Validity and Reliability of Measurements of Elbow Flexion Strength Obtained from Older Adults Using Elastic Bands

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ABSTRACT

Purpose: This study determined the validity and reliability of measurements of elbow flexion strength obtained from older adults using elastic bands. **Methods:** Forty-eight community-dwelling older adults with documented functional limitations completed 3 assessments of elbow flexion strength: a 30-second test using elastic bands to generate resistance, a similar test using dumbbells, and a test using an isokinetic dynamometer. One week later, subjects repeated the 30-second elbow flexion test using elastic bands. **Results:** The 30-second elbow flexion test using elastic bands was significantly correlated with both the 30-second elbow flexion test using dumbbells ($r = 0.62$, $P < 0.01$) and the maximum isokinetic torque of the elbow flexors ($r = 0.46$, $P < 0.01$). The 30-second elbow flexion test using elastic bands demonstrated a high degree of test-retest reliability (intraclass correlation coefficient $= 0.89$, $P < 0.01$). **Conclusion:** The validity and reliability elbow flexion strength measured with elastic bands supports its use among functionally limited elders.

Key Words: Theraband®, muscle strength, measurement, aging

INTRODUCTION

Normal biological aging is accompanied by losses in functional ability and independence.[1] These age-related reductions have been linked to numerous interconnected factors,[2] and are responsible for a host of clinically important problems such as falls[3,4] and osteoarthritis.[5] Precipitating the age-related decline in functional ability is a concomitant decline in skeletal muscle mass and voluntary strength,[2] which has been shown to be mitigated by resistance training.[6-8]

The influence that muscular strength has on functional ability in later life has resulted in the development of a variety of methods for measuring strength. For instance, the American College of Sports Medicine[9] describes one repetition maximum (1RM) and 6-8 RM isotonic protocols using machines as well as free weights. However, these methods of assessing strength lack portability and may be inappropriate with some groups of functionally limited older adults. Isokinetic dynamometer systems such as the KinCom (Chattecx, Chattanooga, Tenn) or Biodex (Biodex Medical, Shirley, NY) provide a detailed description of isometric and or isokinetic strength parameters;[6,10] however, these dynamometers are often impractical for testing or training in the community and may pose a health risk to older adults presenting with cardiovascular disease.[11]

In response to these challenges in documenting gains in muscular strength in older adults, Rikli and Jones[12] developed an assessment of upper body muscular strength based on the number of times a dumbbell of standard weight can be curled through full range of motion over a 30-second time period (dumbbell weighted elbow flexion). While this assessment does not involve a single maximal effort and therefore incorporates a component of muscular endurance, it nevertheless validly and reliably assesses upper limb strength among older adults. Further, it may be more sensitive to training-related improvements, as dumbbells or other hand weights are frequently employed as a mode of generating resistance during resistance training among older adults.[13]

Recently, the utilization of elastic bands as a mode of generating resistance during resistance training has gained popularity in the clinical and research settings. This form of resistance training has proven beneficial in older adults,[14-16] and the inherent properties of the elastic band material may better accommodate the length-tension characteristics of normal joint and muscle actions.[17] Therefore, the development of a method of assessing muscular strength using elastic bands may be more sensitive to gains resulting from this type of training. The purpose of this study was to determine the validity and reliability of measurements of elbow flexion strength

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obtained from older adults using elastic bands. The researchers hypothesized that performance in the 30-sec band test (elastic band resisted elbow flexion) would be significantly correlated with performance measured using the dumbbell weighted arm curl test and the isokinetic dynamometer, and that it would demonstrate high test-retest reliability.

METHODS

Participants

Adults over the age of 65 (40 women, 8 men; age = 73.0 ± 6.7 years), who provided informed consent prior to participating in the study, were recruited from an ongoing study approved by the human research committee at The University of Toledo. Inclusion criteria for this study included being 'functionally limited,' as defined by: (1) scoring below the population segment average on the Physical Functioning Subscale of the MOS Short Form (SF) -36,[18] and (2) performing below the population segment mean for climbing 26 stairs.[19] All subjects were also screened by a physician for the presence of any condition that would contraindicate their participation in a program of regular physical exercise.[9]

Design

Initially, all subjects underwent 3 assesssments of elbow flexion strength during a single visit to the exercise laboratory of a midwest university. All testing procedures were conducted by a single, trained administrator. Prior to testing procedures, subjects performed a warm-up consisting of walking 1 lap around an indoor track (approximately 175 meters) at a self-selected pace, and 25 unweighted elbow flexion movements against gravity. The first 2 assessments were the Rikli & Jones test of elbow flexion strength using a dumbbell (males = 3.6 kg, females=2.3 kg), and the elastic bands test using Thera-Band® (The Hygenic Corporation, Akron, Ohio) [males = blue (3.2 kg), females = green (2.3 kg)].[20] The final assessment consisted of maximal-effort elbow flexion using a KIN-COM 500H isokinetic dynamometer. These assessments were administered on the same day and in the same order to all subjects. In order to minimize the effects of fatigue, at least 15 minutes were provided between each assessment.[21] One week following the first session, subjects (n = 38) again performed the elastic band resisted elbow flexion protocol using the same color elastic band to generate resistance. During the intervening time period, subjects were instructed to maintain current levels of daily activity.

Dumbbell Weighted Elbow Flexion Assessment

The 30-second elbow flexion test was performed as described by Rikil and Jones.[12] Breifly, subjects stood with feet shoulder width apart, with a dumbbell in their right hand perpendicular to the floor. After a demonstration by the administrator, the subject was allowed 2 to 3 practice repetitions to ensure correct form. Subjects were instructed to maintain a normal breathing pattern and to keep their elbow at their side during the entire test. A single repetition consisted of curling the weight from a position of full elbow extension until the weight was at the level of the subject's shoulder and then returning the elbow to full extension. The number of complete repetitions the subject completed in 30 seconds was recorded. Verbal encouragement was provided to encourage maximal effort.

Elastic Band Resisted Elbow Flexion Assessment

The elbow flexion test was conducted with the subject in a standing position using Thera-Band® elastic bands to generate resistance (males = blue; female = green). One end of the elastic band was attached to a handle which was held by the subject and the other end was placed under the subject's foot so that no slack was present in the band with the forearm in full extension. A single repetition consisted of flexing the elbow while elongating the elastic band from a position of full elbow extension until the handle was at the level of the subject's shoulder and then returning the elbow to full extension. This motion resulted in the elastic band being elongated approximately 100%, from about 24 inches at full elbow extension to about 48 inches at full elbow flexion. Previous investigators have documented that 100% elongation of all colors of elastic bands provides a consistent amount of resistance over 5000 trials.[17] Elongating the green TheraBand® elastic band to 100% elongation has been demonstrated to result in 2.3 kg of resistance while elongating the blue TheraBand® elastic band to twice its unstretched length has been shown to result in 3.2 kg of resistance.[20] The number of complete repetitions the subject completed in 30 seconds was recorded.

Isokinetic Assessment

Maximal-effort isokinetic strength of the elbow flexors and extensors was assessed using a KIN-COM 500H isokinetic dynamometer (Chattecx, Chattanooga, Tenn). Subjects were seated in the dynamometer chair with the backrest angle at 90°. The axis of rotation of the right elbow (lateral epicondyle of the humerus) was aligned with the axis of rotation of the dynamometer. The load cell assembly was attached to the distal forearm via a wrist cuff and the upper arm was secured in place through the use of Velcro straps. Subjects were asked to perform 1 warm-up and 3 maximal isokinetic flexion/extension movements of the forearm at 30° per second from 0° to 120° of elbow flexion. Each subject was instructed "curl your arm

as hard as you can and then move your arm straight down as hard as you can while not moving the position of your elbow, remembering to breathe out normally during the trial." Verbal encouragement was provided to facilitate maximal values.[22] Peak elbow flexion torque was considered the greatest peak torque production over the 3 trials.

Data Analysis

Statistical analyses were performed using SPSS software, version 13.0 (Chicago, Ill). Following the calculation of descriptive statistics, the validity of elbow flexion strength measurements obtained using elastic bands was explored by calculating Pearson correlations ($P < 0.05$) between the measurements and elbow flexion strength measured using dumbbells and the isokinetic dynamometer. Validity was further characterized by the Cronbach's alpha between the 3 measures of elbow flexion strength. The intraclass correlation coefficient (ICC) (model 1, 1) was used to examine the test-retest reliability of elbow flexion strength measured with the elastic bands.

RESULTS

Means ± SD for each elbow flexion assessment at time 1, and the elastic band resisted elbow flexion assessment at time 2, are presented in Table 1. Pearson correlations between the measures of elbow flexion indicated that the number of repetitions in the elastic band resisted elbow flexion test at time 1 were moderately correlated with the number of repetitions during the dumbbell weighted elbow flexion test ($r = 0.62$, $P < 0.01$). A moderate correlation was demonstrated between the elastic band resisted elbow flexion test at time 1 and the maximal-effort isokinetic torque generated during maximum elbow flexion ($r = 0.46$, $P < 0.01$). Further, the 3 measures of elbow flexion strength demonstrated good internal consistency, Cronbach's alpha = 0.72. Finally, the results demonstrated a significant intraclass correlation (0.89, 95% CI = 0.35 – 0.76, $P < 0.01$) between the elastic band resisted elbow flexion test at time 1 and time 2.

DISCUSSION

The major findings of the study indicate that the 30-second elbow flexion protocol using elastic bands is a valid and reliable assessment of arm strength among functionally limited older adults. Further, the degree of stability demonstrated by this assessment is similar to that of the dumbbell weighted elbow flexion protocol established by Rikli and Jones.[12] These findings are important because resistance training using elastic bands as the means of generating resistance is becoming increasingly popular and is effective among older adults.[14-16] The principle of specificity of training indicates that the most sensitive method of assessing strength changes as the result of training is recognized when the method of assessment is as similar as possible to the mode of training. Thus, the most sensitive method of assessing an individual who employs elastic bands as their mode of resistance training is an assessment method that also employs elastic bands.

Finally, an advantage of the elastic band resisted elbow flexion assessment is its versatility and ease of implementation. Elastic bands are inexpensive, light-weight, and may be used in the community as a method documenting improvements in muscular strength as measured by community-based exercise leaders or by older adults themselves.

Several limitations were present in this study. Although correlations between measures were significant, limited variance in one variable was explained by another variable. Specifically, only 21% of the variance in isokinetic elbow flexion torque is explained by the number of arm curl reps using elastic bands. This finding was most likely a result of the inherent characteristics of each assessment. For instance, while movement velocity was controlled in the isokinetic assessment, velocity in the dumbbell and elastic band assessments most likely varied throughout the test, and within each repetition of the test. Also, the 30-second dumbbell and elastic band assessments incorporated an element of muscular endurance that was not tested by the isokinetic assessment. The conclusions of the study were also limited by the nonrandomization of testing. While this may reduce variations in motivation that occur within this population,[23] randomization of the tests would have strengthened the study's design. Finally, the study was comprised of a small sample of older individuals who presented with limited functional ability. This particular protocol, therefore, may not be appropriate for higher functioning older adults, and additional research involving this population is needed.

Table 1. Performance on 3 Tests of Elbow Flexion Strength

Test	Time 1 (n = 48)	Time 2 (n = 38)
Dumbbell (repetitions)	21.2 ± 4.2	-
Elastic bands (repetitions)	25.6 ± 6.6	25.2 ± 6.5
Isokinetic elbow flexion (Nm)	43.1 ± 16.5	-

CONCLUSIONS

The validity and reliability of elbow flexion strength measurements obtained using resistance from elastic bands, coupled with the versatility and affordability of this protocol, supports its clinical use.

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