The Effect of Power Training versus Strength Training on Lower Extremity Function in Community-Dwelling Older Adults

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OUTLINE

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Aging population
- 2003, 13% of Canadians > 65 yrs
- By 2031, 23% > 65 yrs

Increased proportion of older adults → increase in chronic disease and co-morbidities

In 2006 4.3 million Canadians were 65 years or older, accounting for one third of Canada’s population (2). The number of senior citizens in Canada is increasing, which will place an increased demand on our health care system.
Background

- Sarcopenia: the age related decline in muscle mass resulting from a decrease in the size and number of muscle fibers\(^2\)
  - decreased ability to produce force
  - increased risk of falls, impaired mobility, decreased functional independence\(^3\)
Background

- **Functional Independence:** the ability to perform ADLs and IADLs without help from other individuals\(^4\)

- LE function is a major component of functional independence

Define LE Function
Background

- Resistance training combats sarcopenia and minimizes the decline in LE function in older adults.
  - reduces fall risk
  - decreases fall-related health care costs
  - reduces the loss of independence

Falls are expensive, as they result in increased hospitalization and decreased functional independence in the older adult (10 and 11).
## Strength and Power Training Definitions

<table>
<thead>
<tr>
<th>Strength training (ST)</th>
<th>Power training (PT)</th>
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<tr>
<td>- multiple- and single-joint exercises performed at a slow velocity for 1-3 sets of 8-10 reps at 60-80% of 1RM$^{15}$</td>
<td>- multiple- and single-joint exercises performed at a high velocity for 1-3 sets of 6-10 reps at 40-60% 1RM$^{15}$</td>
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The first randomized controlled trials (RCTs) studying the effects of ST on muscle mass in the elderly appeared in the literature twenty-five years ago (9).
Power Training

- PT is emerging as an alternative form of resistance training for older adults

- Impaired physical performance may be due to a lack of muscle power rather than a lack of strength. Impaired physical performance may be due to a lack of muscle power rather than a lack of strength. Motor tasks performed under daily conditions require movements at higher speeds and variable external resistance.

- The effects of PT on sarcopenia have not been thoroughly studied.

and may be a more effective intervention than strength training for improving function and decreasing disability in the elderly.
Rationale

- Two systematic reviews have examined the effect of ST on LE function in the older adult\textsuperscript{8, 14}.
  - reviews reported positive effect of ST on lower extremity (LE) strength; few RCTs utilized outcome measures relevant to LE function in older adults such as sit to stand ability\textsuperscript{8, 14}.
Rationale

- No published systematic reviews comparing the effects of PT versus ST

  - Unclear which form of resistance training is more effective in improving LE function in older men and women
Systematic Review Purpose

1. Examine the effect of PT versus ST on LE function in community-dwelling older adults

2. Determine the optimal method of resistance training to maintain and improve LE function in the older adult

Define LE function
METHODS

1. Inclusion Criteria
2. Search Strategy
3. Study Selection
4. Data Extraction
5. Study Quality
6. Data Analysis
Inclusion Criteria

1) Mean age of 65 years or older
2) Independent, community-dwelling adults
   - For example, papers had to mention that subjects were independent with daily living or were well functioning.
3) Direct comparison of only ST and PT
   - No combined training (i.e. no aerobic ex)
4) Published in English
5) Supervised exercise intervention
6) Minimum of one LE function outcome measure
Outcome Measure: LE function

- A tool that assesses components of ADLs involving the LE

- Examples of acceptable LE function outcome measures include:
  
  1) gait speed  
  2) chair-rise time  
  3) functional reach  
  4) static and dynamic balance
Journal articles were selected from numerous databases including:
1. MEDLINE
2. CINAHL
3. EBM Reviews
4. Sports Discus
5. EMBASE

Other Sources:
1. ProQuest and National Research Register for unpublished theses
2. Google scholar
3. Experts in the field
4. Hand searching
<table>
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<th>Search Terms</th>
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| **Power training**          | - high velocity resistance training  
                             | - high intensity resistance training  
                             | - plyometrics                  
                             | - speed training               |
| **Strength training**       | - resistance training          
                             | - weight lifting               
                             | - resistance exercise          
                             | - low velocity resistance training  
                             | - low intensity resistance training  |
Search Strategy

- The search was further limited to:

1. Humans
2. English language
3. Age 65 years or older, or was combined with keywords for older adults (aged, elder, geriatric, senior, older people)
Data Extraction

- Developed and pilot tested own data extraction tool from multiple sources

- Data extraction included:
  1. Study characteristics
  2. Intervention characteristics
  3. Outcome measures
  4. Drop-Outs and Adverse Events
  5. Study quality
  6. Major study conclusions
To assess the quality of the included studies two independent reviewers used the PEDro scale and the Oxford Center of Evidence Based Medicine Levels of Evidence.

PEDro, is a 11 item quality AXIS tool, designed primarily for the evaluation of physiotherapy-based studies.

Although there are limitations to using the PEDro scale such as the difficulty in PT interventions to blind subjects to their tx group, it was sensitive to differences in the quality of the included studies.

A third reviewer resolved any disagreements regarding PEDro scores or the level of evidence assigned to a study.
Data Analysis

- A meta-analysis was planned initially, but was not performed because of statistical and clinical heterogeneity.

- Standardized mean differences and 95% confidence intervals (CI) were calculated for continuous outcome measures using Hedges adjusted $g$, which accounts for small sample size.

- Conventional effect sizes used.
  - $0.2 = \text{small}$
  - $0.5 = \text{medium}$
  - $0.8 = \text{large}$

Cohen’s $d$ does not account for sample size.
Data Analysis

- No significant differences at baseline, therefore post-test scores were used for effect size calculation.

- Only outcome measures that were utilised in the majority of studies were analysed.

- Primary analysis compared PT vs ST

- Secondary analysis compared PT and ST vs control
RESULTS
• Two reviewers independently screened titles and then abstracts from the database searches to identify potentially relevant articles.

• Disagreements during the first two stages of screening were resolved by including the studies for the next stage of review to eliminate selection bias.

• After removal of duplicates 94 articles remained.
• Full evaluation of abstracts excluded several more articles (for reasons such as not a head to head comparison, not a supervised ex. intervention, and age limitations). 29 articles remained.

• Full text copies of the selected studies were then obtained and two reviewers independently reviewed the articles to determine if inclusion criteria were met. Articles were excluded for several reasons (no functional outcome measures, no PT). Any disagreements during the final stage of study selection were resolved by a third reviewer.

• In the end 6 RCTs remained for data extraction.
Study Quality and Level of Evidence

- PEDro
  - Good quality = 3
  - Moderate quality = 2
  - Poor quality = 1

- Intention to treat = 0
- Blinding = 2

- Oxford CEBM Levels of Evidence
  - All 2B, low quality RCTs

Explain what pedro scores mean
Study Characteristics

- Control group = 3
- No control group = 3
- All studies performed in a structured setting
- Female only = 3
- Male only = 1
- Male and female = 2
- Sample size = 20-61 subjects
- Age range = 60-90 years
Study Characteristics

- **Drop-outs**
  - 1-11 subjects, with an average of 5 per study

- **Adverse events**
  - Reported = 3/Unreported = 3

- **Compliance:**
  - Reported = 3/Unreported = 3
  - 88-95% compliance was recorded

- No treatment group had disproportionate drop-outs, adverse events or compliance.

Reasons for drop-out included transportation, personal and family complications, medical issues, and time commitments.

Reported adverse events included exacerbation of plantar fasciitis and pre-existing osteoarthritis (Sayers), as well as six falls and three musculoskeletal injuries including a hamstring tear (Mizko).
Intervention Characteristics

| NUMBER OF EXERCISES | •6-8 exercises = 4 studies  
•2-4 exercises = 2 studies |
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<tbody>
<tr>
<td>SETS</td>
<td>1-3</td>
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<tr>
<td>REPETITIONS</td>
<td>6-8</td>
</tr>
<tr>
<td>TRAINING DURATION</td>
<td>8-16 weeks</td>
</tr>
<tr>
<td>FREQUENCY</td>
<td>2-3 times per week</td>
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| INTENSITY | •Strength: Ranged from body weight to 80% 1RM  
•Power: Ranged from 40-75% 1RM with exception of the weighted vest |

Number of Exercise……

The types of exercise performed in the studies were:

1) leg press (4 studies),
2) knee ext.(all studies),
3) leg curl (5 studies),
4) ankle PF (3 studies),
5) squats (1 study),
6) hip flexion (1 study),
7) chair stands (1 study)

4 studies also included upper extremity exercises in their program such as chest press, seated row, bicep curl, and tricep ext.

All these characteristics met ACSM guidelines for PT and ST except:
1. one study that used BW for ST and a weighted vest for PT as their intensity levels.

The weighted vest was increased by 2% of the subjects BW if the subject was able to perform prior weight with no difficulty.
### Intervention Characteristics

| Exercise Speed (Tempo) | • PT groups completed the exercise as fast as possible  
<table>
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<th>• ST exercises were performed over 4-6 seconds</th>
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| **Equipment**          | • Weight machines = 5  
|                        | • Body weight for ST and weighted vest for PT  
|                        | = 1                                            |
| **Familiarization period** | 2 studies:  
|                        | • 1 included within the treatment time  
|                        | • 1 done prior to baseline measures            |

- PT groups completed the exercise as fast as possible  
- ST exercises were performed over 4-6 seconds

5 studies used various types of exercise equipment, such as an isokinetic dynamometer, Keiser pneumatic equip., Extek resistance equip., and 1 study performed all ex. Sitting in a chair using BW or BW + Weighted Vest.

A familiarization period was included by 2 studies with one being performed before baseline and the other within treatment time.

All these characteristics met ACSM guidelines for PT and ST.
Data Analysis Results

- Effect sizes and 95% CI were calculated for:
  - PT vs ST
  - PT vs Control
  - ST vs Control

- For the following outcome measures:
  - LE strength
  - LE power
  - Chair rise function
  - Gait velocity

As a meta-analysis was not performed due to clinical and statistical heterogeneity between the studies, hedges adjusted g effect sizes and 95% CI were calculated. Our primary comparison was PT vs. ST, however, we also performed secondary comparisons of PT vs. Control and ST vs. Control.

The outcome measures of LE strength, LE power, Chair rise function, and gait velocity were selected for analysis because they were utilized in the majority of the included studies.

Note, complete data was not obtained for two studies (Sayers, Bean) despite efforts to contact authors for additional data. As a result, change mean scores and standard deviations were used for data analysis where available (Bean).
Our first primary comparison was ……
The outcome measure was the same for all studies except Carmel, which used isokinetic knee ext. as their outcome.

To reiterate the effect size levels, a small effect = 0.2, a medium effect = 0.5, and a large effect = 0.8.

For this outcome, effect sizes ranged from negligible at 0.05 to medium at 0.68. However, no clear effect was evident for PT vs. ST as shown by the inconsistent effect measures and large and variable confidence intervals. It is also important to note that No statistical significant differences were found between groups for any of the studies.

Therefore, we could not conclude which training intervention was more effective at improving LE strength.
Our next comparison was........

The outcome measure used by 2 studies was leg press peak power, whereas, the study by Bean used the Wingate anaerobic cycle test for peak power, and the Carmel study used isokinetic knee ext. average power. All measures analysed power in watts.

For this outcome, effect sizes ranged from small at 0.16 to large at 2.87. Two studies were inconclusive about treatment efficacy (miz, car), as evident by small effect sizes and variable CI’s.

On the otherhand, two studies clearly favored PT, as evident by large effect sizes and consistent CI’s supporting PT. Also, both studies found a statistical significant difference for PT vs. ST on this outcome.

Therefore, we could conclude from this analysis that PT may be more effective at improving LE Power compared to ST.
Chair Rise (PT vs. ST)

Our next comparison was.........

The outcome measure used by 3 studies was stand up & sit down measured in seconds. Whereas the study by Bottaro used the number of chair stands in 30 secs to measure this outcome.

For this outcome, effect sizes ranged from small at 0.43 to large at 1.72.

All studies favored the PT group with 2 studies displaying a large effect that clearly favors PT, and 2 studies having small to medium effects. However, the study by Bottaro was not as conclusive due to the variable CI.

2 studies, Bean that clearly favors PT, and Bottaro that is inconclusive, found a statistical significant difference for PT versus ST.

Therefore, we could conclude from this analysis that PT may be more effective at improving chair rise function compared to ST. However caution must be taken when drawing conclusions due to the lack of statistical significance across all studies, particularly those that appear to favour PT.
Lastly, we compared........

The outcome measures used by 2 studies was Gait velocity in m/sec, whereas the study by Henwood measured time to walk 6m in seconds. Distances walked ranged from 2.4m to 6m.

For this outcome, effect sizes ranged from no effect at 0.0 to medium at 0.45.

The study by Carmel had an insignificant effect size with a large and variable CI, thus making the result inconclusive.

And the study by Bean had a medium effect size favoring PT, however the large and variable CI makes the result inconclusive again.

Also, No statistical significant differences for PT vs ST were found for any of the studies.

Therefore, we could not conclude which training intervention was more effective at improving Gait Velocity.

Continuous Scale Physical Function Performance (CS-PFP) test, a global outcome measure for function, was used for one study.

A large effect size, favoring the power training group (SMD 0.79;95% CI -0.04,1.63) was calculated for the CS-PFP total score. Statistical significance found for PT vs ST.
ST vs Control for analyzed outcome measures

- Data was obtained from the three studies that had control groups. Large and medium effect sizes for LE strength favored strength training for all three studies. Significant difference found in 2 studies.

- Medium effect sizes favoring strength training were also calculated on LE power for two studies. No significant difference found in either study.

- Chair rise performance favored the control group for one study and strength training for the other. No significant difference found in either study.

- A small gait velocity effect size favored the control group for one study and a medium effect size favored strength training for the other. Significant difference found in one study in favor of control group.

Conclusions:

LE Strength – ST may be > Cont
LE Power – ST may be > Cont, however caution as no sig. diff. and only med effect.
Chair Rise – inconclusive
Gait Velocity - inconclusive
Of the three studies that had control groups, insignificant to large effect sizes favoring the PT group were found for LE strength. Significant difference found in one study only.

Medium and large effect sizes for LE power and chair rise function favored the PT group respectively. Significant difference found for one study for chair rise function.

The control group was favored for one study and PT group for one study, for measures of gait velocity. No significant differences found for either study.

Conclusions:

LE Strength – PT may be > Cont.
LE Power – PT may be > Cont., however caution due to no significant diff and variable CI
Chair Rise – PT may be > Cont.
Gait Velocity – Inconclusive

Comprehensive Conclusion:

LE Strength – PT = ST, PT & ST may be > Cont.
LE Power – PT may be > ST, PT & ST may be > Cont with Caution
Chair Rise – PT may be > ST with Caution, PT may be > Cont., ST = Cont
Gait Velocity – PT = ST, PT = Cont., ST = Cont.
DISCUSSION
A major finding was that research conducted on the topic was generally lacking methodological quality.

Lack of blinding and intention to treat

Due to the nature of the physiotherapy interventions in the included studies, it was only possible to blind the assessors; however, only two of the six studies did so (Be, Ca).

Without blinding and intention to treat, there is an increased risk for observation bias which may influence recording and reporting of outcomes; therefore, caution is required when drawing conclusions from this data.
All studies had small sample sizes, ranging from 20 to 61 participants.

No pre-hoc power analysis.

A post-hoc power analysis concluded that a sample size between 46 and 150 subjects per group would be necessary to identify differences in functional outcome measures.

In a post-hoc power analysis, Sayers et al. concluded that a sample size between 46 and 150 subjects per group would be necessary to identify differences in functional outcome measures between power and strength training groups.
The inclusion of community-dwelling older adults may account for the limited amount of change observed in the studies.

A ceiling effect may have limited the gains in functional performance.
Adverse Events

- Although there were no reports of serious injury associated with PT or ST, adverse events were poorly reported/defined in most of the trials.

- This makes it difficult to come to a definite decision regarding the safety of PT and ST.

- It is important to note that inactivity also has serious negative consequences for older people.
Intervention Design: Familiarization

- Two studies utilized a familiarization period
- Initial gains in strength during resistance training have been attributed to neural adaptations resulting in increased muscle fiber recruitment, rather than actual increase in muscle size\(^9\)

The lack of familiarization period in other studies may confound the results, with the score changes potentially being a product of motor learning versus a power or strength training effect. In addition, a familiarization period may potentially increase safety and thereby decrease number of adverse events. (REF ??)
Intervention Design: Training Specificity

- Most studies employed non-functional exercises.

- 1 study included functional exercises of sit-to-stand and step up. There was significant improvement in chair-rise time.

- Improvement in functional performance may be enhanced by using function-specific exercises.
Intervention Design: Characteristics

- It requires 3-4 months, 2-3 times a week of training to have a 2 to 3 times increase in strength from baseline\textsuperscript{9}
  - 4 of 6 studies met this criteria
Various workloads were used between studies with no definitive conclusion on an ideal absolute total work.

- With a lower workload there may be increased exercise compliance and relatively lower perceived exertion.\(^{13}\)
CONCLUSION
The results are inconclusive as to the effectiveness of PT versus ST on LE function in community-dwelling older adults.

Three of the six studies found that PT was significantly more effective than ST for improving LE function in older adults.

Three of the six studies found no significant difference between PT and ST.
Conclusion

- Although the results were inconclusive in this review, a trend was evident that power training may be as effective or better in improving functional measures in older adults when compared to strength training.

- The inability of this review to find a conclusive answer is partially due to the moderate to low quality of the included studies.
RECOMMENDATIONS
Recommendations

1. Utilize rigorous research designs that minimize bias, have an adequate sample size and carefully monitor adverse events.

2. Expanded sample population to at-risk participants, such as older adults with pre-existing functional limitations and disability.

3. Perform follow-up assessment to determine the long-term effects of the interventions.
References


References

THANK-YOU:
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Charlotte Beck
Questions?