Archives of Gerontology and Geriatrics 79 (2018) 21–26

Contents lists available at ScienceDirect

Archives of Gerontology and Geriatrics

journal homepage: www.elsevier.com/locate/archger

Relationship between swallowing muscles and trunk muscle mass in healthy elderly individuals: A cross-sectional study

Kanako Yoshimi, Koji Hara, Haruka Tohara*, Ayako Nakane, Kazuharu Nakagawa, Kohei Yamaguchi, Yukiko Kurosawa, Saori Yoshida, Chantaramanee Ariya, Shunsuke Minakuchi

Department of Gerodontology, Division of Gerontology and Gerodontology, Tokyo Medical and Dental University, Tokyo, Japan

ARTICLE INFO

Keywords:
Swallowing muscles
Elderly
Survey
Trunk muscle mass index

ABSTRACT

Background and objective: A decrease of swallowing muscle strength causes dysphagia, and a relationship between swallowing muscle strength and appendicular muscle mass has been reported. Moreover, the effect of trunk retention function on swallowing function has been clinically recognized. However, the relationship between trunk muscle mass and swallowing muscle strength is unclear. We aimed to clarify the association between these variables in elderly individuals.

Methods: Subjects were 118 healthy community-dwelling individuals aged ≥65 years (men: 37, women: 81). We measured total muscle mass, grip strength, jaw-opening force, tongue pressure, cross-sectional area (CSA) of the geniohyoid muscle, and tongue muscle thickness. The appendicular skeletal muscle mass index (ASMI) and trunk muscle mass index (TMI) were calculated based on the appendicular skeletal muscle mass and trunk muscle mass, and corrected by height squared. Multiple regression analysis was performed with jaw-opening force and tongue pressure as dependent variables and with age, sex, grip strength, ASMI, TMI, CSA of the geniohyoid muscle, and tongue muscle thickness as independent variables.

Results: Significant explanatory factors for jaw-opening force were sex ($p = 0.002$) and TMI ($p = 0.003$). Significant explanatory factors for tongue pressure were aging ($p = 0.001$), tongue muscle thickness ($p = 0.027$), and TMI ($p = 0.033$).

Conclusions: Until now, the relationship between swallowing muscles and whole body muscle mass has been reported using ASMI as the indicator of whole body muscle mass. This study suggests that TMI may be used as a highly relevant indicator of swallowing muscles rather than ASMI.

1. Introduction

Various muscles cooperate to achieve safe swallowing (Dodds et al., 1989). Among the swallowing muscles, the suprahyoid muscles are involved in laryngeal elevation, and the tongue muscles are involved in bolus formation and feeding. The force of the suprahyoid muscle can be evaluated by measuring the jaw-opening force (JOF) (Hara et al., 2014), and the force of the tongue muscle can be evaluated by measuring tongue pressure (TP) (Utanohara et al., 2008). Previous studies reported that the JOF and TP decreased with aging (Iida et al., 2013; Utanohara et al., 2008) and sarcopenia (Machida et al., 2017). Moreover, a decrease of swallowing muscle strength causes dysphagia (Maeda & Akagi, 2015; Hara et al., 2014). Therefore, it is important to evaluate swallowing muscle strength and investigate factors related to it.

Moreover, a study on the relationship between the stability of posture and swallowing disorders reported that elderly people with unstable posture during eating were significantly more likely to choke than those with a stable posture (Tamura et al., 1997). Hence, the relationship between trunk retention function and swallowing function is clinically recognized.

Until now, the relationships between appendicular muscle mass and swallowing muscle strength (Kajisa et al., 2018), and swallowing function (Murakami et al., 2015) have been reported; however, no

---

Abbreviations: CSA, cross-sectional area; ASMI, appendicular skeletal muscle mass index; TMI, trunk muscle mass index; JOF, jaw-opening force; TP, tongue pressure; ADL, activities of daily living; BIA, bioelectrical impedance analysis; ECW, extracellular water; TBW, total body water; GH, geniohyoid muscle; ICC, intraclass correlation coefficient

* Corresponding author at: Department of Gerodontology, Division of Gerontology and Gerodontology, Tokyo Medical and Dental University, 1-5-45 Yushima Bunkyo-ku, Tokyo 113-8510, Japan.

E-mail address: haruka-t@rd5.so-net.ne.jp (H. Tohara).

https://doi.org/10.1016/j.archger.2018.07.018
Received 31 May 2018; Received in revised form 26 July 2018; Accepted 27 July 2018

study has shown the relationship between swallowing muscles and trunk muscle mass. Therefore, the aim of the present study was to clarify the relationship between the muscle strength of swallowing muscles and trunk muscle mass in healthy elderly individuals.

2. Materials and methods

2.1. Study design

This was a cross-sectional study. This study was performed after approval from the Tokyo Medical and Dental University Ethics Review Committee (number D2014-047) and carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki). Informed consent was obtained from all participants.

2.2. Participants

We enrolled 118 healthy elderly individuals aged over 65 years (37 men, 81 women). The participants were recruited from a health survey in Oyama City, Tochigi, Japan. Measurements were performed in October 2017. Inclusion criteria were subjects who were independent according to the activities of daily living (ADL) scale, those able to be surveyed, and those without a history of swallowing disorder. Exclusion criterion was subjects with a progressive neurological disorder.

2.3. Procedures

2.3.1. Jaw-opening force

A jaw-opening sthenometer (Livet Inc., Tokyo Japan) was used to measure JOF. The participant was placed in the sitting position, with mouth closed and teeth clenched lightly; the belts of the device were placed around the participant's head and mandible. We instructed the participants to open their mouths as wide as possible. A value (kg) showing the force at maximum mouth opening was used as the maximum JOF. The measurement was conducted three times, and the average value was calculated.

2.3.2. Tongue pressure

The JMS TP device (JMS, Hiroshima, Japan) was used. The participant was placed in the sitting position, and the tip of the probe was held to the participant's front teeth. The maximum pressure (kPa) assessed by the probe when the participant's tongue pressed against the palate was recorded as the maximum TP. The measurement was performed three times, and the average value was calculated.

2.3.3. Skeletal muscle mass

Whole body muscle mass was measured by bioelectrical impedance analysis (BIA) using InBodyS10 (InBody Japan, Tokyo, Japan). The soft lean mass measured by InBody S10 is consistent with the definition of lean soft tissue mass, as measured by dual energy x-ray absorptiometry (including blood vessels, blood, and intercellular spaces) (National Institutes of Health, 1996). Therefore, the trunk muscle used in this study included blood, water, and connective tissue in addition to skeletal muscle, visceral smooth muscle, and the myocardium.

Additionally, in BIA, the body composition was analyzed from the chemical viewpoint; the measured muscle mass varies depending on the extracellular water (ECW) to total body water (TBW) ratio, representing the body water content. ECW/TBW is commonly used as an index showing the severity of edema and disease, and its reference value is 0.038 to 0.400 (Malbrain et al., 2014). Because of the decrease in body water content with aging, ECW/TBW may exceed the reference value even if there is no underlying disease (Ohashi et al., 2018). The participants were healthy elderly individuals so it seems that muscle mass error due to ECW/TBW fluctuation is negligible, but since muscle mass tends to be affected by edema, those with ECW/TBW exceeding 0.400 were excluded.

According to Baumgartner et al. (2004), the index of muscle mass was calculated from the muscle mass of the upper and lower limbs (appendicular skeletal muscle mass) corrected by height squared, and we defined it as the appendicular skeletal muscle mass index (ASMI). Similarly, trunk muscle mass was corrected by height squared, and the trunk muscle mass index (TMI) was used. A previous study reported that the length of the torso and the length of the limb are related to height (Gallagher et al., 1997), and it is better to adjust the skeletal muscle mass by height than by body weight (Han et al., 2016). For this reason, trunk muscle mass was corrected by height squared in this study. Regarding the reliability of TMI, we calculated the intraclass correlation coefficient (ICC). Eight healthy volunteers participated; the trunk muscle was measured twice, and the second measurement was performed on another day. The ICC (1,1) was 0.969, and the ICC (1.2) was 0.984, showing high reliability.

2.3.4. Muscle mass of the swallowing muscles

The cross-sectional area (CSA) of the geniohyoid muscle (GH) and the thickness of tongue muscle were measured by an ultrasonic measuring device in B mode (SonoSite M-turbo, Fujifilm, Tokyo, Japan). A linear probe with a wideband frequency of 6–13 MHz was used to measure the GH, and a convex probe with a wideband frequency of 2–5 MHz was used to measure the tongue muscle. Measurement of the GH was based on Kajisa et al.'s method (2018).

First, we instructed the participant to lightly close their mouth while facing forward in the sitting position. Second, the probe was placed vertically on the lower surface of the mandible covered with ultrasonic gel, and the probe adhered sufficiently to the skin without applying pressure on the tissue. The position of the probe was one-third in front of the position connecting the parotid and the mandible, and the cross-

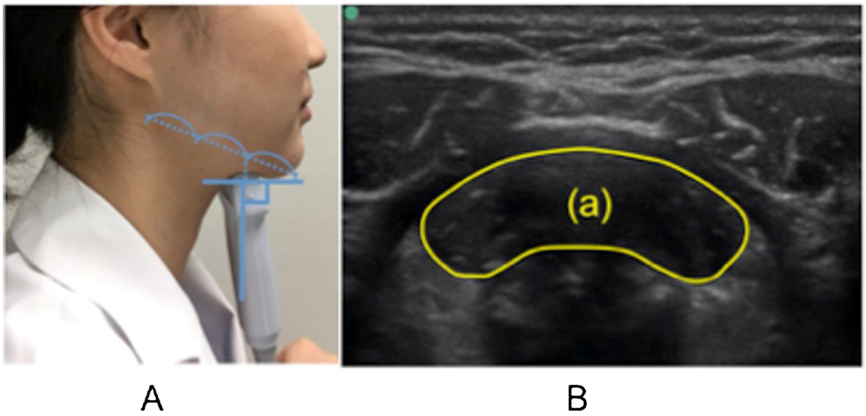

Fig. 1. Ultrasonographic measurement of the geniohyoid muscle (GH). (A) Position of the probe. (B) Ultrasonographic image of the (a) GH.