The Influence of Isometric Strength Specificity on Functional Task Abilities

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ABSTRACT

PURPOSE: To determine if a multi-joint, isometric leg press muscle strength assessment is more strongly associated with functional task performance [i.e., star excursion balance tests (SEBT), countermovement vertical jump test (CMJ), stair climb (SC) assessment] than traditional single-joint measures of leg extension isometric strength. **METHODS:** Forty-one men and women (age = 24 ± 5 years) performed an initial familiarization visit. On visit two, peak force (PF) was measured during 3 maximum voluntary contractions (MVCs) on an isometric leg press dynamometer, followed by a timed and weighted (22.73 kg vest) SC. On visit three, leg extension peak torque (PT) was also determined during 3 MVCs, followed by the CMJ and SEBT assessments. Pearson's product-moment correlation coefficients evaluated the relationships between each muscle strength value (PF and PT) and each functional measure of performance with alpha level of 0.05. Steiger Z calculations determined the difference between the relationships for each respective functional task, with z >1.96 being significant. **RESULTS:** Isometric PT and PF were associated with higher CMJ average power (r = 0.756, r = 0.817) and faster SC times (r = -0.592, r = -0.599), respectively. No significant correlation existed between the SEBT for both legs and PT or PF. When comparing correlation values for each measure of strength, no significant difference ($P \geq$ 0.483) existed in the relationships with each functional task. **CONCLUSION:** Traditional measures of isometric leg extension strength and multi-joint leg press isometric strength demonstrated similar relationships with CMJ power output and SC time.

BACKGROUND

- Muscle strength is one of the most commonly examined measures of function, as it is associated with mortality, the ability to perform activities of daily living, and athletic performance [1-3]
- Strength has traditionally been measured in the laboratory using single-joint isometric dynamometers during maximal voluntary contractions, but it may not necessarily reflect the biomechanical and neuromuscular specificity of activities of daily living and functional tasks [4]
- Previous studies have suggested that strength measured during multi-joint movements are associated with activities of daily living and functional tasks [5-6]

PURPOSE: To determine if a multi-joint, isometric leg press assessment of muscle strength is more strongly associated with functional [i.e., star excursion balance tests (SEBT), countermovement vertical jump test (CMJ), stair climb assessment (SC)] task performance than single-joint measures of leg extension isometric strength.

METHODS

EXPERIMENTAL DESIGN:

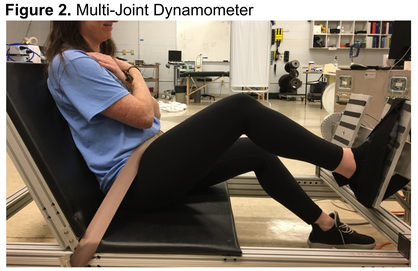
- Forty-one healthy men and women (mean ± SD: age = 24 ± 5 years, BMI = 23.1 ± 3.1 kg/m^2) volunteered for this investigation
- Testing consisted of 3 separate visits to the laboratory around the same time of day
  - 1st Visit: Familiarization with single- and multi-joint strength assessments
  - 2nd Visit: Perform the multi-joint isometric muscle strength assessment and weighted stair climb assessment
  - 3rd Visit: Perform the single-joint isometric muscle strength assessment, countermovement vertical jump test, and star excursion balance test

MUSCLE STRENGTH ASSESSMENTS:

- Single-joint leg extension peak torque (Nm) was measured during an isometric maximum voluntary contraction (MVC) while seated in a isometric dynamometer
  - The limb was extended to 60° below the horizontal plane
- Multi-joint leg extension peak force (N) was measured during a MVC while seated in an isometric, leg press dynamometer
  - The participant sat with the knee at 60º of flexion, hip at 90º while sitting upright, and ankle joint 0° of plantarflexion
- Participants performed 3 MVCs using the dominant leg for each muscle strength assessment
- The force and torque signals were corrected for baseline passive tension and filtered using a fourth order, zero phase shift low pass (150 Hz) Butterworth filter

Figure 1. Single-Joint Dynamometer

Figure 2. Multi-Joint Dynamometer



WEIGHTED STAIR CLIMB ASSESSMENT:

- Ascended and descended 26 steps, 4 times wearing a 22.73 kg weighted vest
- Time (s) taken to complete the task was recorded

COUNTERMOVEMENT VERTICAL JUMP TEST:

- Stood with their feet shoulder width apart in the center of the mat and squatted down prior to jumping up
- Average power output (W) was recorded during the CMJ from a linear position transducer

STAR EXCURSION BALANCE TEST:

- Stood single-stance on one leg and reached with the other leg in the anterior, posteromedial, and posterolateral directions, performed on both legs
- Composite distance reached (in) for each leg was normalized to leg length

STATISTICAL ANALYSIS:

- Pearson's product-moment correlation coefficient was used to evaluate the relationships between highest muscle strength values and the best outcome of each functional measure of performance (i.e., SC time, SEBT distance, and CMJ average power) with *a priori* alpha level of 0.05
- Steiger Z calculation was used to determine if there was a significant difference between the relationships for each respective functional task.
- All statistical procedures were performed using SPSS software (version 19.0, IBM SPSS Inc., Chicago, IL) and R Studio (version 1.2, RStudio Inc., Boston, MA).

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RESULTS

- There was a significant correlation (P < 0.01) with CMJ average power (r = 0.756, r = 0.817) and SC time (r = -0.617, r = -0.599) for single- and multi-joint measures of strength, respectively
- No significant correlation (P > 0.05) existed between the normalized distance reached for both legs and the measures of strength
- When comparing correlation values for each measure of strength, no significant difference existed in the relationships with each functional task ($P \geq$ 0.483)

Table 1. Pearson's Product-Moment Correlation Coefficients Between Functional Task Outcomes and Measures of Strength, Steiger Z Comparing the Pearson's Product-Moment Correlation Coefficients

Variable	Peak Force	Peak Torque	Steiger Z	*P* value
Stair Climb Time	-0.599*	-0.592*	0.047	0.962
Average Power	0.817*	0.756*	0.701	0.483
Normalized Left Leg Distance	0.065	0.202	0.601	0.548
Normalized Right Leg Distance	-0.018	0.139	0.679	0.497

* Correlation is significant at the 0.01 level (2-tailed).

DISCUSSION

Our findings suggest that traditional measures of single-joint isometric leg extension strength and multi-joint leg press isometric strength demonstrated similar relationships with CMJ power output, SC time, and normalized distanced reached during the SEBT. It is possible that knee joint angle may be more important than the strength testing modality.

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