



Original Article

Standard values for temporal muscle thickness in the Japanese population who undergo brain check-up by magnetic resonance imaging

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ABSTRACT

Background: Skeletal muscle mass is an important factor for various diseases' outcomes. The psoas muscle cross-sectional area on the abdominal computed tomography (CT), gait speed, and handgrip strength is used to measure it. However, it is difficult to measure the neurological patients' muscle mass or function because (1) we do not perform abdominal CT. (2) Such patients have impaired consciousness, gait disturbance, paresis, and need of rest. Temporal muscle thickness (TMT) on magnetic resonance imaging (MRI) is now attractive for skeletal muscle volume indicator, but the reference values are not established. We herein investigated the standard value of the Japanese TMT using the brain check-up database by MRI.

Methods: We retrospectively investigated 360 Japanese individuals from two institutions between 2017 and 2019. We measured TMT on the T1-weighted images in the previously reported way. The associations between TMT and other variables were analyzed.

Results: TMT of 214 women and 146 men, ranging from 35 to 84 years old, was investigated. TMT ranged from 3.69 to 16.90 mm. Mean TMT values were significantly higher in men compared to women except for the over 70-year-old cohort. TMT was correlated to weight and body mass index in both sexes.

Conclusion: This is the first retrospective study on the standard TMT values from the Japanese brain check-up database. Our results were just reference values, but these would be useful for further investigation in other neurosurgical and neurological diseases regarding muscle volume or sarcopenia.

Keywords: Aging, Nutrition, Sarcopenia, Skeletal muscle volume, Temporal muscle thickness

INTRODUCTION

Low skeletal muscle mass due to low nutrition or aging (sarcopenia in the broadest sense^[4,7,27,31]) is clinically important in the various diseases both in elderly and nonelderly populations.^[36,38] Regarding neurosurgical and neurological patients, total body skeletal muscle mass is important to obtain better functional outcomes after stroke rehabilitation.^[28,32] To measure the total body skeletal muscle mass, psoas muscle cross-sectional area at the level of the third lumbar vertebra

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on the abdominal computed tomography (CT),^[17] gait speed, and handgrip strength is usually used.^[6] However, it is difficult to measure muscle mass or muscle function of the neurosurgical or neurological patients in those ways, because we do not usually perform abdominal CT and the neurosurgical or neurological patients often have impaired consciousness, gait disturbance, paresis, and need of rest considering the risk of aneurysm rerupture or cerebral hemorrhage rebleeding by increased blood pressure.

Therefore, we focused on the temporal muscle thickness (TMT) on magnetic resonance imaging (MRI). Recently, TMT is substituted as a useful and safe measure of the total body skeletal muscle mass.^[13,25,33] TMT is also featured and reported as clinically useful parameters; they are indicators of nutrition,^[13] prognosis of glioblastoma,^[1,12,15,26,30,41] and newly diagnosed brain metastasis.^[10,11] TMT is a predictor of sarcopenia in neurological patients.^[39] Furthermore, TMT is reported as potential prognostic factor for aneurysmal subarachnoid hemorrhage patients treated by endovascular coiling^[22] and clipping.^[19,24] Similar researches in intracerebral hemorrhage,^[20,21] Parkinson's disease,^[41] and cadaver dissection^[37] were also preliminarily performed. Therefore, TMT would be a useful surrogate marker and integrated into neurological patients' diagnostic workup to prevent, delay, or treat sarcopenia and to predict diseases' outcomes.^[39]

The standard TMT values of healthy Caucasian individuals were reported,^[39] but those of Mongoloid have not been reported. Therefore, we investigated the standard values of the Japanese TMT using the database from the brain check-up by MRI.

MATERIALS AND METHODS

Study population

We retrospectively retrieved data from the brain check-up database of all the 360 healthy Japanese individuals at two institutions. One hospital provided 149 individuals between 2017 and 2019, and the other hospital provided 211 individuals during 2018. People who underwent brain check-up had to pay 24,000 JPY. The hospitals' research ethics committees approved this study. We gained written informed consent for this study from all of the individuals. All methods were carried out under relevant guidelines and regulations (Declaration of Helsinki).

Clinical variables

We collected data of age, sex, height, weight, and body mass index (BMI). We used SIGNA Pioneer 3.0T (GE Healthcare Life Sciences, Buckinghamshire, England) by a 24-channel head-neck coil and acquired MR images. We measured TMT on an axial plane of the T1-weighted image (T1WI) in the previously reported way.^[39] Predefined anatomical

landmarks, such as the Sylvian fissure (anterior-posterior orientation) and the orbital roof (craniocaudal orientation), were used to guarantee a high reproducibility of TMT values. Two investigators measured the TMT using SYNAPSE V 4.1.5 imaging software (Fujifilm Medical, Tokyo, Japan). TMT was assessed on both sides in each individual, and the mean TMT was calculated by summing up those measurements and dividing them by two. There were no individuals with muscle edema, atrophy due to craniotomy or radiation therapy, trigeminal nerve disease, nor myopathy, which might be related to smaller TMT.

According to the Fazekas scale, we also evaluated periventricular hyperintensity (PVH) on fluid-attenuated inversion recovery images.^[9] We also counted the number of microbleeds on the T2* image and detected intracranial cerebral aneurysm on magnetic resonance angiography.

Statistical analysis

Intraclass correlation coefficients tested the inter-rater reliabilities of TMT. The results are described as mean \pm standard deviation (SD), and sex- and age-related mean TMT reference values were given as means with SDs and ranges. The associations between TMT and other factors were investigated by the Mann-Whitney U-test or Spearman's coefficient correlation. $R > 0.2$ was defined that there was a significant correlation. A two-tailed $P < 0.05$ was considered statistically significant. We conducted this calculation using the SPSS software version 24.0.0. (IBM, New York, USA).

RESULTS

Clinical characteristics and TMT

TMT characteristics of the 360 individuals (214 women and 146 men) ranging from 35 to 84 years old are summarized in [Table 1]. The intraclass correlation coefficients (2, 2) measuring TMT were 0.845. TMT values in the retrospective normal cohort ranged from 3.69 to 16.90 mm. Mean TMT values were significantly higher in men compared to women except for over 70-year-old cohort (overall, $P < 0.001$; 35–49 years, $P = 0.001$; 50–59 years, $P < 0.001$; 60–69 years, $P = 0.009$; and 70 < years, $P = 0.120$).

TMT and other variables

TMT was correlated to weight and BMI in both sexes (TMT vs. weight in men; $r = 0.262$; $P = 0.001$, TMT vs. BMI in men; $r = 0.231$; $P = 0.005$, TMT vs. weight in women; $r = 0.415$; $P < 0.001$, TMT vs. BMI in women; $r = 0.432$; $P < 0.001$). Age, height, Fazekas PVH scale, the numbers of microbleeds, and aneurysms were not correlated to TMT in both sexes ($P > 0.05$) [Table 2].

Table 1: Age- and sex-related mean, minimum, and maximum TMT values and SD per subgroup.

Sex	Age group	n	Mean TMT (mm)	Minimum TMT (mm)	Maximum TMT (mm)	SD
Men	35–39	2	8.65	8.64	8.65	0.01
	40–49	56	10.21	4.85	14.30	2.08
	50–59	44	10.30	6.68	16.90	2.58
	60–69	24	9.90	6.98	12.90	1.95
	70–79	16	8.80	6.35	11.44	1.94
	80 <	4	12.99	10.45	15.48	2.84
	All	146	10.09	4.85	16.90	2.29
Women	35–39	14	10.01	6.09	12.50	2.22
	40–49	56	8.57	3.90	11.72	1.95
	50–59	90	7.78	4.30	11.32	1.80
	60–69	38	8.38	4.30	14.71	1.95
	70–79	12	9.14	6.33	11.29	1.75
	80<	4	5.05	3.69	6.41	1.57
	All	214	8.31	3.69	14.71	2.24

SD: Standard deviation, TMT: Temporal muscle thickness

Table 2: Associations between TMT and other variables.

Sex	Variable	Mean or (number)	SD	Coefficient	P-value
Men (n=164)	Age (y.o.)	54.1	11.2	-0.060	0.475
	Height (cm)	168.7	6.0	0.067	0.432
	Weight (kg)	69.7	12.1	0.262	0.001*
	Body mass index (kg/m ²)	24.5	3.9	0.231	0.005*
	Fazekas scale of PVH	0.63	0.8	-0.125	0.131
	0	(80)			
	1	(44)			
	2	(37)			
	3	(3)			
	Number of microbleeds	0.03	0.2	-0.115	0.165
	0	(142)			
1	(4)				
Number of aneurysms	0.01	0.1	0.028	0.738	
0	(144)				
1	(2)				
Women (n=214)	Age (y.o.)	54.2	10.0	-0.103	0.132
	Height (cm)	156.7	6.3	0.048	0.483
	Weight (kg)	55.9	9.1	0.415	<0.001*
	Body mass index (kg/m ²)	22.8	3.5	0.432	<0.001*
	Fazekas scale of PVH	0.57	0.7	-0.036	0.597
	0	(114)			
	1	(83)			
	2	(11)			
	3	(6)			
	Number of microbleeds	0.07	0.4	0.061	0.377
	0	(202)			
1	(10)				
3	(2)				
Number of aneurysms	0.02	0.1	-0.011	0.877	
0	(210)				
1	(4)				

*P<0.05 by Spearman's coefficient correlation. PVH: Periventricular hyperintensity, SD: Standard deviation, TMT: Temporal muscle thickness

DISCUSSION

We retrospectively investigated TMT from the brain check-up database from two institutions. Our results were just reference values, but this is the first report regarding TMT standard values of Japanese individuals who underwent brain check-up.

The usefulness of TMT as indicators of skeletal muscle mass in neurosurgical and neurological diseases

Several reports on the association between skeletal muscle mass and neurosurgical diseases are reported. Higher skeletal muscle mass reduces the risk of intracranial arterial stenosis and may protect against ischemic stroke.^[18,29] Sarcopenia, loss of skeletal muscle mass in the elderly, also relates to the medium-term outcomes of carotid artery stenting,^[16] mortality after percutaneous vertebral augmentation,^[2] and traumatic brain injury.^[40] However, many studies on the association between skeletal muscle mass and outcomes used psoas muscle cross-sectional area at the third lumbar vertebra level,^[17] systemic muscle mass, gait speed, and handgrip strength as indicators of sarcopenia.^[6] Mainly, the systemic muscle mass and its function are important for diagnosis and indicators of sarcopenia,^[4] and muscle strength was at the forefront as it was recognized that strength was better than mass in predicting adverse outcomes.^[3,5,23,35] However, we sometimes cannot perform muscle function tests for neurosurgical and neurological patients due to the patients' impaired consciousness, gait disturbance, paresis, aneurysm rupture, and cerebral hemorrhage rebleeding concerns. Therefore, we hypothesized that TMT on MRI would be a useful surrogate marker of skeletal muscle mass, and it would be helpful to clinical application for various neurosurgical and neurological diseases patients. However, there are no reports on Mongoloid standard TMT, so we investigated standard TMT values from the brain check-up cohort.

Previously, TMT thresholds in the MRI for the outcomes in various diseases were investigated, but some studies yielded inconsistent results in TMT values. TMT in MRI over the median was associated with favorable outcomes in brain metastasis.^[11] The medians were not described, but the mean TMT was 5.0 mm in females, 6.2 in males. TMT in MRI over 4.9 mm,^[41] 7.1 mm,^[12] or 9.2 mm^[26] was thresholds for the prognosis of glioblastoma patients regardless of sex. Another study reported that 7.20 mm of male and 5.54 mm of female were cutoff points for the prognosis of the newly diagnosed glioblastoma patients.^[1] On the other hand, Muglia revealed that TMT was not associated with prognosis in his cohort of patients with glioblastoma at diagnosis.^[30] In other studies, the cutoff points of TMT in MRI to diagnose sarcopenia are 6.3 mm for male patients and 5.2 mm for female patients, respectively.^[39] Katsuki reported that the TMT thresholds for

the subarachnoid hemorrhage outcome on CT images were 4.9 mm in females and 6.7 mm in males, respectively.^[19]

It is not easy to compare the threshold values of TMT because the investigator, methods, and modality were different in each study. However, research on the temporalis muscle is still in its infancy. Therefore, investigating the threshold is meaningful for the clinical practice, and further prospective studies are desired.

The difference from the previous study on Caucasian

Steindl reported standard TMT values of healthy Caucasian individuals.^[39] Compared to the study, our results did not seem significantly different. We first hypothesized that Japanese TMT would be smaller than that of Caucasian because the criteria of sarcopenia are different between Europe and Asia.^[4,7] Furthermore, the psoas muscle is not different between Caucasians and Asians, but paraspinal muscle is greater in Caucasians in the degenerative spine patients.^[14] However, the results of TMT did not look different between Steindl's and ours. Furthermore, Japanese individuals have bigger TMT than Caucasian individuals in some age groups, such as 60–69 and 70–79. This may not be from racial differences. Our cohort took the trouble of paying money for a brain check-up. That was how health conscious they were, and they may have usually been paying attention to exercise and nutrition. Therefore, this study could not support the hypothesis that TMT is different between races, and further study is needed.

Limitations

First, the sample size was small. Second, we did not measure actual skeletal muscle volume nor muscle function. Therefore, it is uncertain that TMT was really surrogate markers of skeletal muscle mass in this study. Furthermore, it is unknown that TMT was determined congenitally and whether they can be enlarged by training like chewing. Third, we did not investigate laboratory test results, such as albumin, total cholesterol, nor lymphocyte count, which are marker of nutrition status.^[8] Fourth, accurate and standard methods of TMT measurements were not established. Ranganathan *et al.*^[33] and Rinkinen *et al.*^[34] used image analysis and engineering software to measure temporal muscle. Hsieh *et al.*^[15] measured the TM width using an average of the four slices of head CT images. Katsuki used CT to measure TMT.^[22,24] Furtner *et al.*^[10-12,39] provided the measuring method in this study. In any way, TMT was manually measured perpendicular to the temporal muscle's long axis, so lack of accuracy and reproducibility is possible. In this study, the intraclass correlation coefficient of the two investigators was sufficient, but the best way to measure TMT should be discussed.

CONCLUSION

We retrospectively investigated standard TMT values from the brain check-up database of two institutions. Our results were just reference values, but these would be useful for further investigation in other neurosurgical and neurological diseases regarding muscle volume or sarcopenia.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent.

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Nil.

Conflicts of interest

There are no conflicts of interest.

REFERENCES

- An G, Ahn S, Park JS, Jeun SS, Hong YK. Association between temporal muscle thickness and clinical outcomes in patients with newly diagnosed glioblastoma. *J Cancer Res Clin Oncol* 2020;147:901-9.
- Bayram S, Akgül T, Adiyaman AE, Karalar Ş, Dölen D, Aydoseli A. Effect of sarcopenia on mortality after percutaneous vertebral augmentation treatment for osteoporotic vertebral compression fractures in elderly patients: A retrospective cohort study. *World Neurosurg* 2020;138:e354-60.
- Binay Safer V, Safer U. Comment on Clinical characteristics of aneurysmal subarachnoid hemorrhage (SAH) in the elderly over 75: Would temporal muscle be a potential prognostic factor as an indicator of sarcopenia? *Clin Neurol Neurosurg* 2020;188:105600.
- Chen LK, Liu LK, Woo J, Assantachai P, Auyeung TW, Bahyah KS, *et al.* Sarcopenia in Asia: Consensus report of the Asian working group for sarcopenia. *J Am Med Dir Assoc* 2014;15:95-101.
- Cinkir HY, Er HC. Is temporal muscle thickness a survival predictor in newly diagnosed glioblastoma multiforme? *Asia Pac J Clin Oncol* 2020;16:e223-7.
- Cruz-Jentoft AJ, Baeyens JP, Bauer JM, Boirie Y, Cederholm T, Landi F, *et al.* Sarcopenia: European consensus on definition and diagnosis: Report of the European working group on sarcopenia in older people. *Age Ageing* 2010;39:412-23.
- Cruz-Jentoft AJ, Bahat G, Bauer J, Boirie Y, Bruyère O, Cederholm T, *et al.* Sarcopenia: Revised European consensus on definition and diagnosis. *Age Ageing* 2019;48:16-31.
- de Ulíbarri JJ, González-Madroño A, de Villar NG, González P, González B, Mancha A, *et al.* CONUT: A tool for controlling nutritional status. First validation in a hospital population. *Nutr Hosp* 2005;20:38-45.
- Fazekas F, Kleinert R, Offenbacher H, Payer F, Schmidt R, Kleinert G, *et al.* The morphologic correlate of incidental punctate white matter hyperintensities on MR images. *AJNR Am J Neuroradiol* 1991;12:915-21.
- Furtner J, Berghoff AS, Albtoush OM, Woitek R, Asenbaum U, Prayer D, *et al.* Survival prediction using temporal muscle thickness measurements on cranial magnetic resonance images in patients with newly diagnosed brain metastases. *Eur Radiol* 2017;27:3167-73.
- Furtner J, Berghoff AS, Schöpf V, Reumann R, Pascher B, Woitek R, *et al.* Temporal muscle thickness is an independent prognostic marker in melanoma patients with newly diagnosed brain metastases. *J Neurooncol* 2018;140:173-8.
- Furtner J, Genbrugge E, Gorlia T, Bendszus M, Nowosielski M, Golfopoulos V, *et al.* Temporal muscle thickness is an independent prognostic marker in patients with progressive glioblastoma: Translational imaging analysis of the EORTC 26101 trial. *Neuro Oncol* 2019;21:1587-94.
- Hasegawa Y, Yoshida M, Sato A, Fujimoto Y, Minematsu T, Sugama J, *et al.* Temporal muscle thickness as a new indicator of nutritional status in older individuals. *Geriatr Gerontol Int* 2019;19:135-40.
- Hida T, Eastlack RK, Kanemura T, Mundis GM, Imagama S, Akbarnia BA. Effect of race, age, and gender on lumbar muscle volume and fat infiltration in the degenerative spine. *J Orthop Sci* 2020. Doi: 10.1016/j.jos.2019.09.006.
- Hsieh K, Hwang M, Estevez-Inoa G, Saraf A, Spina CS, Smith D, *et al.* Temporalis muscle width as a measure of sarcopenia independently predicts overall survival in patients with newly diagnosed glioblastoma. *Int J Radiat Oncol* 2018;102:e225.
- Ishihara H, Oka F, Goto H, Nishimoto T, Okazaki K, Sadahiro H, *et al.* Impact of frailty on medium-term outcome in asymptomatic patients after carotid artery stenting. *World Neurosurg* 2019;127:e396-9.
- Jones KI, Doleman B, Scott S, Lund JN, Williams JP. Simple psoas cross-sectional area measurement is a quick and easy method to assess sarcopenia and predicts major surgical complications. *Colorectal Dis* 2015;17:O20-6.
- Jung HJ, Jung H, Lee T, Kim J, Park J, Kim H, *et al.* Decreased muscle mass in Korean subjects with intracranial arterial stenosis: The Kangbuk samsung health study. *Atherosclerosis* 2017;256:89-93.
- Katsuki M, Kakizawa Y, Nishikawa A, Yamamoto Y, Uchiyama T. Temporal muscle thickness and area are an independent prognostic factors in patients aged 75 or younger with aneurysmal subarachnoid hemorrhage treated by clipping. *Surg Neurol Int* 2021.
- Katsuki M, Kakizawa Y, Nishikawa A, Yasunaga Y, Toshiya U. Total protein and neuronavigation are novel prognostic factors of endoscopic hematoma removal for intracerebral hemorrhage. *J Stroke Cerebrovasc Dis* 2020;29:105050.
- Katsuki M, Kakizawa Y, Nishikawa A, Yasunaga Y, Uchiyama T. Endoscopic hematoma removal of supratentorial intracerebral hemorrhage under local anesthesia reduces operative time compared to craniotomy. *Sci Rep* 2020;10:10389.
- Katsuki M, Suzuki Y, Kunitoki K, Sato Y, Sasaki K, Mashiyama S, *et al.* Temporal muscle as an indicator of sarcopenia is independently associated with Hunt and Kosnik grade on admission and the modified rankin scale score at

- 6 months of patients with subarachnoid hemorrhage treated by endovascular coiling. *World Neurosurg* 2020;137:e526-34.
23. Katsuki M, Suzuki Y, Sato Y, Sasaki K, Shingai Y, Mashiyama S, *et al.* In reply to the letter to the editor regarding temporal muscle as an indicator of sarcopenia is independently associated with Hunt and Kosnik grade on admission and the modified rankin scale at 6 months of patients with subarachnoid hemorrhage treated by endovascular coiling. *World Neurosurg* 2020;140:433.
 24. Katsuki M, Yamamoto Y, Uchiyama T, Wada N, Kakizawa Y. Clinical characteristics of aneurysmal subarachnoid hemorrhage in the elderly over 75; would temporal muscle be a potential prognostic factor as an indicator of sarcopenia? *Clin Neurol Neurosurg* 2019;186:105535.
 25. Leitner J, Pelster S, Schöpf V, Berghoff AS, Woitek R, Asenbaum U, *et al.* High correlation of temporal muscle thickness with lumbar skeletal muscle cross-sectional area in patients with brain metastases. *PLoS One* 2018;13:e0207849.
 26. Liu F, Xing D, Zha Y, Wang L, Dong W, Li L, *et al.* Predictive value of temporal muscle thickness measurements on cranial magnetic resonance images in the prognosis of patients with primary glioblastoma. *Front Neurol* 2020;11:523292.
 27. Malmstrom TK, Morley JE. SARC-F: A simple questionnaire to rapidly diagnose sarcopenia. *J Am Med Dir Assoc* 2013;14:531-2.
 28. Matsushita T, Nishioka S, Taguchi S, Yamanouchi A, Nakashima R, Wakabayashi H. Sarcopenic obesity and activities of daily living in stroke rehabilitation patients: A cross-sectional study. *Healthcare (Basel)* 2020;8:255.
 29. Minn YK, Suk SH. Higher skeletal muscle mass may protect against ischemic stroke in community-dwelling adults without stroke and dementia: The PRESENT project. *BMC Geriatr* 2017;17:45.
 30. Muglia R, Simonelli M, Pessina F, Morengi E, Navarria P, Persico P, *et al.* Prognostic relevance of temporal muscle thickness as a marker of sarcopenia in patients with glioblastoma at diagnosis. *Eur Radiol* 2020. Doi: 10.1007/s00330-020-07471-8.
 31. Nishiguchi S, Hino K, Moriya K, Shiraki M, Hiramatsu A, Nishikawa H. Assessment criteria for sarcopenia in liver disease (first edition): Report from the working group for creation of sarcopenia assessment criteria in the Japan society of hepatology. *Kanzo* 2016;57:353-68. Available from: https://www.jstage.jst.go.jp/article/kanzo/57/7/57_353/_article/-char/ja. [Last accessed on 2020 Apr 24].
 32. Nozoe M, Kanai M, Kubo H, Kobayashi M, Yamamoto M, Shimada S, *et al.* Quadriceps muscle thickness changes in patients with aneurysmal subarachnoid hemorrhage during the acute phase. *Top Stroke Rehabil* 2018;25:209-13.
 33. Ranganathan K, Terjimanian M, Lisecki J, Rinkinen J, Mukkamala A, Brownley C, *et al.* Temporalis muscle morphomics: The psoas of the craniofacial skeleton. *J Surg Res* 2014;186:246-52.
 34. Rinkinen J, Zhang P, Wang L, Enchakalody B, Terjimanian M, Holcomb S, *et al.* Novel temporalis muscle and fat pad morphomic analyses aids preoperative risk evaluation and outcome assessment in nonsyndromic craniosynostosis. *J Craniofac Surg* 2013;24:250-5.
 35. Safer U, Tasci I, Safer VB. Letter to the editor regarding effect of sarcopenia on mortality after percutaneous vertebral augmentation treatment for osteoporotic vertebral compression fractures in elderly patients: A retrospective cohort study. *World Neurosurg* 2020;139:710.
 36. Someya Y, Tamura Y, Suzuki R, Kaga H, Kadowaki S, Sugimoto D, *et al.* Characteristics of glucose metabolism in underweight Japanese women. *J Endocr Soc* 2018;2:279-89.
 37. Song WC, Choi HG, Kim SH, Kim SH, Hu KS, Kim HJ, *et al.* Topographic anatomy of the zygomatic arch and temporal fossa: A cadaveric study. *J Plast Reconstr Aesthet Surg* 2009;62:1375-8.
 38. Sousa AS, Guerra RS, Fonseca I, Pichel F, Ferreira S, Amaral TF. Financial impact of sarcopenia on hospitalization costs. *Eur J Clin Nutr* 2016;70:1046-51.
 39. Steindl A, Leitner J, Schwarz M, Nennung KH, Asenbaum U, Mayer S, *et al.* Sarcopenia in neurological patients: Standard values for temporal muscle thickness and muscle strength evaluation. *J Clin Med* 2020;9:1272.
 40. Uhlich R, Hu P. Sarcopenia diagnosed using masseter muscle area predictive of early mortality following severe traumatic brain injury. *Neural Regen Res* 2018;13:2089-90.
 41. Verri ED, da Silva GP, Fioco EM, da Silva NS, Fabrin SC, Zanella CA, *et al.* Effects of Parkinson's disease on molar bite force, electromyographic activity and muscle thickness of the masseter, temporal and sternocleidomastoid muscles: A case-control study. *J Oral Rehabil* 2019;9:1272.

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