Relationship between weight loss and regular dental management of older adults residing in long-term care facilities: A 1-year multicenter longitudinal study

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Key summary points

Aim

This study aimed to clarify the relationship between weight loss and regular dental management among older adults in long-term care facilities through a 1-year, multicenter longitudinal study.

Findings

The absence of regular dental management among older residents in long-term care facilities (who follow regular diets) was associated with weight loss and malnourishment.

Message

Regular dental care procedures among older residents (who follow regular diets) in long-term care facilities may reduce weight loss and prevent malnutrition.

Abstract

Purpose

This study aimed to determine the association between home visits by a dentist and regular oral hygiene management by a dental hygienist (regular dental management: RDM) and weight loss among older adults in long-term care facilities.

Methods

A total of 468 older residents from 26 Japanese long-term care facilities participated in two surveys in 2018 and 2019. Participants were divided into two groups based on their diet during the baseline survey (regular diet, n=256; dysphagia diet, n=212). Participants with a regular diet were further divided into those who exhibited a weight loss ≥5% over 1 year (weight loss group: n=77) and those with a weight loss <5% (consistent weight group: n=179). The explanatory variables were age, sex, baseline weight, Barthel Index, and Clinical Dementia Rating, as well as the patients' medical history of pneumonia, stroke, diabetes, and depression (which is reportedly associated with weight). Additionally, a Poisson regression with robust standard error, was carried out to analyze the explanatory variables, namely the prevalence of RDM noted during the study and functional teeth (which seemed to affect weight loss).

Results

A multivariate analysis revealed that older residents' lack of RDM, clinical dementia assessment, and their history of pneumonia (prevalence rate ratio: 0.35, 95% confidence interval: 0.24–0.95) were all significantly associated with weight loss when on a regular diet.

Conclusion

Thus, weight loss and RDM were related to each other. Weight loss may be suppressed by incorporating RDMs during the early nursing care for older residents on regular diets.

Keywords

Regular dental management, weight loss, long-term care, facility residents, regular diet, dysphasia diet

Introduction

Japan has the fastest aging population in the world [1]. Consequently, the number of older adults that require long-term care insurance is constantly increasing [2]. As the life expectancy of older adults in Japan is higher [1], they require extended periods of care. Further, the number of older residents in long-term care facilities who need advanced care is also steadily increasing [3]. However, Japan has a chronic shortage of long-term care facility personnel [4].

Preventing infections, such as pneumonia, is crucial for maintaining the well-being of older adults [5], and oral care is one way of achieving this goal [6,7]. However, due to a lack of nurses and caregivers, many care institutions find it difficult to provide adequate oral care. Furthermore, an increase in the number of older residents admitted to long-term care facilities is inevitable. Therefore, the patients' risk of contracting pneumonia will likely increase, which is problematic as pneumonia is the leading cause of death in Japan [8]. Reportedly, the most frequent form of pneumonia among older adults is aspiration pneumonia, caused by the aspiration of oral bacteria in saliva and food [9,10]. Yoneyama demonstrated, by studying 11 special nursing homes across Japan, that aspiration pneumonia can be effectively prevented through specialized mechanical mouth cleaning—conducted by dentists or dental hygienists 1–2 times a week—in addition to the oral cleaning routines performed by the residents and their caregivers [11,12]. These studies emphasized the need for regular oral hygiene management by dental hygienists in Japan.

Accordingly, to preserve the oral health of older adults in nursing care, a long-term care service related to oral hygiene management was introduced into Japan's long-term care insurance system. This nursing service, that is, regular dental management (RDM) provides long-term care facility residents with both home visits by dentists and professional oral care from dental hygienists (at least twice a month) and daily oral care support, including specific technical advice and guidance to nurses. The primary aim of dental care home visits is to improve the treatment of dental diseases and oral healthcare, which ultimately improves patients' oral health status and functions. Studies investigating the differences in oral status between older adults, who did and did not receive dental care home visits, reported that oral health was significantly maintained by the home visits [13]. Studies have also reported that oral care proved effective in preventing pneumonia by reducing the inhalation of oral bacteria and inducing the swallowing reflex [14,15]. Moreover, no other mechanisms preventing pneumonia by oral care have been reported.

Several studies asserted that nutritional interventions may reduce the readmissions of undernourished elderly people suffering from pneumonia to the hospital [16]. Thus, we hypothesized that home visits by a dentist and regular oral hygiene management by a dental hygienist (RDM) could prevent undernutrition and reduce the development of pneumonia. To the best of our knowledge, this is the first study to examine the association between RDM and weight loss in institutionalized older residents. We investigated the current situation regarding the RDM of 468 residents in long-term care facilities and clarified its relationship with weight loss, which is an index of malnutrition. On this basis, we conducted a 1-year, multicenter, longitudinal study involving long-term care facility residents.

Methods

Study Design

This was a 1-year, prospective, multicenter, longitudinal study of Japanese residents in long-term care facilities.

Participants

During the survey, a workshop was conducted with 30 members from the special committee of the Japan Geriatrics Society and the Japan Gerontology Society to explain the study content and establish the evaluation criteria for the survey content. These members then explained the study content to the directors and staff of their relevant long-term care facilities. Thereafter, in September 2018, the staff of the long-term care facility who cooperated with this study asked both the participants themselves and their families to confirm their intention to participate in the study in advance. If consent could be obtained from the individual, the investigator directly explained the research content and obtained their written consent to participate in the research. If it was difficult to obtain the consent of the person because of cognitive decline, the research content was sent to the family in writing, and the written consent was obtained. An initial baseline survey was conducted between October 2018 and February 2019; a request for re-investigation was made a year later. The institutional personnel from the 26 institutions collaborating in this study provided data concerning the bodyweight of 468 participants during the previous year and who remained in the facilities 1 year later.

This study was approved by the Ethics Committee of the Japanese Society of Gerodontology (2018-1, 2019-3) and the Ethics Review Committee of the Graduate School of Dentistry and Epidemiological Research of Hokkaido University (2020-4).

Survey Items

During the baseline survey, the committee members provided training concerning the assessment of the survey items to each facility's nurses. Afterward, the evaluation criteria were unified. The attending nurses then inspected the participants' basic information. Oral examinations were performed by a dentist and dental hygienist who directly examined the participants while visiting the collaborating facilities.

Basic Information

Participants' basic information was collected from their care records and included their age, sex, weight, medical history (pneumonia, aspiration pneumonia, stroke diabetes, depression), food morphology, and the presence of RDM. The study participants were divided into two groups: The RDM group included people who accrued a history of dental visits after their admission to the facility and underwent oral hygiene management at least twice a month. The group that did not receive RDM included people with a history of no dental visits or oral hygiene routines.

The food survey form used in this study was based on the dysphagia diet classification (2013) of the

Japanese Society for Eating and Swallowing Rehabilitation [17]. Codes 0 to 4 represented the *Dysphasia Diet*, while another food form reflecting a regular diet more closely represented the *Regular Diet*.

The activities of daily living were assessed using the Barthel index (BI) [18]. Additionally, the residents' clinical dementia ratings (CDR) were assessed using Morris' assessment methodology [19]. The final decisions concerning the CDR were made by a psychiatrist.

Intraoral Examination

We measured the number of stumps of tooth in the oral cavity. Teeth roots with disrupted crowns, or teeth affected by severe periodontitis, were excluded. To measure the severity of periodontal disease, Miller's classification that indicates the degree of tooth agitation was used, according to which, a degree of mobility of 3 was defined as a severe periodontal disease [20]. Functional dentulous teeth included the pontics of fixable prosthetic devices with bridges or implant support, as well as the number of dental implants and denture prostheses. Edentulous teeth were defined as the absence of teeth, regardless of the presence of dentures. Data concerning whether participants used their dentures during mealtimes were obtained from relevant care staff. Denture prostheses in participants who did not use dentures during mealtimes were not considered functional teeth in this study.

Statistical Analysis

In 2018, the 468 participants were divided into two groups: those on a dysphagia diet (dysphagia diet group) and those on a regular diet (regular diet group; see Fig 1). Thereafter, item-specific comparisons were made between the two groups (Table 1). The regular diet group was further divided into those that exhibited ≥ 5% weight loss 1 year after the baseline survey (weight loss group) and those that exhibited no significant signs of weight loss (consistent weight group). Item-specific comparisons were then made between the two groups (Table 2). Similarly, the dysphagia diet group was divided into those that exhibited ≥ 5% weight loss 1 year after the baseline survey (weight loss group) and those that exhibited no significant signs of weight loss (consistent weight group). Item-specific comparisons were made between these two groups (Appendix Table 1). For each two-group comparison, the categorical variables were analyzed using a chi-square test, and the continuous variables were analyzed using the Mann–Whitney U test after verifying a normal data distribution. Furthermore, the comparisons between the weight loss and consistent weight groups were also analyzed using the Mann–Whitney U test (for continuous variables) and the chi-square test (for categorical variables).

In a Poisson regression with robust standard, the weight loss and consistent weight groups were designated as objective variables. The explanatory variables included: residents' age [21], sex [21], weight [21], BI [22], CDR [22], and medical history of pneumonia [22], stroke [22], diabetes [22], and depression (which is reportedly associated with bodyweight) [22]. Additionally, both RDM and functional teeth, which seem to affect weight loss, were also designated as explanatory variables. Due to their multiple collinearities with functional teeth, present teeth and dentures were not designated as explanatory variables. Furthermore, the Poisson regression with robust standard used data from a multicenter study, while the random effects of the long-term

care insurance facility were confirmed using multilevel analysis. A Poisson regression with robust standard with robust standard error computations was performed to obtain an adjusted prevalence ratio (95% confidence interval [CI]). All statistical analyses were performed using SPSS Statistics 26 (IBM, USA), with a significance level of less than 5% (p<.05).

Results

In this study, data from 468 older residents who participated in two surveys were analyzed (Fig 1). Their baseline traits for the median interquartile ranges (IQRs) were age: 87.0 [82.0, 92.0] and BI:30.0 [5.0, 50.0]. Additionally, 71.0% of the residents exhibited moderate to severe cognitive decline (CDR 2 and 3), according to their CDRs. The IQRs of residents' dentulous teeth were: 5.0 [0.0, 16.0], and the number of edentulous residents were 158 (34.0%). Of the 468 participants, 212 (45.3%) were in the dysphagia diet group, and 256 (54.7%) were in the regular diet group. When comparing these two groups, the dysphagia diet group exhibited lower body weight and BIs, more severe CDRs, a poor oral condition (i.e., fewer teeth and fewer functional teeth), a higher edentulous rate, and fewer denture users than the regular diet group. The results also revealed that participants with a history of pneumonia are at an increased risk for its recurrence (Table 1).

Of the 256 participants in the regular diet group, 77 (30.1%) belonged to the weight loss group and 179 (69.9%) belonged to the consistent weight group. When comparing these two groups, the weight loss group possessed a higher proportion of participants with severe CDRs, a lower proportion of participants with RDM, and a higher proportion of participants with a history of pneumonia. However, this group had a low proportion of participants with a history of depression (Table 2).

The likelihood ratio test, which compared the multilevel model against a single-level model containing the same predictors, was not significant. Accordingly, we selected a non-nested model. Thereafter, Poisson regression analyses of the weight loss and consistent weight groups as objective variables were carried out. As a result, age (PRR: 1.03, 95% CI: 1.00–1.06, p=0.024), CDR 2 (PRR: 3.21, 95% CI: 1.26–8.19, p=0.015), CDR 3 (PRR: 2.92, 95% CI: 1.08–7.88, p=0.036), RDM (PRR: 0.48, 95% CI: 0.24–0.95, p =0.026), and pneumonia history (PRR: 3.72, 95% CI: 2.34–5.92, p <0.001) were all significantly related to each other. (Table 3).

Of the 212 participants in the dysphagia diet group, the weight loss group consisted of 62 participants (29.2%), while the consistent weight group consisted of 150 participants (70.8%). When comparing these two groups, the weight loss group exhibited significantly lower body weight and BIs than the consistent weight group. However, there were no significant differences in the items related to dentistry, such as RDMs or oral condition (present teeth, functional teeth, edentulousness, prosthesis use）(Appendix Table 1). In the Poisson regression with robust standard, the dysphagia group's baseline weight (PRR: 1.04, 95% CI: 1.01–1.03, p = 0.008) and BI (PRR: 1.02, 95% CI: 1.01–1.03, p < 0.001) were significantly associated (Appendix Table 2).

Discussion

The results of this study suggest that home visits by a dentist and regular oral hygiene management by a dental hygienist (RDM) may reduce weight loss and prevent undernutrition in older adults who require nursing care and consume a regular diet. Several studies have reported on the association between undernutrition and oral hygiene [23–25]. Furthermore, studies also assert that oral care (including oral healthcare) is effective at preventing undernutrition and aspiration pneumonia as well as extending patients' life expectancy [24–27]. The effectiveness of oral care in preventing pneumonia is attributable to reducing oral bacteria and inducing swallowing reflexes [14,15]; however, no other reports support this finding. Weight loss is a significant indicator of undernutrition [28]. Furthermore, as the continued inability to eat will result in weight loss through the atrophy of muscle and fat [29], it also increases the risk of falling, decreased physical functions, and a weak immune system [30]. While several reports are discussing the association between undernutrition and oral hygiene in long-term care facility residents [23–25], no studies examined the association between weight loss and the RDM of older adults who require nursing care from dental care providers. Moreover, studies assert that nutritional interventions can reduce pneumonia readmissions in undernourished older adults who have previously suffered from pneumonia [16]. Therefore, we hypothesized that RDMs would eliminate dental problems, such as pain in the oral cavity, and prevent undernutrition among older residents. We also posited that improving eating and swallowing functions would make them less susceptible to pneumonia. Thus, we examined the association between RDMs and weight loss as well.

Previous studies related to undernutrition in older adults revealed that poor oral health affects food choices and nutrient intake, leading to malnutrition, frailty, and sarcopenia [23]. Additionally, an association was found between nutritional status and activities of daily living [31]. In this study, an association was found between weight loss and low scores in BI in the dysphagia diet. This result was supported by previous studies [23] that found that compared to the regular diet, the dysphagia diet lowers BI, including swallowing function, leading to malnutrition and weight loss. Furthermore, deterioration of oral condition may be the cause of malnutrition, and subsequent undernourishment may further worsen oral condition.

Factors such as diseases, mental illness, and aging can result in weight loss that leads to a deterioration in health; in fact, weight loss of more than 5% within a 6–12-month period is associated with increased mortality [21, 32]. Nevertheless, proper diet and exercise can prevent weight loss—even in its early stages—as well as maintaining and improving physical functions, disease prevention, and mental support [23, 33]. In this study, RDMs were carried out from when a regular diet was still possible. This created an environment that made nutrient intake easily manageable, which may have prevented weight loss. Meanwhile, a relationship between RDMs and weight loss was not observed in the dysphagia diet group. However, this may not be statistically significant, as only 92.7% of the dysphagia diet consistent weight group received RDM. It is also possible that the RDM aims differed between the dysphagia diet and regular diet group.

This study did not find any significant relationship between RDMs and weight loss when the data from the regular diet and dysphagia diet groups were analyzed together. During this analysis, weight loss was considered the dependent variable, in addition to similar independent variables, and dietary morphology was designated as an independent variable. Studies on Japanese long-term care facility residents reported an association between

the intervention focus of oral healthcare dental treatments and dietary morphology. In this study, the interventions for the regular diet group were primarily aimed at restoring occlusal support and maintaining oral functions. Conversely, the interventions for the dysphagia diet group were mostly aimed at periodontal treatment and oral hygiene management to prevent infectious diseases such as pneumonia, as the activities of daily living and cognitive decline deteriorated the oral environment. It is possible that the different intervention objectives of the dental profession influenced the results. We believe that these are good explained of what we often experience in our dental visits treatment.

Interventional studies are needed to test the effectiveness of oral healthcare in preventing weight loss. However, as it is ethically challenging to conduct these intervention studies using newly implemented RDMs, we conducted this observational study instead. In a study that examined the association between nutritional status and mortality among 157 nursing home residents in Japan [34], the demographic proportions were as follows: 82.0% were women, mean age 84.4 years, mean weight 43.7 kg, BI total mean 37.1, and the CDR mean was 2.1. Another study focusing on the nutritional status of 248 Korean long-term care residents reported the demographic proportions as follows: 79.2% were women, mean age 81.2 years, and BI total mean 35.3 [35]. Lastly, in a survey concerning the oral health status of 176 Italian residents in special nursing homes [36], 39.8% of the patients were edentulous. Therefore, the participants of the current study were similar to those of previous studies [34–36] as all of them included the elderly receiving nursing care at common long-term care facilities.

One of the aims of the baseline survey of this study was to understand the oral conditions of Japanese long-term care facility residents. Accordingly, we asked as many institutions as possible to collaborate and recruit participants. Subsequently, we recruited 468 participants, for whom a 1-year follow-up was possible; we consider this to be an adequate sample size when compared with previous studies. However, in this study, some facilities were attended by all residents of the long-term care insurance facility, while others were targeted only at those who were in one unit. We asked the staff of the nursing care facility to participate in the research in advance, and the investigator explained to the participants themselves and obtained their consent. If it was difficult to obtain consent from the individual because of cognitive decline or any other factor, we sent the instructions and consent form for participation in the research to the family and obtained consent. Therefore, we do not know the number of people who explained the research to the participants, the number of people who declined, and the reason for the decline. Hence, the results of this study should be interpreted with caution, as selection bias may exist. Participants who could not be tracked were discharged from the long-term care insurance facility due to death or other reasons. As this study had a 1-year weight loss outcome, we used a dataset of 468 Japanese long-term care facility residents who participated in two surveys in 2018 and 2019. Those who died were excluded from the dataset as their weight data after 1 year were not available. We believe that these fatalities have little impact on the results of this study.

Recent studies show that, as aging populations have advanced, so has geriatric depression [19]. Reports assert that the mental health aspects of older adults are correlated with weight loss [37,38]. However, in this study, the percentage of residents following a regular diet with a history of depression was significantly higher in the consistent weight group than in the weight loss group. This could be explained by the cognitive decline

experienced in the weight loss group. Even though cognitive decline is associated with weight loss, it could have also made it difficult to prompt recollections of depression from the residents or their families. Consequently, fewer individuals conveyed their histories of depression, which possibly influenced the results. However, we found that cognitive decline above CDR 2 was significantly associated with weight loss. This is reflected in the results of previous studies, which assert that cognitive decline reduces dietary intake and body weight [38,39]. Therefore, regarding cognitive function, our results were supported by previous studies.

The study does, however, has several limitations. The resident groups were divided according to regular diet and dysphagia diet food forms. However, these forms were not designed by physicians or dentists who are experts in observing eating and swallowing functions. Therefore, some residents in the regular diet group may have belonged to the dysphagia diet group. Conversely, members of the dysphagia diet group may have been able to consume a regular diet. Consequently, those who exhibited discordant feeding and swallowing functions and diet morphology may have deteriorated their nutritional status and lost weight. Thus, the diet status of individuals could have changed during the study period, but this possibility was not investigated. In addition, this study did not collect data that could have had a significant impact on oral or general health, such as socioeconomic status, smoking history, and alcohol intake. It is possible that these factors have affected the results. However, participants in this study had few activities of daily living and high CDRs, and only a few currently smoke or consume alcohol. Additionally, as the living environment and long-term care content of Japanese long-term care facilities are unified by the long-term care insurance, which is a social insurance, we believe that socio-economic factors have little effect on oral and general health. Also, disrupted crown (stumps of tooth), severe periodontitis, dry mouth, salivary hypofunction, xerostomia may interfere with oral intake and promote weight loss. Participants who were found to have these problems during the oral examination were asked to report it to the facility staff. However, we could not find any reports of such issues. We believe that this was because it was a related facility for members of the Geriatric Dentistry Society.

Furthermore, home visits by dentists and oral hygiene management by dental hygienists provided to older residents depended on the care they required. Therefore, the services provided were highly individualized and conducted by different dentists and dental hygienists; in other words, there was no unified oral hygiene management or guidance. Consequently, the suitability of the food forms, the intervention focus, and the duration of dental treatments and care may have influenced the results. In the future, studies could unify the guidance content of oral hygiene management and RDM and consider the evaluation of swallowing function, dietary intake method, and dietary form. Additionally, we believe that it is necessary to conduct a detailed examination of what kind of dental treatment and RDM are associated with the suppression of weight loss in various kinds of subjects. Further research, such as intervention research, is needed to confirm the findings of this study. Furthermore, it is necessary to verify whether RDM suppresses weight loss and the onset of pneumonia based on the results of this study.

Conclusion

If RDMs are not performed with older adults, who require nursing care and consume regular diets, they will lose weight, leading to an overall decline in their health. Therefore, by incorporating RDMs during the early stages of nursing care, long-term care facilities can prevent weight loss, and by doing so, ensure better overall health for their residents. Governments or long-term care facilities need to implement RDM to protect the overall health of residents and continue to conduct research aimed at extending healthy life expectancy.

Declarations

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Conflicts of Interest

The authors have no conflict of interest to declare that are relevant to this article.

Data Availability Statement

The data presented in this study are available upon request from the corresponding author. The data are not publicly available due to ethical–legal restrictions imposed by the Ethics Committee of the Japanese Society of Gerodontology.

Authors' Contributions

Conceptualization: H.S., Y.W., Y.O., M.I, and M.Y.; Formal analysis: H.S, Y.W. Y.O., and M.I.; Investigation: H.S., H.T., Y.W., T.M., M.S., K.I., J.N., Y.I., M.I., R.S., Y.N., J.F., Yo.W., Y.I., and H.H.; Data curation: H.S, Y.W, Y.O., J.N. Yo.W, and M.Y.; Writing—original draft preparation: H.S., Y.W., Y.O., and M.I.; Writing—review and editing: H.S, H.T., Y.W., T.M., Y.O., M.I., K.I., J.N., Y.I., M.I., R.S., Y.N., J.F., Yo.W., M.Y., and Y.Y.; Supervision: H.H., Y.S., and Y.Y.; Project administration: Y.W., Y.O., M.Y., H.H., and Y.Y.; Funding acquisition: Y.W., M.Y., and Y.S. All authors have read and agreed to the published version of the manuscript.

Ethics Approval

This study was reviewed and approved by the ethics committee of the Japanese Society of Gerodontology (2018–1, 2019–3) and the Clinical and Epidemiological Research Ethics Committee of the Faculty of Dental Medicine at Hokkaido University (2020–4). It was conducted in accordance with the ethical principles of the Declaration of Helsinki.

Consent to Participate

Informed consent was obtained from all individual participants and their families included in the study.

References

[1] Arai H, Ouchi Y, Yokode M, Ito H, Uematsu H, Eto F, Oshima S, Ota K, Saito Y, Sasaki H, Tsubota K, Fukuyama H, Honda Y, Iguchi A, Toba K, Hosoi T, Kita T, Members of Subcommittee for Aging. Toward the realization of a better aged society: messages from gerontology and geriatrics. Geriatr Gerontol Int. 2012; 12(1):16–22. https://doi.org/10.1111/j.1447-0594.2011.00776.x

[2] Ito K, Kawai H, Tsuruta H, Obuchi S. Predicting incidence of long-term care insurance certification in Japan with the Kihon Checklist for frailty screening tool: analysis of local government survey data. B.M.C. Geriatr. 2021; 21(1):1–8. https://doi.org/10.21203/rs.3.rs-60249/v1

[3] Ohno S, Chen Y, Sakamaki H, Matsumaru N, Yoshino M, Tsukamoto K. Humanistic burden among caregivers of patients with Alzheimer's disease or dementia in Japan: a large-scale cross-sectional survey. J Med Econ. 2021; 24(1):181–192. https://doi.org/10.1080/13696998.2021.1877149

[4] Rachel H, Francesco S. Factors associated with and impact of burnout in nursing and residential home care workers for the elderly. Acta Bio Medica: Atenei Parmensis. 2018; 89 (Suppl 7) : 60.

[5] Noe CA, Barry PP. Healthy aging: guidelines for cancer screening and immunizations. Geriatrics. 1996; 51(1):75–7.

[6] Wong FMF, Ng YTY, Keung Leung W. Oral health and its associated factors among older institutionalized residents—a systematic review. Int J Environ Res Public Health. 2019; 16(21):4132. https://doi.org/10.3390/ijerph16214132

[7] Tashiro H, Kikutani T, Tamura F, Takahashi N, Tohara T, Nawachi K, Maekawa K, Kuboki T. Relationship between oral environment and development of pneumonia and acute viral respiratory infection in dependent older individuals. Geriatr Gerontol Int. 2019; 19(11):1136–40. https://doi.org/10.1111/ggi.13784

[8] Yamazaki S, Yamagishi K, Murata S, Yokoyama I, Yahaba M, Takayanagi S, Kawasaki Y, Taniguchi T, Ishii I, Igari H. Antibiotics prescriptions for pneumonia analyzed by claim information in Japan. Int J Clin Pharmacol Ther. 2020; 10:5414. https://doi.org/10.5414/CP203780

[9] Scannapieco FA, Stewart EM, Mylotte JM. Colonization of dental plaque by respiratory pathogens in medical intensive care patients. Crit Care Med. 1992; 20(6):740–5. https://doi.org/10.1097/00003246-199206000-00007

[10] Abe S, Ishihara K, Adachi M, Okuda K. Oral hygiene evaluation for effective oral care in preventing pneumonia in dentate elderly. Arch Gerontol Geriatr. 2006; 43(1):53–64. https://doi.org/10.1016/j.archger.2005.09.002

[11] Yoneyama T, Yoshida M, Ohrui T, Mukaiyama H, Okamoto H, Hoshiba K, Ihara S, Yanagisawa S, Ariumi S, Morita T, Mizuno Y. Oral care reduces pneumonia in older patients in nursing homes. J Am Geriatr Soc. 2002; 50(3):430–3. https://doi.org/10.1046/j.1532-5415.2002.50106.x.

[12] Yoneyama T, Yoshida M, Matsui T, Sasaki H. Oral Care Working Group. Oral care and pneumonia. Lancet. 1999; 354(9177):515. https://doi.org/10.1016/s0140-6736(05)75550-1

[13] Foiles Sifuentes AM, Castaneda-Avila MA, Lapane KL. The relationship of aging, complete tooth loss, and having a dental visit in the last 12 months. Clin Exp Dent Res. 2020; 6(5):550–7. https://doi.org/10.1002/cre2.309

[14] Khadka S, Khan S, King A, Goldberg LR, Crocombe L, Bettiol S. Poor oral hygiene, oral microorganisms and aspiration pneumonia risk in older people in residential aged care: a systematic review. Age and Ageing. 2021; 50(1):81–7. https://doi.org/10.1093/ageing/afaa102

[15] van der Maarel-Wierink CD, Vanobbergen JNO, Bronkhorst EM, Schols JM, de Baat C. Oral health care and aspiration pneumonia in frail older people: a systematic literature review. Gerodontology. 2013; 30(1):3–9. https://doi.org/10.1111/j.1741-2358.2012.00637.x.

[16] Yang PH, Lin MC, Liu YY, Lee CL, Chang NJ. Effect of nutritional intervention programs on nutritional status and readmission rate in malnourished older adults with pneumonia: a randomized control trial. Int J Environ Res Public Health. 2019; 16(23):4758. https://doi.org/10.3390/ijerph16234758

[17] Matsuo K, Fujishima I. Textural changes by mastication and proper food texture for patients with oropharyngeal dysphagia. Nutrients. 2020; 12(6):1613. https://doi.org/10.3390/nu12061613

[18] Gaewkhiew P, Sabbah W, Bernabé E. Functional dentition and 12-month changes in body measurements among Thai older adults. Int J Environ Res Public Health. 2020; 17(12):4200. https://doi.org/10.3390/ijerph17124200

[19] Friedlander AH, Friedlander IK, Gallas M, Velasco E. Late-life depression: its oral health significance. Int Dent J. 2003; 53(1):41–50. https://doi.org/10.1111/j.1875-595x.2003.tb00655.x.

[20] Miller SC. Textbook of periodontia. 3rd ed. Philadelphia: Blakiston Co Inc;1950, pp 125, 212.

[21] De Stefani FDC, Pietraroia PS, Fernandes-Silva MM, Faria-Neto J, Baena CP. Observational evidence for unintentional weight loss in all-cause mortality and major cardiovascular events: a systematic review and meta-analysis. Sci Rep. 2018; 8(1):1-1. https://doi.org/10.1038/s41598-018-33563-z

[22] Gazeivood JD, Mehr DR. Diagnosis and management of weight loss in the elderly. J Fam Pract. 1998; 47(1):19–25.

[23] Domenico A, Pier CP, Paolo De A, Giovan BP, Antonio D, Matteo C. Poor oral health as a determinant of malnutrition and sarcopenia. Nutrients. 2019; 11(12):2898. https://doi.org/10.3390/nu11122898

[24] Maria A, Theodoros V. Breaking the vicious circle of diet, malnutrition and oral health for the independent elderly. Crit Rev Food Sci Nutr. 2020: 1–23. https://doi.org/10.1080/10408398.2020.1793729

[25] Rahman N, Walls, A. Nutrient deficiencies and oral health. Monogr Oral Sci 2020; 28:114–24. https://doi.org/10.1159/000455379

[26] Nawata W, Umezaki Y, Yamaguchi M, Nakajima M, Makino M, Yoneda M, Hirofuji T, Yamano T, Ooboshi H, Morita H. Continuous professional oral health care intervention improves severe aspiration pneumonia. Case Rep Dent. 2019:4945921. doi.org/10.1155/2019/4945921

[27] Oliveira EJP, Alves LC, Duarte YA, Andrade FB. Life expectancy with negative physical oral health impact on quality of life in older adults. Cad Saúde Publ. 2020; 36:e00119119. https://doi.org/10.1590/0102-311X00119119

[28] Desport J-C, Jésus P, Fayemendy P, Linut R. Food and malnutrition in the elderly. Rev prat 2018; 68(3):312–8.

[29] Finn PF, Dice JF. Proteolytic and lipolytic responses to starvation. Nutrition. 2006; 22(7–8):830–44. https://doi.org/10.1016/j.nut.2006.04.008

[30] Urquiza M, Fernandez N, Arrinda I, Sierra I, Irazusta J, Rodriguez Larrad A. Nutritional status is associated with function, physical performance and falls in older adults admitted to geriatric rehabilitation: a retrospective cohort study. Nutrients. 2020; 12(9):2855. https://doi.org/10.3390/nu12092855

[31] Fashho E, Ahmed T, Garden G, Readman D, Storey L, Wilkinson L, Wilson G, Slee A. Investigating the prevalence of malnutrition, frailty and physical disability and the association between them amongst older care home residents. Clin Nutr E.S.P.E.N. 2020; 40:231–6. https://doi.org/10.1016/j.clnesp.2020.09.014

[32] Wallace JI, Schwartz RS, LaCroix AZ, Uhlmann RF, Pearlman RA. Involuntary weight loss in older outpatients: incidence and clinical significance. J Am Geriatr Soc. 1995; 43(4):329–37. https://doi.org/10.1111/j.1532-5415.1995.tb05803.x.

[33] McKendry J, Currier BS, Lim C, Mcleod JC, Thomas ACQ, Phillips SM. Nutritional supplements to support resistance exercise in countering the sarcopenia of aging. Nutrients. 2020;12(7):2057. https://doi.org/10.3390/nu12072057

[34] Motokawa K, Yasuda J, Mikami Y, Edahiro A, Morishita S, Shirobe M, Ohara Y, Nohara K, Hirano H, Watanabe Y. The Mini Nutritional Assessment-Short Form as a predictor of nursing home mortality in Japan: a 30-month longitudinal study. Arch Gerontol Geriatr. 2020;86:103954. https://doi.org/10.1016/j.archger.2019.103954

[35] Park M, Song JA, Lee M, Jeong H, Lim S, Lee H, Kim CG, Kim JS, Kim KS, Lee YW, Lim YM, Park YS, Yoon JC, Kim KW, Hong GS. National study of the nutritional status of Korean older adults with dementia who are living in long-term care settings. Jpn. J Nurs Sci. 2018;15(4):318–29. https://doi.org/10.1111/jjns.12203.

[36] Chiesi F, Grazzini M, Innocenti M, Giammarco B, Simoncini E, Garamella G, Zanobini P, Perra C, Baggiani L, Lorini C, Bonaccorsi G. Older people living in nursing homes: an oral health screening survey in Florence, Italy. Int J Environ Res Public Health. 2019;16(18):3492. https://doi.org/10.3390/ijerph16183492

[37] Merchant RA, Chen MZ, Wong BL, Ng SE, Shirooka H, Lim JY, Sandrasageran S, Morley JE. Relationship between fear of falling, fear-related activity restriction, frailty, and sarcopenia. J Am Geriatr Soc. 2020;68(11):2602–8. https://doi.org/10.1111/jgs.16719

[38] Furtado GE, Caldo A, Vieira-Pedrosa A, Letieri RV, Hogervorst E, Teixeira AM, Ferreira JP. Emotional well-being and cognitive function have robust relationship with physical frailty in institutionalized older women. Front Psychol. 2020;11:1568. https://doi.org/10.3389/fpsyg.2020.01568

[39] Verhaar BJH, de Leeuw FA, Doorduijn AS, Jay LP. Field House, Ondine van de Rest, Charlotte E Teunissen, Bart N M van Berckel, Frederik Barkhof, Marjolein Visser, Marian A E de van der Schueren,

Philip Scheltens, Maartje I Kester, Majon Muller, Wiesje M van der Flier. 2020. Nutritional status and structural brain changes in Alzheimer's disease: the NUDAD project. Alzheimer's & Dementia 12:e12063. https://doi.org/10.1002/dad2.12063

Tables

Table 1 Characteristics of the study participants, and comparison between the regular diet group and dysphagia diet group

Variable	Overall（*n* = 468）		Dysphagia diet （*n* = 212）		Regular diet（*n* = 256）		*P*-value
	Mean ± SD *n* (%)	Median [Q1,Q3]	Mean ± SD *n* (%)	Median [Q1,Q3]	Mean ± SD *n* (%)	Median [Q1,Q3]	
Age (years)	86.4 ± 7.8	87.0 [82.0, 92.0]	87.1 ± 7.6	88.0 [82.0, 93.0]	85.9 ± 7.9	87.0 [81.0, 92.0]	0.390
Sex (female)	379 81.0		174 82.1		205 80.1		0.637
Weight (baseline)	46.0 ± 8.6	45.1 [40.0, 51.7]	43.1 ± 6.9	42.8 [38.4, 48.1]	48.4 ± 9.1	47.6 [41.8, 53.5]	< 0.001
Weight loss ≧ 5%, n (%)	139 29.7		62 29.2		77 30.1		0.919
Barthel index	32.2 ± 26.2	30.0 [5.0, 50.0]	17.6 ± 19.7	10.0 [00.0, 30.0]	44.4 ± 24.6	45.0 [25.0, 65.0]	< 0.001
Clinical dementia rating							
0, 0.5	44 (9.5)		6 (2.9)		38 (14.9)		< 0.001
1	90 (19.5)		19 (9.2)		71 (27.8)		
2	136 (29.4)		52 (25.1)		84 (32.9)		
3	192 (41.6)		130 (62.8)		62 (24.3)		
Oral conditions							
Regular dental management	98 20.9		52 24.5		46 18.0		0.088
Present teeth	8.3 ± 8.9	5.0 [0.0, 16.0]	6.4 ± 7.7	3.0 [0.0, 11.0]	9.9 ± 9.5	7.0 [0.0, 19.0]	< 0.001
Functional teeth	19.8 ± 10.3	25.0 [12.0, 28.0]	16.0 ± 11.4	18.0 [4.0, 28.0]	22.9 ± 8.1	28.0 [22.8, 28.0]	< 0.001
Edentulous, *n* (%)	158 34.0		88 41.7		70 27.6		0.002
Prosthesis use, *n* (%)	242 52.0		90 42.7		152 59.8		< 0.001
Medical history							
Pneumonia, *n* (%)	36 7.7		31 14.6		5 2.0		< 0.001
Stroke, *n* (%)	161 34.5		67 31.6		94 36.9		0.242
Diabetes mellitus, *n* (%)	74 15.8		35 16.5		39 15.3		0.799
Depression, *n* (%)	32 6.9		15 7.1		17 6.7		0.857

Categorical variables are shown as the numbers (percentage) that were analyzed with the chi-square test. A p-value of < 0.05 was considered statistically significant. Continuous variables were analyzed with the Mann−Whitney U test, for which a p-value of < 0.05 was considered statistically significant. Q1, first quartile; Q3, third quartile; SD, standard deviation

Table 2 Comparison between the baselines of the regular diet groups' weight loss and weight maintenance sub-groups

Variable	Regular Diet 2018 (*n* = 256)								
	Weight Loss < 5% (*n* = 179)				Weight Loss ≧ 5% (*n* = 77)				*P*-value
	Mean ± SD *n* (%)			Median [Q1, Q3]	Mean ± SD *n* (%)			Median [Q1, Q3]	
Age (years)	87.0	±	7.8	87.0 [84.3, 92.8]	85.4	±	8.0	86.0 [80.0, 91.0]	0.178
Sex (female)	145		81.0		60		77.9		0.610
Weight (baseline)	49.0	±	9.1	48.7 [42.1, 54.7]	48.2	±	9.1	47.1 [41.8, 53.4]	0.403
Barthel index	41.1	±	23.3	40.0 [25.0, 60.0]	45.8	±	25.1	45.0 [25.0, 65.0]	0.200
Clinical dementia rating									
0, 0.5	34		(19.0)		4		(5.3)		0.034
1	50		(27.9)		21		(27.6)		
2	54		(30.2)		30		(39.5)		
3	41		(22.9)		21		(27.6)		
Oral conditions									
Regular dental management	39		21.8		7		9.1		0.020
Present teeth	10.6	±	9.8	8.0 [0.0, 20.0]	9.6	±	9.4	7.0 [0.0, 18.0]	0.519
Functional teeth	21.9	±	8.9	26.0 [20.0, 28.0]	23.4	±	7.7	28.0 [22.0, 28.0]	0.118
Edentulous, *n* (%)	49		27.7		21		27.3		0.860
Prosthesis use, *n* (%)	111		62.7		41		53.2		0.166
Medical history									
Pneumonia, *n* (%)	1		0.6		4		5.2		0.030
Stroke, *n* (%)	64		68.1		30		31.9		0.673
Diabetes mellitus, *n* (%)	27		15.2		12		15.6		1.000
Depression, *n* (%)	16		9.0		1		1.3		0.027

Categorical variables are shown as the numbers (percentage) that were analyzed with the chi-square test. A p-value of < 0.05 was considered statistically significant. Continuous variables were analyzed with the Mann–Whitney U test, for which a p-value of < 0.05 was considered statistically significant. Q1, first quartile; Q3, third quartile; SD, standard deviation

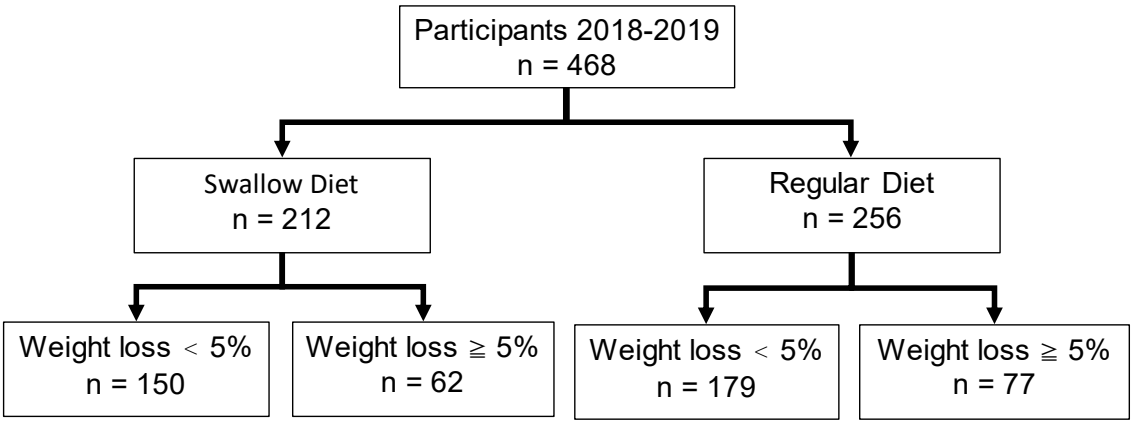
Table 3 Poisson regression analyses between the baseline weight loss and the weight maintenance sub-groups in the regular diet group

	IRR	95% CI			*P*-value
Age（years）	1.03	1.00	—	1.06	0.024
Sex (female)	0.93	0.58	—	1.48	0.748
Weight (baseline)	1.02	1.00		1.04	0.045
Barthel index	1.00	0.99	—	1.01	0.945
Clinical dementia rating					
0, 0.5	Reference				
1	2.49	0.93	—	6.67	0.068
2	3.21	1.26	—	8.19	0.015
3	2.92	1.08	—	7.88	0.034
Functional teeth	0.99	0.97	—	1.01	0.160
Regular dental management	0.48	0.24	—	0.95	0.036
Pneumonia (0: no, 1: yes)	3.72	2.34	—	5.92	< 0.001
Stroke (0: no, 1: yes)	1.10	0.73	—	1.65	0.649
Diabetes mellitus (0: no, 1: yes)	1.07	0.65	—	1.74	0.796
Depression (0: no, 1: yes)	0.02	0.03	—	1.31	0.093

CI = confidence interval, PRR = prevalence rate ratio

Figure Captions

Fig 1 Analytical subjects of this study



Appendix

Appendix Table 1 Comparison between the baseline weight loss and weight maintenance sub-groups in the dysphagia diet group

Variable	Dysphagia Diet 2018 (*n* = 212)								
	Weight loss ＜ 5％ (*n* = 150)				Weight loss ≧ 5％ (*n* = 62)				*P*-value
	Mean ± SD *n* (%)			Median [Q1,Q3]	Mean ± SD *n* (%)			Median [Q1, Q3]	
Age（years）	86.6	±	7.7	87.0 [82.0, 92.0]	88.3	±	7.4	89.0 [82.0, 83.0]	0.200
Sex (female)	120		80.0		54		87.1		0.245
Weight (baseline)	43.7	±	7.1	43.2 [39.3, 48.0]	39.7	±	6.7	40.3 [35.6, 44.7]	<0.001
Barthel index	15.0	±	18.6	5.0 [0.0, 25.0]	23.7	±	20.9	17.5 [5.0, 40.0]	0.004
Clinical dementia rating									
0, 0.5	4		(2.7)		2		(3.3)		0.794
1	12		(8.2)		7		(11.7)		
2	39		(26.5)		13		(21.7)		
3	92		(62.6)		38		(63.3)		
Oral conditions									
Regular dental Management	139		92.7		27		43.5		0.540
Present teeth	6.9	±	7.6	4.0 [0.0, 12.0]	5.2	±	8.0	2.0 [0.0, 8.0]	0.068
Functional teeth	15.3	±	11.2	16.0 [4.0, 28.0]	17.4	±	11.8	24.0 [4.0, 28.0]	0.163
Edentulous, *n* (%)	57		38.0		31		50.8		0.127
Prosthesis use, *n* (%)	59		39.3		31		50.8		0.173
Medical history									
Pneumonia, *n* (%)	26		17.3		5		8.1		0.091
Stroke, *n* (%)	48		32.0		19		30.6		0.873
Diabetes mellitus, *n* (%)	22		14.7		13		21.0		0.310
Depression, *n* (%)	9		6.0		6		9.7		0.381

Categorical variables are shown as the numbers(percentage) that were analyzed with the chi-square test. A p-value of < 0.05 was considered statistically significant. Continuous variables were analyzed with the Mann–Whitney U test, for which a p-value of < 0.05 was considered statistically significant. Q1, first quartile; Q3, third quartile; SD, standard deviation

Appendix Table 2 Poisson regression analyses between the baseline weight loss and weight maintenance sub-groups in the dysphagia diet group

	IRR	95% CI			*P*-value
Age（years）	1.01	0.98	−	1.04	0.391
Sex (female)	1.55	0.81	−	2.96	0.181
Weight (baseline)	1.04	1.01		1.08	0.008
Barthel index	1.02	1.01	−	1.03	< 0.001
Clinical dementia rating					
0, 0.5	Reference				
1	2.09	0.56	−	7.83	0.276
2	1.38	0.37	−	5.23	0.634
3	2.68	0.70	−	10.24	0.148
Functional teeth	1.00	0.98	−	1.02	0.740
Regular dental management	0.99	0.61	−	1.60	0.958
Pneumonia (0: no, 1: yes)	0.67	0.29	−	1.53	0.337
Stroke (0: no, 1: yes)	1.00	0.61	−	1.64	0.999
Diabetes mellitus (0: no, 1: yes)	1.36	0.85	−	2.19	0.204
Depression (0: no, 1: yes)	1.58	0.83	−	0.06	0.165

CI = confidence interval, PRR = prevalence rate ratio