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Does difficulty in chewing induce subjective musculoskeletal symptoms? A case-control study

Naomichi Tani,1 Masanori Ohta,2 Yoshiyuki Higuchi,3 Ryoko Yamamoto,4 Junichi Akatsu5

ABSTRACT

Objectives Risk factors associated with the development of musculoskeletal disorders and symptoms remain an important issue worldwide. This study aimed to investigate the relationship between oral health problems such as difficulty chewing and the occurrence of stiff neck/shoulders (SN/S) and low back pain (LBP).

Methods We defined the chewing condition using a questionnaire, and workers who responded with 'I can chew anything' were classified as the good condition group (GCG), and those who responded with 'Sometimes I have difficulty chewing due to problems with the teeth, gums, or bite' or 'I can hardly chew' were classified as the poor condition group (PCG). Setting the year 2018 as the baseline, we performed a logistic regression model using propensity score and inverse probability weighting (IPW) methods and chewing condition groups as explanatory variables and SN/S and LBP as objective variables.

Results The IPW-adjusted logistic regression model showed that the OR of SN/S was approximately 1.25 (95% CI 1.17 to 1.33) times higher in the PCG than in the GCG (p<0.001). Similarly, the OR of LBP was about 1.37 (95% CI 1.27 to 1.48) times higher in the PCG than that in the GCG in the IPW-adjusted logistic regression model (p<0.001).

Conclusions Our study suggests that the occurrence of SN/S and LBP symptoms in workers could be predicted depending on the presence of difficulty in chewing. Therefore, oral health and health guidance are gaining importance for the prevention of subjective musculoskeletal symptoms.

INTRODUCTION

Musculoskeletal disorders and symptoms, especially pain in the neck and lower back, have been studied worldwide. Previous studies have reported an association between oral health and several diseases such as high blood pressure, Alzheimer's disease, dementia, diabetes, atherosclerotic heart disease and depressive disorders. However, little is known about the relationship between oral health, especially chewing conditions, musculoskeletal disorders and their symptoms. Several interesting studies have been conducted. A cross-sectional study reported a relationship between chewing difficulty and LBP. Since this study is a cross-sectional...
study conducted on people aged <50 years, it is difficult to determine a causal relationship. However, this report is novel and interesting. In addition, an association between oral health and neck pain has been reported in several studies. A previous cohort study reported a relationship between temporomandibular disorders (TMD) and neck pain. A previous cohort study of female workers reported on the relationship between dental occlusion free from interferences and the reduced demand for treatment of cervicobrachial symptoms; other clinical reports have shown that treatment with occlusal adjustment improves the visual analogue scale score of chronic cervical pain. Difficulty chewing may occur from the on-stage or prestage where oral diseases were diagnosed. Therefore, it is possible that the difficulty in chewing is also related to the symptoms of the neck, but this has not yet been verified. Additionally, the longitudinal relationship between the subjective difficulty in chewing and back pain has not been reported. Therefore, more evidence is needed to prove that oral health problems, such as difficulty in chewing, may be related to the development of SN/S and LBP.

In Japan, specific health check-ups and questionnaires were provided to all workers aged 40–74 years since the fiscal year (FY) 2008. The aim of a specific health check-up and questionnaire was to identify persons requiring specific health guidance and to decrease the number of people with metabolic syndrome risk and metabolic syndrome. In FY2018, the Ministry of Health, Labor, and Welfare in Japan added items on chewing conditions to a specific health questionnaire. Therefore, it may be possible to investigate the hypothesis that people who have subjective symptoms of difficulty chewing may be more likely to develop SN/S and LBP than those who do not, using data from Japanese workers. This study aimed to investigate the relationship between oral health problems of difficulty in chewing and the occurrence of SN/S and LBP using employment-based large-size longitudinal data. This study is significant because it contributes to understanding the longitudinal relationship between chewing difficulty and the development of subjective musculoskeletal symptoms.

**METHODS**

**Study design and data collection**

This was a case-controlled study that used 1-year longitudinal data. The employment-based annual health check-up data were collected at clinics (Tokyo, Osaka, Nagoya and Fukuoka) and on-site health check-up services owned by the Association for Preventive Medicine of Japan from 1 April 2018 to 31 March 2020 (FY2018 to FY2019). The baseline data included health check-up items by the Japanese Industrial Safety and Health Act (eg, height, weight, blood pressure, liver function, blood lipid, chest radiography), demographic characteristics (age and sex), obesity status (body mass index and waist circumference), medical history, medication use, lifestyle questionnaire and specific health check-up questionnaire. In 2019, occupation classification information was added to the questionnaire.

**Measurements**

**Lifestyle questionnaires and subjective musculoskeletal symptoms**

In general, early consultation with a physician is important because musculoskeletal symptoms that become more intense or chronic can lead to decreased work productivity, absence due to sickness, and presenteeism (attending work despite health problems). The lifestyle questionnaire was developed in 1994 based on the opinions of physicians and experts involved in health check-ups, and plays an important role as an aid to physicians’ diagnosis and consultation regarding musculoskeletal diseases. The lifestyle questionnaire focused on smoking status (never, former and current smoking), alcohol drinking (no drinking, sometimes, every day), good health habits, dietary habits and daily living and activities. Good health habits, dietary habits and daily living and activities were evaluated as either ‘applicable’ or ‘inapplicable’. Good health habits consisted of a total of five items that included smoking status, alcohol drinking, and the following items: ‘Exercise at least twice a week’, ‘Have three meals almost at the same time every day’ and ‘Sleep for 7–8 hours’. The dietary habits included the following 17 items; ‘Aware of a balanced diet’, ‘Eat protein dishes with every meal’, ‘Eat rice, bread, or noodles with every meal’, ‘Eat slowly and chewing well’, ‘Eat two or more kinds (packs) of Western or Japanese confectioneries or snacks on average a day’, ‘Finish eating at least 2 hours before bedtime’, ‘Frequently eat deep-fried food, such as fried dishes and pork cutlets’, ‘Frequently eat heavy meat dishes’, ‘Frequently eat salty food’, ‘Frequently eat seaweed and small fish’, ‘Frequently have dairy products (milk, yogurt, or cheese)’, ‘Frequently have instant food’, ‘Frequently have dairy products’, ‘Frequently have dairy products’, ‘Frequently have dairy products’, ‘Frequently have dairy products’. The daily living and activities included the following 13 items: ‘Belonged to a sports club when in school’, ‘Can walk for about one hour non-stop without getting tired’, ‘Doing sports during free time at least once a month’, ‘Have a moderate level of stress’, ‘Have worse condition than six months ago’, ‘Prefer to spend time in nature such as the mountains, seas, and rivers’, ‘Regularly go outside’, ‘Regularly move around at work or housework’, ‘Regularly walk’, ‘Satisfied with everyday life’, ‘Walk at least one time for 10 minutes/ time every day’, ‘Walk or bike when commuting’, and ‘Work for less than nine hours’. Furthermore, the respondents were asked to evaluate their medical history and whether their subjective symptoms within the past month were as follows: ‘Symptoms within the past month’, ‘Select where appropriate’, ‘SN/S applicable or inapplicable’, and ‘SN/S applicable or inapplicable’. The outcome variable was whether an SN/S or LBP event occurred.
The specific health check-up questionnaire could be answered not only by people older than 40 years but also by people younger than 40 years. The questionnaire items included medication use (antihypertensive, antidiabetic and antihyperlipidemic drugs), medical history of a specific disease (stroke, heart disease, kidney disease and anaemia), number of cigarettes smoked, amount of alcohol consumed, physical activity, exercise intensity, walking speed and eating habits. In 2018, the Ministry of Health, Labor, and Welfare in Japan added the following questions: ‘When you chew your food, which most accurately describes your chewing?’ The respondents answered, ‘I can chew anything’, ‘Sometimes I have difficulty chewing, due to problems with the teeth, gums, or bite’, or ‘I can hardly chew’. We defined the chewing conditions and subsequently classified the workers who responded with ‘I can chew anything’ were classified as the good condition group (GCG), and those who responded ‘Sometimes I have difficulty chewing, due to problems with the teeth, gums, or bite’ or ‘I can hardly chew’ were classified as the poor condition group (PCG). Furthermore, we selected these two groups as the explanatory variables.

**Study population**

The study sample initially consisted of 537,495 workers among 646,281 who underwent health check-ups and completed a lifestyle questionnaire at the Association for Preventive Medicine of Japan in 2018. We then extracted those who had no medical history, had no medication use and were not undergoing treatment. Moreover, we excluded those who responded as having SN/S and LBP. Furthermore, we excluded workers who did not respond to the occupational classification in 2019. Finally, we extracted information from 77,341 workers aged 15–64 years with sufficient data and no subjective symptoms among those who continued to undergo health check-ups and completed the questionnaire from 2018 to 2019 (figure 1).

**Patient and public involvement**

Patients were not involved in this study.

**Statistical analysis**

First, we conducted a descriptive statistical analysis to clarify the basic information at baseline. Moreover, we calculated the incidence rate of SN/S and LBP using the presence of subjective symptoms, such as SN/S or LBP, as the incident cases in 2019. Continuous and categorical variables were calculated as mean±SD, count (n) and percentage. The unpaired t-test and \( \chi^2 \) test were used for the significance tests.

We then investigated the association between the SN/S or LBP from 2019 as objective variables and chewing condition groups from 2018 as explanatory variables and estimated the OR and 95% CI using a logistic regression unadjusted model. Additionally, we calculated the propensity score (PS), the probability of effect of treatment exposure on covariates, using multivariable logistic regression analysis with the objective variable as chewing condition groups GCG versus PCG and the covariates of sex, age and 31 lifestyle questionnaires, including ‘Smoking status’ and ‘Alcohol drinking’. We excluded body mass index, ‘Have a moderate level of stress’, and ‘Work for less than nine hours’, which may have been significantly different due to the higher power of the larger study population. Moreover, we also excluded the questionnaire items ‘Eat rice, bread, or noodles with every meal’, and ‘Regularly move around at work or housework’, which were not significantly different. We used inverse probability weighting (IPW) to adjust for confounding factors in order to evaluate the associations between the two groups (GCG vs PCG) and the primary outcome (SN/S and LBP). We also used a logistic regression IPW-adjusted model. In this method, workers in the PCG were weighted for the reciprocal of the PS, and those in the GCG were weighted for the reciprocal of one minus PS. Furthermore, we conducted a subgroup analysis limited to the sex and age groups. The WHO defines workers aged >45 years as old. Therefore, we divided workers into groups, 15–44 years and 45–64 years. We also applied the IPW framework to subgroup analysis.

All analyses were performed using EZR V.1.52, which is a graphical user interface for R (R Foundation for Statistical Computing, Vienna, Austria). The statistical significance level was set at p<0.05. Since this analysis was conducted using existing data, no preliminary estimate of sample size/power was provided.

**RESULTS**

Table 1 shows the characteristics of the participants according to the chewing conditions at baseline. The
Table 1  Characteristics of the participants according to the chewing condition at baseline (n=77341)

| Characteristics                                      | GCG (n=69065) |              | PCG (n=8276) |              | P value* |
|------------------------------------------------------|--------------|--------------|--------------|--------------|----------|
|                                                      | n  | %  | Mean | SD   | n  | %  | Mean | SD   |           |
| Sex                                                  |    |    |      |      |    |    |      |      | <0.001    |
| Men                                                  | 49627 | 71.9 | 6380 | 77.1 |       |    |      |      |           |
| Women                                                | 19438 | 28.1 | 1896 | 22.9 |       |    |      |      |           |
| Age                                                  | 39.8 | 10.62 | 43.4 | 10.67 | <0.001† |
| BMI                                                  | 22.7 | 3.52 | 22.9 | 3.66  | 0.001† |
| Lifestyle questionnaires‡                            |    |    |      |      |        |    |      |      |           |
| Good health habits                                   |    |    |      |      |        |    |      |      |           |
| Smoking status                                       |    |    |      |      |        |    |      |      | <0.001    |
| Never                                                | 46621 | 67.5 | 4441 | 53.7 |       |    |      |      |           |
| Former                                               | 3257  | 4.7  | 358  | 4.3  |       |    |      |      |           |
| Current smoking                                      | 19187 | 27.8 | 3477 | 42.0 |       |    |      |      |           |
| Alcohol drinking                                     |    |    |      |      |        |    |      |      | <0.001    |
| No drinking                                          | 26350 | 38.2 | 3227 | 39.0 |       |    |      |      |           |
| Sometimes                                            | 2236  | 3.2  | 133  | 1.6  |       |    |      |      |           |
| Every day                                            | 40479 | 58.6 | 4916 | 59.4 |       |    |      |      |           |
| Exercise at least twice a week                       | 14817 | 21.5 | 1430 | 17.3 | <0.001 |
| Have three meals almost at the same time every day   | 25641 | 37.1 | 2496 | 30.2 | <0.001 |
| Sleep for 7–8 hours                                  | 21222 | 30.7 | 2059 | 24.9 | <0.001 |
| Dietary habits                                        |    |    |      |      |        |    |      |      |           |
| Aware of a balanced diet                             | 24281 | 35.2 | 2122 | 25.6 | <0.001 |
| Eat protein dishes with every meal                   | 17337 | 25.1 | 1772 | 21.4 | <0.001 |
| Eat rice, bread, or noodles with every meal          | 45540 | 65.9 | 5414 | 65.4 | 0.352  |
| Eat slowly chewing well                              | 9917  | 14.4 | 807  | 9.8  | <0.001 |
| Eat two or more kinds (packs) of Western or Japanese confectioneries or snacks on average a day | 7160  | 10.4 | 1012 | 12.2 | <0.001 |
| Finish eating at least 2 hours before bedtime        | 24461 | 35.4 | 2338 | 28.3 | <0.001 |
| Frequently eat deep-fried food, such as fried dishes and pork cutlets | 14880 | 21.5 | 2218 | 26.8 | <0.001 |
| Frequently eat heavy meat dishes                     | 13064 | 18.9 | 1864 | 22.5 | <0.001 |
| Frequently eat salty food                            | 13140 | 19.0 | 2100 | 25.4 | <0.001 |
| Frequently eat seaweed and small fish                | 8450  | 12.2 | 848  | 10.2 | <0.001 |
| Frequently have dairy products (milk, yoghurt or cheese) | 26883 | 38.9 | 2728 | 33.0 | <0.001 |
| Frequently have instant food or processed food       | 15134 | 21.9 | 2453 | 29.6 | <0.001 |
| Have breakfast almost every day                      | 43730 | 63.3 | 4645 | 56.1 | <0.001 |
| Have juice or canned coffee two bottles (two cups) or more on average a day | 18665 | 27.0 | 3330 | 40.2 | <0.001 |
| Regularly eat dark green and deep yellow vegetables  | 19348 | 28.0 | 1738 | 21.0 | <0.001 |
| Regularly eat fruits                                 | 11971 | 17.3 | 1002 | 12.1 | <0.001 |
| Regularly have snacks or late-night meals            | 10710 | 15.5 | 1643 | 19.9 | <0.001 |
| Daily living and activities                          |    |    |      |      |        |    |      |      |           |
| Belonged to a sports club while in school            | 38390 | 55.6 | 4147 | 50.1 | <0.001 |
| Can walk for about 1 hour non-stop without getting tired | 23847 | 34.5 | 2087 | 25.2 | <0.001 |

Continued
study participants were divided into two groups based on chewing conditions: GCG and PCG. Unadjusted analysis showed significant differences in all items except ‘Regularly move around at work or housework’ and ‘Eat rice, bread, or noodles with every meal’.

Table 2 shows the results of the incidence rates and the logistic regression analysis model according to the chewing conditions in 2019. We extracted information from those who responded that SN/S and LBP were not present in 2018, but the SN/S incidence rates were 13.6% and 16.5% in the GCG and PCG, respectively ($\chi^2$ test, $p<0.001$). Additionally, the LBP incidence rates were 7.4% and 11.0% in GCG and PCG, respectively, at the time of the 2019 health check-ups ($\chi^2$ test, $p<0.001$).

The unadjusted logistic regression model with SN/S as the objective variable exhibited statistically significant differences (OR=1.25; 95% CI 1.17 to 1.33). Moreover, unadjusted logistic regression analyses with LBP as the objective variable also revealed significant differences (OR=1.55; 95% CI 1.44 to 1.67). Furthermore, as a result of the IPW-adjusted logistic regression model, the OR of SN/S was approximately 1.25 (95% CI 1.17 to 1.33) times higher in the PCG than in the GCG ($p<0.001$). Similarly, the OR of LBP was approximately 1.37 (95% CI 1.27 to 1.48) times higher in the PCG than in the GCG in the IPW-adjusted logistic regression model ($p<0.001$).

Figure 2 shows the subgroups delineated by sex and age groups. As a result of the IPW-adjusted logistic regression model in sex and age group with the SN/S as the objective variable, significant differences were observed between GCG and PCG for men belonging to both age groups (under 45 years; OR=1.31; 95% CI 1.18 to 1.45, over 45 years; OR=1.31; 95% CI 1.18 to 1.47), but no significant differences were observed in women in both age groups.
periodontal disease, absence of functional dentitions, and induce musculoskeletal symptoms. A previous study suggested that the masticatory and cervical muscle coactivation mechanisms may indirectly affect the muscle activity of the lumbar region. It could also be considered indirect evidence that subjective musculoskeletal symptoms often occur in people with oral health problems, including difficulty in chewing. In this study, we demonstrated that LBP incidence was significantly higher in workers with poor chewing conditions than in those with good chewing conditions. This result is consistent with those of a previous cross-sectional study. Furthermore, there are differences in the masticatory cycle depending on the sex of the individual, and chewing force is also greater in men than in women. These findings suggest that men may be more susceptible to the effects of chewing difficulty than women.

Conversely, the psychological factors may have increased. Psychological distress has been reported as a risk factor for musculoskeletal disorders. Similarly, a previous study reported a relationship between perceived stress and poor oral health. This suggests that oral health problems may be associated with traditional biopsychosocial frameworks. Additionally, it has been recently reported that stress caused by pain stimulates degeneration of the central nucleus of the amygdala and causes pain sensitivity in areas of the body away from the site of inflammation. Therefore, difficulty in chewing, including pain in the teeth and gums, may induce stress and cause pain in the musculoskeletal system. Reports of work-related mental disorders also indicate that men are more likely to develop mental disorders attributed to long working hours than women in Japan. This may be a potential reason why men are more susceptible to the effects of difficulty in chewing, as the study population of this analysis comprised workers.

Finally, social factors must be considered. A recent study has suggested that oral health problems, ageing, smoking, education level and income are involved in chewing difficulties. It is clear that social factors are involved in the development of difficulty in chewing. This composition approximates the mechanism of musculoskeletal pain. In other words, the development of musculoskeletal pain involves biomechanical factors due to the load on the
intervertebral discs, muscles and ligaments and social factors such as ageing, smoking, education level and income. Although our study did not include information on social factors, there are likely multiple common social risk factors between factors related to the development of chewing difficulty and factors related to the development of musculoskeletal symptoms.

Our findings highlight the need for specific interventions to address oral health for specific groups with difficulty in chewing, especially men, in the workplace. The purpose of this specific intervention is not only to improve oral health, but also to prevent the development of subjective musculoskeletal symptoms. Possible interventions include specific health guidance with oral hygienists, early oral rehabilitation and the development of standard checklists for the check-up of oral health and musculoskeletal symptoms.

The strengths of our study are the large sample size and calculation of PS using extensive lifestyle questionnaires including items on dietary habits, daily living and activities. However, the following limitations should be noted regarding the generalisability of this study. First, our study focused on corporate employees; thus, a selection bias may have occurred. Second, there is a suspicion that the hypothesis for the observed relevance is not exact, and insufficient questionnaire items for psychosocial factors (eg, mental stress, education level, and income) and self-reported annual lifestyle questionnaire data may have been affected by recall bias. Third, the lifestyle questionnaire is a tool to assist physicians’ medical examinations and is not a standardised musculoskeletal disease questionnaire. Finally, oral health habits vary by country. In future studies, further intervention studies and analysis of long-term cohort data are needed.

CONCLUSIONS

In our analysis, poor chewing condition was found to be a strong predictor of subjective musculoskeletal symptoms. In addition, men are more likely than women to develop subjective musculoskeletal symptoms because of the difficulty in chewing. Therefore, oral health and health guidance are gaining importance for the prevention of subjective musculoskeletal symptoms.

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ORCID iD Naomichi Tani http://orcid.org/0000-0002-8317-5273

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