ผลของการฝึกความต้านทานของลิ้นต่อการเพิ่มความแข็งแรงของการบีบมือในผู้มีภาวะมวลกล้ามเนื้อน้อย: การศึกษาแบบไปข้างหน้า

Effect of Tongue Resistance Training on the Improvement of Handgrip Strength in Individuals with Possible Sarcopenia: A Prospective Study

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บทคัดย่อ

วัตถุประสงค์ : เพื่อศึกษาผลของการฝึกความต้านทานของลิ้นเป็นเวลา 8 สัปดาห์ ต่อความแข็งแรงของการบีบมือและความดันของลิ้นในวัยกลางคนและผู้สูงอายุที่มีความเสี่ยงสูงต่อภาวะซาร์โคพีเนีย

รูปแบบและวิธีวิจัย : การศึกษานำร่องเชิงไปข้างหน้าแบบก่อน–หลัง ในผู้เข้าร่วมอายุ 55 ปีขึ้นไป ที่รับการดูแลในคลินิกผู้สูงอายุ จำนวน 38 คน ผู้เข้าร่วมทำแบบฝึกความต้านทานของลิ้นทุกวันต่อเนื่องเป็นเวลา 8 สัปดาห์ โดยวัดแรงบีบมือด้วยเครื่องไดนาโมมิเตอร์ และวัดความดันของลิ้นด้วยอุปกรณ์ Iowa Oral Performance Instrument ทั้งก่อนและหลังการฝึก รวมถึงการเก็บข้อมูลพื้นฐานเกี่ยวกับภาวะโภชนาการ (โดยใช้แบบประเมิน Mini Nutritional Assessment: MNA) และระดับกิจกรรมทางกายของผู้เข้าร่วมด้วย ข้อมูลได้รับการวิเคราะห์โดยใช้สถิติเชิงพรรณนาเพื่ออธิบายลักษณะของกลุ่มตัวอย่าง และสถิติเชิงอนุมานโดยใช้ t-test แบบจับคู่เพื่อตรวจสอบความแตกต่างของแรงบีบมือและแรงกดของลิ้นก่อนและหลังการฝึก กำหนดระดับนัยสำคัญทางสถิติที่ $p<0.05$

ผลการศึกษา : หลังการฝึก 8 สัปดาห์ แรงบีบมือเพิ่มขึ้นเฉลี่ย 1.4±2.5 กิโลกรัม ($p=0.002$) และความดันของลิ้นเพิ่มขึ้น 6.0±9.1 กิโลปาสกาล ($p<0.001$) โดยผลลัพธ์ที่ชัดเจนพบในกลุ่มที่มีแรงบีบมือต่ำตั้งแต่เริ่มต้น โดยเฉพาะในผู้หญิง

สรุปผลการศึกษา : การฝึกความต้านทานของลิ้นช่วยเพิ่มสมรรถภาพของกล้ามเนื้อทั้งในช่องปากและทั่วร่างกายอย่างมีนัยสำคัญ วิธีนี้อาจช่วยเสริมการรักษาภาวะมวลกล้ามเนื้อน้อยแบบดั้งเดิม โดยช่วยให้การกลืนและความแข็งแรงของกล้ามเนื้อโดยรวมดีขึ้น

คำสำคัญ : แรงบีบมือ, ผู้สูงอายุ, ซาร์โคพีเนีย, ฝึกความต้านทานของลิ้น

ABSTRACT

Objective : To determine the effect of an 8-week tongue resistance training program on handgrip strength and tongue pressure in middle-aged and older adults at high risk for sarcopenia.

Methods : This prospective pre–post pilot study was conducted in 38 participants aged 55 years and older who received care at a geriatric clinic. Participants performed daily tongue resistance exercises continuously for 8 weeks. Handgrip strength was measured using a dynamometer, and tongue pressure was assessed using the Iowa Oral Performance Instrument (IOPI) both before and after the intervention. Baseline data on nutritional status (using the Mini Nutritional Assessment, MNA) and physical activity levels were also collected. Descriptive statistics were used to summarize participant characteristics, and paired t-tests were used to compare handgrip strength and tongue pressure before and after the intervention. A p-value of <0.05 was considered statistically significant.

Results : After 8 weeks, handgrip strength increased by 1.4±2.5 kg ($p=0.002$), and tongue pressure increased by 6.0±9.1 kPa ($p<0.001$). The most pronounced improvements were observed in participants with low baseline handgrip strength, particularly females.

Conclusion : Tongue resistance training significantly improved both orofacial and systemic muscle function. This approach may complement traditional sarcopenia management by enhancing swallowing ability and overall muscle strength.

Keywords : Handgrip strength, Older adults, Sarcopenia, Tongue resistance training

Introduction

As the global population continues to age[1], sarcopenia, a condition characterized by the progressive loss of skeletal muscle mass and strength, has emerged as a major public health issue. It is estimated that approximately 12% of adults over the age of 60 suffer from sarcopenia globally, and this figure is expected to rise alongside increasing life expectancy.[2] Sarcopenia is linked to significant health risks, including frailty, loss of independence, increased risk of falls, and higher mortality rates. Furthermore, it can lead to secondary conditions such as malnutrition and impaired oral function due to the weakening of orofacial muscles, particularly the tongue, which plays a crucial role in swallowing, speaking, and respiratory function. The Asian Working Group for Sarcopenia (AWGS) 2019 introduced 'possible sarcopenia,' defined as low muscle strength or physical performance without confirmed loss of muscle mass. This highlights the importance of early interventions to prevent progression to sarcopenia.[3] This study was designed as a pilot to assess feasibility and explore preliminary effects.

Background

Sarcopenia treatments focus on large muscle groups, often neglecting orofacial muscles like the tongue. A recent study found a positive correlation between handgrip strength and tongue pressure, indicating that age-related sarcopenia similarly affects orofacial muscles, such as the tongue, which are vital for critical functions like swallowing and speech.[4–7] Emerging evidence further underscores the tongue's role in overall muscular health, with research showing that weakened orofacial muscles significantly contribute to sarcopenia-related complications, such as malnutrition and reduced physical performance. Studies by *Clark and Solomon*[8] and *Nagano et al.*[9], highlight the potential benefit of targeted interventions like tongue resistance training.[10–12]

Recognizing the tongue's influence on overall muscle health, this study examines whether tongue resistance training can enhance handgrip strength in middle-aged and older adults. Grounded in evidence suggesting a link between orofacial muscle strength and general physical function, we hypothesize that structured tongue exercises will yield notable improvements in handgrip strength. This innovative approach could complement traditional sarcopenia therapies, potentially boosting physical performance and functional independence in older adults across both clinical and community rehabilitation settings.

Objective

To determine whether an 8-week tongue resistance training program improves handgrip strength and tongue pressure in middle-aged and older adults at high risk for sarcopenia.

Method

This prospective pre–post intervention study, approved by the Human Research Ethics Committee of Khon Kaen Hospital (Reference number: KEF67037), evaluated the impact of an 8-week tongue resistance training program on handgrip strength and tongue pressure. Data were collected between December 1, 2024, and February 28, 2025.

Population and Sample

This study recruited middle-aged and older adults (≥55 years) from a geriatric clinic who were considered at high risk for sarcopenia, defined as having at least one of the following: low physical activity level or reduced nutritional intake (MNA-SF≤11), without meeting the full diagnostic criteria for sarcopenia. Participants with mild Parkinson's disease or early-stage dementia were eligible if they could follow instructions and complete the training protocol. Exclusion criteria included severe cognitive impairment, history of head or neck surgery, tracheostomy, pre-existing hand conditions (e.g., arthritis, recent injury, or neurological deficits affecting hand function), or participation in hand-specific rehabilitation or strength training that could affect handgrip outcomes. Participants were withdrawn if they developed new health issues, could not adhere to the protocol, or chose to discontinue.

Sample Size Calculation

The sample size was calculated to assess the effect of tongue resistance training on handgrip strength using a pre–post (within-group) design. The calculation was based on the paired t-test formula:

Using an estimated mean difference (Δ) of 4.1 kPa in tongue pressure and the standard deviation (σ_d) of 6.0 kPa, derived from the study by Yano, et al[13]. the sample size was calculated as:

$$n = \left(\frac{1.96 + 0.84}{4.1 / 6}\right)^2$$

The minimum required sample size was 17 participants to detect a statistically significant change with 80% power and a two-sided alpha of 0.05. To account for potential dropouts or incomplete data, a total of 20 participants was considered an appropriate recruitment target. The final sample size exceeded this estimate, enhancing statistical power.

Intervention

This pilot pre–post intervention study was conducted over 8 weeks. Participants performed three orofacial exercises twice daily. Although categorized as orofacial exercises, the intervention primarily focused on tongue resistance. Techniques such as the Masako maneuver and chin-supported tongue holding involved active tongue pressure against resistance, aligning with the principles of tongue resistance training.

The three main exercises included:

1. Chin Support: Holding a water bottle or ball under the chin for 5–20 seconds, repeated 20 times.

2. Masako Technique: Biting the tongue tip while swallowing saliva, repeated 5–10 times.

3. Combination Exercise: Performing chin support and the Masako technique simultaneously, repeated 5–10 times.

Adherence was monitored using daily logs, and a phone call at Week 4 was made to reinforce compliance.

Measurements

All assessments were conducted at baseline and at the end of the 8-week intervention.

Primary Outcome:

- Handgrip Strength (HGS): Measured using a Jamar® dynamometer.

Secondary Outcome:

- Tongue Pressure: Assessed using the Iowa Oral Performance Instrument (IOPI).

- Nutritional Status: Measured at baseline using the Mini Nutritional Assessment (MNA).

Key confounders—including age, sex, MNA score, physical activity, comorbidities, and baseline HGS/tongue pressure—were recorded via standardized questionnaires, medical history review, and physical examinations.

Research Instruments

1. Iowa Oral Performance Instrument (IOPI):

A validated device used to measure tongue pressure by compressing an air-filled bulb. Output is in kilopascals (kPa). It demonstrates high construct validity and inter-rater reliability (ICC>0.85) and is widely accepted in clinical and research settings for assessing orofacial strength.

2. Jamar® dynamometer:

Recognized as the gold standard for measuring handgrip strength, with excellent test–retest reliability (ICC=0.95–0.98). Endorsed by the American Society of Hand Therapists (ASHT), it is widely used in geriatrics, rehabilitation, and sports medicine.

3. Demographic and Health Questionnaire:

Collected data on participant characteristics, comorbidities, nutritional status (MNA), and physical activity levels.

4. Exercise Logbook:

Completed by participants to monitor daily adherence to the exercise protocol.

5. Telephone Follow-up Checklist:

Administered at Week 4 to promote compliance and address any issues encountered during the intervention.

Statistical Analysis

Descriptive statistics

Baseline demographic and clinical characteristics of the study population were summarized using descriptive statistics. Continuous variables (e.g., age, handgrip strength, tongue pressure, and MNA score) were expressed as means and standard deviations (SD) for normally distributed data, or as medians and interquartile ranges (IQR) for non-normally distributed data. Categorical variables (e.g., sex and nutritional risk status) were reported as frequencies and percentages.

Inferential statistics

Paired t-tests were employed to assess within-group changes in handgrip strength and tongue pressure before and after the intervention.

Ethical Considerations

Written informed consent was obtained from all participants prior to enrollment. Participants were informed about the study's purpose, procedures, potential risks, and their right to withdraw at any point without affecting their ongoing medical care.

Result

A total of 38 participants were included, with a mean age of 68.2±10.0 years and 73.7% female. Baseline handgrip strength was 25.7±9.5 kg for males and 23.0±5.9 kg for females. Mean tongue pressure was 42.4±14.7 kPa. Common comorbidities included hypertension, dementia, and dyslipidemia. Detailed baseline characteristics are shown in Table 1.

Table 1 Baseline Characteristics of Study Participants (n=38)

Characteristic	**n (%) or mean±SD**
Age (years)	68.2±10.0
Female	28 (73.7)
Handgrip Strength (kg)	
- Male	25.7±9.5
- Female	23.0±5.9
Low handgrip	13 (34.2)
Male (<28 kg)	7 (70.0)
Female (<18 kg)	6 (21.4)
Tongue Pressure (kPa)	42.4±14.7
Body Mass Index (BMI)	24.1±4.4
MNA score	26.4±3.3
Underlying disease	
HT	12 (31.6)
DLP	8 (21.1)
CKD	3 (7.9)
Stroke	4 (10.5)

Characteristic	n (%) or mean±SD
Dementia	9 (23.7)
Other (Parkinson disease, CAD, thyroid, asthma, gout)	15 (39)

Handgrip strength increased significantly from 23.7±6.9 kg to 25.1±7.1 kg (mean change: 1.4±2.5 kg, p=0.002), and tongue pressure rose from 42.4±14.5 kPa to 48.4±14.3 kPa (mean change: 6.0±9.1 kPa, p<0.001), as shown in Table 2.

Table 2 Changes in Handgrip Strength and Tongue Pressure (Pre- and Post-Intervention)

Outcome	Pre-Intervention (Mean±SD)	Post-Intervention (Mean±SD)	Mean Change±SD (95% CI)	p-value
Handgrip Strength (kg)	23.7±6.9	25.1±7.1	1.4±2.5 [0.6, 2.2]	0.002
Tongue Pressure (kPa)	42.4±14.5	48.4±14.3	6.0±9.1 [3.1, 8.9]	< 0.001

Participants with low baseline handgrip strength exhibited greater improvements compared to those with normal handgrip strength (Table 3). Low handgrip males showed an increase from 20.8±3.4 kg to 22.5±3.6 kg, with a mean change of 1.7±1.8 kg (p=0.042, 95% CI [0.4, 3.0]). Low handgrip females exhibited a greater mean change of 2.7±2.6 kg, increasing from 14.7±1.7 kg to 17.4±2.2 kg (p=0.049, 95% CI [0.7, 4.8]). In contrast, participants with normal baseline handgrip strength showed limited or statistically insignificant improvements. Normal handgrip males demonstrated an observed increase from 37.0±7.8 kg to 42.9±3.3 kg, with a mean change of 5.9±6.4 kg that did not reach statistical significance (p=0.249, 95% CI [-1.3, 13.1]). Normal handgrip females showed a minimal increase from 25.3±4.3 kg to 25.6±4.2 kg, with a mean change of 0.3±0.6 kg (p=0.028, 95% CI [0.0, 0.5]).

Table 3 Subgroup Low vs Normal Handgrip Improvement by Gender

	Pre-Intervention (Mean±SD)	Post-Intervention (Mean±SD)	Mean Change ±SD (95% CI)	p-value
Low Handgrip Male	20.8±3.4	22.5±3.6	1.7±1.8 [0.4, 3.0]	0.042
Low Handgrip Female	14.7±1.7	17.4±2.2	2.7±2.6 [0.7, 4.8]	0.049
Normal Handgrip Male	37.0±7.8	42.9±3.3	5.9±6.4 [-1.3, 13.1]	0.249
Normal Handgrip Female	25.3±4.3	25.6±4.2	0.3±0.6 [0.0, 0.5]	0.028

Discussion

Although the improvement in handgrip strength reached statistical significance, the relatively large standard deviation (±2.5 kg) indicates substantial variability in individual responses. This suggests that while some participants experienced considerable gains, others showed minimal or no improvement, highlighting the heterogeneity in response to the intervention.

The overall gains of 1.4±2.5 kg in handgrip strength (p=0.002) and 6.0±9.1 kPa in tongue pressure (p<0.001) suggest enhanced neuromuscular coordination, which may account for the concurrent improvements in handgrip performance. Even small increases in muscle strength may yield meaningful functional improvements, particularly in frail individuals. Participants with low baseline handgrip strength, especially females, showed the greatest improvements (2.7±2.6 kg in females vs. 1.7±1.8 kg in males), likely due to lower initial strength and a greater relative deficit.

In contrast, males with normal baseline handgrip strength showed a substantial mean improvement (5.9±6.4 kg), which did not reach statistical significance—likely due to the small sample size (n=3) and high variability. These findings underscore the need for larger, stratified samples in future studies to address variability and improve statistical robustness.

These findings support the potential of tongue resistance training as a practical adjunct in sarcopenia management by improving tongue strength and, consequently, swallowing and nutritional intake—both critical to slowing sarcopenia progression and reducing healthcare costs.

To our knowledge, this is one of the first studies to demonstrate that tongue resistance training can enhance systemic muscle strength, as evidenced by improvements in handgrip strength through targeted orofacial muscle activation. This novel approach could be incorporated into clinical and community-based programs for early sarcopenia intervention. The observed gains in tongue pressure and handgrip strength may result from improved neuromuscular coordination and activation of both central and peripheral pathways. By stimulating orofacial muscle fibers, tongue resistance training may induce broader neuromuscular adaptations that enhance overall muscular performance.

These results are consistent with previous studies by Nagano et al. and Yano et al., which reported improvements in tongue pressure and systemic muscle function through orofacial muscle training. Our findings extend this body of evidence by showing that tongue resistance training can also enhance handgrip strength—a key marker of systemic muscle health. Similarly, Shimizu et al. reported that tongue pressure is associated with improved swallowing and nutritional outcomes in older adults with sarcopenic dysphagia. In addition, Moynihan and Teo emphasized the association between oral function, protein intake, and sarcopenia risk, highlighting the importance of integrated oropharyngeal and nutritional strategies in sarcopenia prevention.

Although our final sample size exceeded the initially calculated requirement, this study was designed as a preliminary investigation. The primary aims were to assess feasibility and detect initial effects, rather than to generate generalizable conclusions. The small sample size was acknowledged as a limitation, and a paired pre–post design was used to maximize statistical power. These findings provide essential data to guide sample size calculations and inform future randomized controlled trial designs.

Despite achieving statistical significance, the relatively high variability in handgrip strength (±2.5 kg) reinforces the need to report effect sizes and confidence intervals alongside p-values, as statistical significance alone may not fully reflect clinical relevance or the consistency of observed effects.

Limitations

This study has several limitations. First, the absence of a control group restricts the ability to attribute the observed improvements solely to the tongue resistance training. Some participants may have engaged in general exercise routines independently, particularly in the geriatric clinic setting, which may have contributed to improvements in handgrip strength. However, the fact that some participants did not improve despite such exposure suggests a potential additive or synergistic effect of tongue resistance training.

Second, reliance on self-reported adherence introduces potential recall or reporting bias. Future studies should utilize objective monitoring tools, such as wearable devices or digital logs, to validate adherence.

Third, the relatively small sample size and high inter-individual variability may limit the generalizability of the findings.

Conclusion

This study suggests that tongue resistance training may improve both handgrip strength and tongue pressure in individuals at risk for sarcopenia. These findings support orofacial training as a complementary strategy in sarcopenia management. Ongoing research should refine these methods and investigate how they might further improve physical and functional health in older adults.

Recommendations for Future Research

To draw more robust conclusions, future studies should recalculate sample sizes based on observed effect sizes and adopt randomized controlled designs that account for baseline physical activity levels. Moreover, research should explore the neuromuscular mechanisms underlying the improvements, assess the long-term sustainability of the observed benefits, and evaluate the broader clinical impact of the intervention.

Given its low cost, safety, and ease of implementation, tongue resistance training should be further investigated as part of community-based sarcopenia prevention strategies—particularly for older adults at risk of muscle decline and dysphagia.

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