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

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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).

Design Case-control study.

Setting and participants This study was conducted from 1 April 2018 to 31 March 2020. The subjects were 77 341 workers among 646 281 workers from several employers in Japan.

Outcome measures Participants were asked to evaluate their subjective SN/S and LBP symptoms using a self-administered questionnaire.

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 that 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.

Strengths and limitations of this study

- The strengths of our study are the large sample size and calculation of propensity scores using extensive lifestyle questionnaires.
- A limitation of this study is that it focused on corporate employees; thus, a selection bias may have occurred.
- There is a suspicion that the hypothesis for the observed relevance is not exact, and insufficient questionnaire items for psychosocial factors and self-reported annual lifestyle questionnaire data may have been affected by recall bias.

INTRODUCTION

Musculoskeletal disorders and symptoms, especially pain in the neck and lower back, have been studied worldwide for many years.[1–3] The causes and countermeasures are still of concern to researchers, and the need for further public health management, prevention and treatment strategies has been suggested.[4] According to the Comprehensive Survey of Living Conditions conducted by the Ministry of Health, Labour and Welfare in Japan, the complaint rates for stiff shoulders were 57.2/1000 and 113.8/1000 people for adult men and women, respectively.[5] Furthermore, low back pain (LBP) was the main complaint for both sexes, with complaint rates of 91.2/1000 and 113.3/1000 for men and women, respectively; therefore, preventing stiff neck/shoulders (SN/S) and LBP is an important issue in Japan. Additionally, it is important to consider new preventive strategies and interventions for SN/S and LBP.

The relationship between oral health and various diseases and symptoms has been studied worldwide. Previous studies have reported an association between oral health and several diseases such as high blood pressure,[6] Alzheimer's disease, dementia,[7–9] diabetes,[10] atherosclerotic heart disease[11] and depressive disorders.[12] 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.[13] 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.[14] 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[15]; other clinical reports have shown that treatment with occlusal adjustment improves the visual analogue scale score of chronic cervical pain.[16] Difficulty chewing may occur from the on-stage or prestage where oral diseases were diagnosed.[17 18] 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,[19] and presenteeism (attending work despite health problems).[20] 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.[21] 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.[21 22] 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 or processed food', 'Have breakfast almost every day', 'Have juice or canned coffee two bottles (two cups) or more on average every day', 'Regularly eat dark green and deep yellow vegetables', 'Regularly eat fruits', and 'Regularly have snacks or late-night meals'. 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, circle where appropriate', 'SN/S applicable or inapplicable', and 'LBP applicable or inapplicable'. The outcome variable was whether an SN/S or LBP event occurred.

Specific health check-up questionnaire

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 χ^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

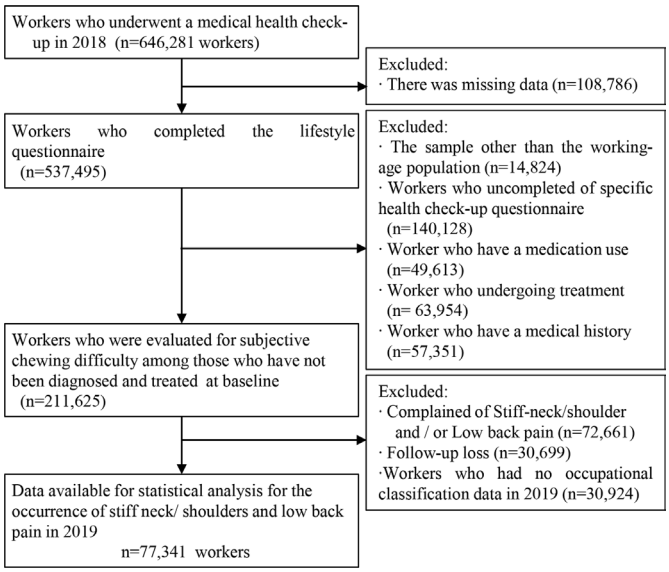

Figure 1 Flow chart for identification of the study population.

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[23] 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.[24] Therefore, we divided workers into two 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[25] 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=77 341)

Characteristics	GCG (n=69 065)				PCG (n=8276)				P value*
	n	%	Mean	SD	n	%	Mean	SD	
Sex									<0.001
Men	49 627	71.9			6380	77.1			
Women	19 438	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	46 621	67.5			4441	53.7			
Former	3257	4.7			358	4.3			
Current smoking	19 187	27.8			3477	42.0			
Alcohol drinking									<0.001
No drinking	26 350	38.2			3227	39.0			
Sometimes	2236	3.2			133	1.6			
Every day	40 479	58.6			4916	59.4			
Exercise at least twice a week	14 817	21.5			1430	17.3			<0.001
Have three meals almost at the same time every day	25 641	37.1			2496	30.2			<0.001
Sleep for 7–8 hours	21 222	30.7			2059	24.9			<0.001
Dietary habits									
Aware of a balanced diet	24 281	35.2			2122	25.6			<0.001
Eat protein dishes with every meal	17 337	25.1			1772	21.4			<0.001
Eat rice, bread, or noodles with every meal	45 540	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	24 461	35.4			2338	28.3			<0.001
Frequently eat deep-fried food, such as fried dishes and pork cutlets	14 880	21.5			2218	26.8			<0.001
Frequently eat heavy meat dishes	13 064	18.9			1864	22.5			<0.001
Frequently eat salty food	13 140	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)	26 883	38.9			2728	33.0			<0.001
Frequently have instant food or processed food	15 134	21.9			2453	29.6			<0.001
Have breakfast almost every day	43 730	63.3			4645	56.1			<0.001
Have juice or canned coffee two bottles (two cups) or more on average a day	18 665	27.0			3330	40.2			<0.001
Regularly eat dark green and deep yellow vegetables	19 348	28.0			1738	21.0			<0.001
Regularly eat fruits	11 971	17.3			1002	12.1			<0.001
Regularly have snacks or late-night meals	10 710	15.5			1643	19.9			<0.001
Daily living and activities									
Belonged to a sports club while in school	38 390	55.6			4147	50.1			<0.001
Can walk for about 1 hour non-stop without getting tired	23 847	34.5			2087	25.2			<0.001

Continued

Table 1 Continued

Characteristics	GCG (n=69 065) n	%	Mean	SD	PCG (n=8276) n	%	Mean	SD	P value*
Doing sports during free time at least once time a month	20 738	30.0			1837	22.2			<0.001
Have a moderate level of stress	31 632	45.8			3900	47.1			0.023
Have worse condition than 6 months ago	3179	4.6			590	7.1			<0.001
Prefer to spend time out in nature such as the mountains, sea, and river	25 022	36.2			2500	30.2			<0.001
Regularly go outside	24 201	35.0			2372	28.7			<0.001
Regularly move around at work or housework	19 860	28.8			2426	29.3			0.295
Regularly walk	24 203	35.0			2225	26.9			<0.001
Satisfied with everyday life	23 000	33.3			1964	23.7			<0.001
Walk at least one time for ten minutes per time every day	39 499	57.2			4221	51.0			<0.001
Walk or bike when commuting	26 415	38.2			2723	32.9			<0.001
Work for less than 9 hours	28 044	40.6			3202	38.7			0.001

* χ^2 test.
† Unpaired t-test.
‡ Except for smoking status and alcohol drinking, only 'applicable' cases were listed.
BMI, body mass index; GCC, good condition group; PCG, poor condition group.

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 (χ^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 (χ^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

Table 2 Associations between the chewing condition groups and stiff neck and shoulder and low back pain in 2019 (n=77 341)

	Unadjusted incidence rates n	%	Unadjusted model OR	95% CI	P value	IPW-adjusted model OR	95% CI	P value
Stiff neck and shoulder								
Good condition group	9417	13.6	1.00			1.00		
Poor condition group	1364	16.5	1.25	1.17 to 1.33	<0.001	1.25	1.17 to 1.33	<0.001
Low back pain								
Good condition group	5098	7.4	1.00			1.00		
Poor condition group	909	11.0	1.55	1.44 to 1.67	<0.001	1.37	1.27 to 1.48	<0.001

IPW, inverse probability weighting; P, p-value.

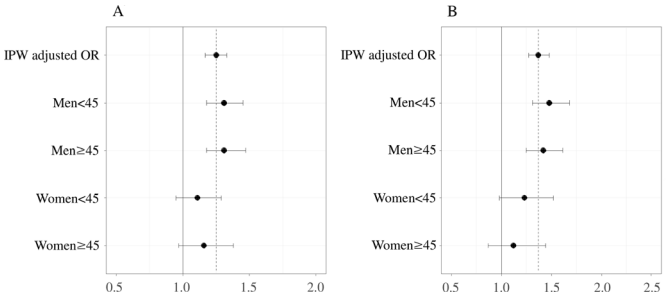

Figure 2 The results of analyses with stiff neck/shoulders (A) and low back pain (B) as objective variables. Values are presented as estimated ORs and 95% CIs from the inverse probability weighting adjusted logistic regression analysis. The solid line delineates the reference group (good condition group).

(under 45 years; OR=1.11; 95% CI 0.95 to 1.29, over 45 years; OR=1.16; 95% CI 0.97 to 1.38). As a result of the IPW-adjusted logistic regression model with LBP as the objective variable, all results were the same as above, with significant differences observed in men (under 45 years; OR=1.48; 95% CI 1.31 to 1.68, over 45 years; OR=1.42; 95% CI 1.25 to 1.61), but no significant differences were observed in women (under 45 years; OR=1.23; 95% CI 0.98 to 1.52, over 45 years; OR=1.12; 95% CI 0.87 to 1.44).

DISCUSSION

In this study, we examined the association between chewing difficulty and subjective musculoskeletal symptoms. The incidence rates of SN/S and LBP were higher in the PCG (SN/S, 16.5%; LBP, 11.0%) than in the GCG (SN/S=13.6%; LBP=7.4%). In addition, we compared the risk between the two groups (GCG and PCG) using a logistic regression model with PS and IPW methods. Consequently, significant differences in risk were observed in the logistic regression model using PS and IPW, suggesting that it could predict SN/S and LBP symptom occurrence in workers depending on the presence of difficulty in chewing. Moreover, we showed that men are more likely than women to develop subjective musculoskeletal symptoms due to the effects of chewing difficulty.

The development of musculoskeletal symptoms has often been explained in the context of biopsychosocial frameworks.[4 21 26] Therefore, we argue that chewing difficulty gives rise to subjective musculoskeletal symptoms. First, we considered this from a biomechanical perspective. Previous studies have shown that chewing difficulties are associated with dental caries, missing teeth, periodontal disease, absence of functional dentitions, dental prosthesis use, oral pain and TMD.[17 18 27] It may be apparent that various oral health problems can affect occlusion and chewing status. Importantly, the loss of an occlusal relationship unilaterally or bilaterally with oral health problems can lead to malocclusion, which can affect the craniocervicomandibular system, body posture and induce musculoskeletal symptoms.[28] A previous study argued that there is a functional link between the masticatory and sternocleidomastoid and trapezius muscles through a coactivation mechanism, and the spread of pain and tension from the masticatory region to the cervical region.[29] We considered that the presence of difficulty in chewing leads to overloading of the masticatory muscles, which could indirectly affect the development of stiff sternocleidomastoid and trapezius muscles. Additionally, previous studies have reported a bidirectional relationship between oral health problems (eg, TMD and occlusal interferences and adjustment) and neck pain.[14–16] Our finding that difficulty in chewing was associated with SN/shoulders supports these studies. Moreover, the position of the head seems to affect the muscle activity of the lumbar region.[28 30] In particular, head posture may affect pelvic position and sitting posture.[31 32] We considered that the masticatory and cervical muscle coactivation mechanisms may indirectly affect the muscle activity of the lumbar region.[28] 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.[13] Furthermore, there are differences in the masticatory cycle depending on the sex of the individual,[33] and chewing force is also greater in men than in women.[34] 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.[35 36] Similarly, a previous study reported a relationship between perceived stress and poor oral health.[37] This suggests that oral health problems may be associated with traditional biopsychosocial frameworks. Additionally, it has been recently reported that stress caused by pain stimuli degenerates the central nucleus of the amygdala and causes pain sensitivity in areas of the body away from the site of inflammation.[38] 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.[39] 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.[18] 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.[1 2 40] 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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