were collected for each patient each time an exercise was performed demonstrating that BandPass and app are feasible for at home use.

Acknowledgments

Work was supported in part by grant number K23-AG051681 from the National Institute on Aging of the National Institute of Health, and a pilot grant from the NIDA/NIH P30DA029926. CLP is also supported by the Burroughs-Wellcome Fund: Big Data in the Life Sciences at Dartmouth. CLP, CMM, SM, RJH, JAB have equity in SynchroHealth LLC and a patent pending for BandPass titled "Instrumented Resistance Exercise Device".

REFERENCES

[1]. Lauretani F, Russo C, Bandinelli S, Bartali B, Cavazzin iC, Di Iorio A, et al. Age-associated Changes in Skeletal Muscles and Their Effect on Mobility: An Operational Diagnosis of Sarcopenia. Journal of applied physiology 2003;95(5). doi: 10.1152/japplphysiol.00246.2003..

[2]. Pahor M, Guralnik JM, Ambrosius WT, et al. Effect of structured physical activity on prevention of major mobility disability in older adults: The life study randomized clinical trial. JAMA. 2014;311(23):2387–96. doi: 10.1001/jama.2014.5616. [PubMed: 24866862]

[3]. Vlietstra L, Hendrickx W, Waters D. Exercise interventions in healthy older adults with sarcopenia: A systematic review and meta-analysis. Australasian journal on ageing. 2018;37(3). doi: 10.1111/ajag.12521.

[4]. Martin LR, Williams SL, Haskard KB, DiMatteo MR. The challenge of patient adherence. Therapeutics and Clinical Risk Management. 2005;1(3):189–99. [PubMed: 18360559]

[5]. Petersen CL, Wechsler EV, Halter RJ, Boateng GG, Proctor PO, Kotz DF, et al. Detection and Monitoring of Repetitions Using an mHealth-Enabled Resistance Band. 2018 IEEE/ACM International Conference on Connected Health: Applications, Systems and Engineering Technologies (CHASE); Washington D.C.: IEEE; 2018. p. 22–4.

[6]. Petersen C, Halter R, Kotz D, Loeb L, Cook S, Pidgeon D, et al. Using Natural Language Processing and Sentiment Analysis to Augment Traditional User-Centered Design: Development and Usability Study. JMIR mHealth and uHealth. 2020;8(8). doi: 10.2196/16862.

CCS CONCEPTS

• Applied computing ~ Consumer health • Applied computing ~ Health informatics • Social and professional topics ~ Remote medicine

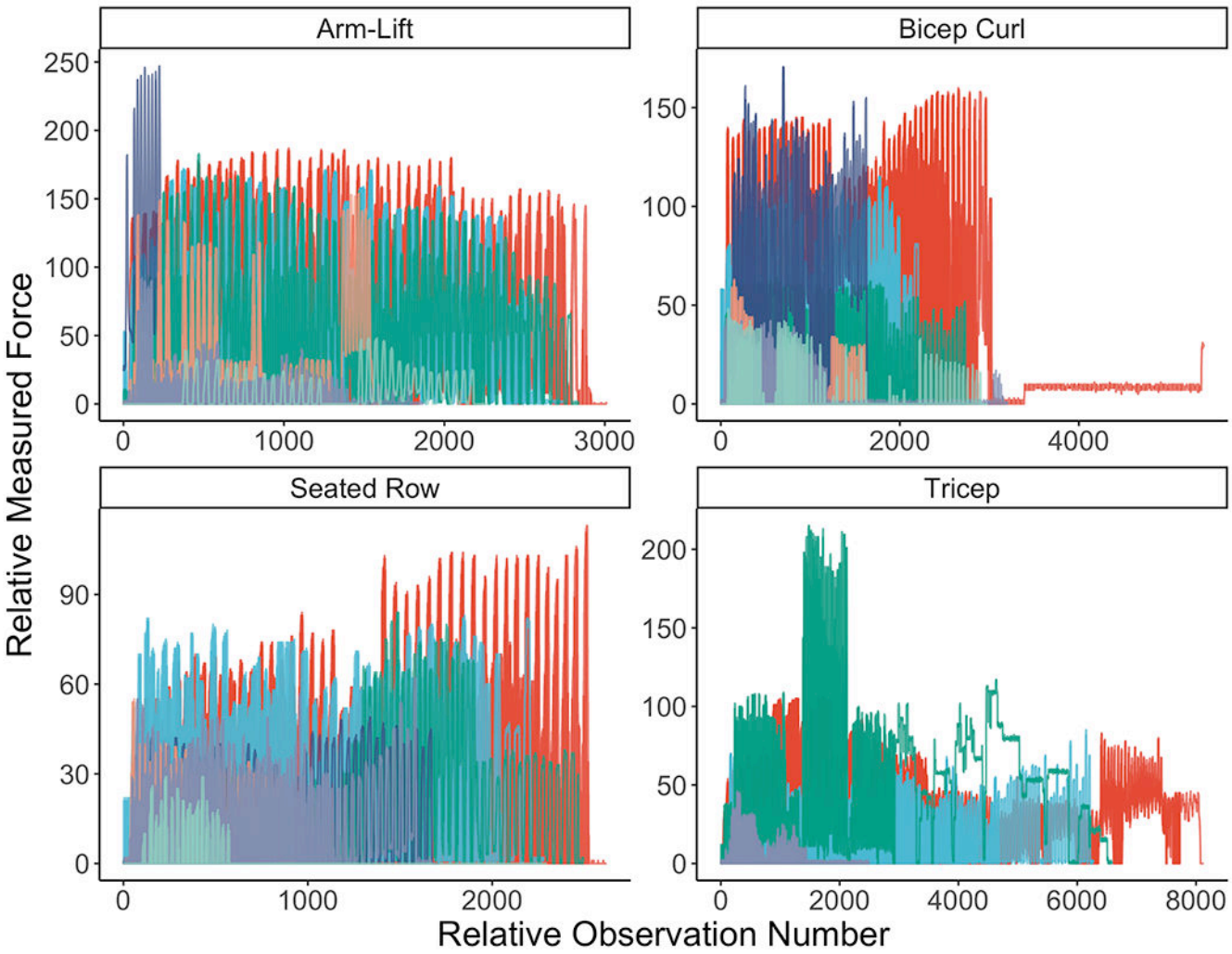

Figure 1:
Force over the course of each exercise using the BandPass system