Four-Year Longitudinal Course of TMD Symptoms in an Adult Population and the Estimation of Risk Factors in Relation to Symptoms

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Aims: *To investigate the natural course of symptoms of temporomandibular disorders (TMD) in a non-patient population and to estimate the strength of the relationship between several hypothesized risk factors and precipitation and perpetuation of the symptoms.* **Methods:** *A total of 672 randomly selected citizens of Okayama City was requested to answer the same self-administered questionnaire that they had answered 4 years earlier. The mailed questionnaire failed to reach 58 subjects at the second survey, and 367 of the remaining subjects (59.8%) responded. The fluctuation of TMD symptoms was assessed by comparison of 6 pairs of answers for questions regarding temporomandibular joint (TMJ) pain, limitation of mouth opening, TMJ noise, headache, neck pain, and shoulder stiffness. Six factors (age under 40, female, clenching habit, history of extrinsic trauma, sleep disturbance, and family history of TMD) were tested for their relative risk in precipitating and perpetuating each TMD symptom by the use of its confidence interval to define significance.* **Results:** *The incidence of TMD symptoms ranged from 6.1% (TMJ pain) to 12.9% (TMJ noise). More than half of the subjects who had reported TMJ and neck pain at the initial survey no longer reported these symptoms at the second survey, whereas TMJ noise and shoulder stiffness remained in more than 70% of the subjects. Individuals under 40 years old had a 3.3:1 increased risk of precipitating TMJ noise ($P < 0.01$), individuals with a history of extrinsic trauma had a 2.85:1 increased risk of precipitating limited mouth opening ($P < 0.01$), and females had a 2.81:1 increased risk of perpetuating TMJ pain ($P < 0.01$).* **Conclusion:** *The possible etiologic significance of these factors in TMD should be validated by future research.*

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Key words: temporomandibular disorders, population characteristics, disease progression, risk assessment, questionnaires

Many cross-sectional epidemiologic studies have shown a high prevalence of signs and symptoms of temporomandibular disorders (TMD) in the non-patient population.[1–5] A previous epidemiologic study also revealed a high prevalence in the adult Japanese non-patient population.[6] A meta-analysis revealed that TMD signs and symptoms were more prevalent in younger people than in elderly people.[5] Although the study could not clarify the reason for this, spontaneous remission of TMD signs and symptoms with age may be considered an important trend. In fact, several studies have evaluated the natural course of non-reducing anterior disc displacement of the temporomandibular joint (TMJ) and reported a high percentage of

spontaneous alleviation of symptoms over time in the patient population.[7–9] However, only a few studies have investigated the fluctuating nature of TMD signs and symptoms in the non-patient population.[10–16] In addition, the available longitudinal epidemiologic surveys have been conducted within limited age groups. Therefore, the incidence over a broad age range of TMD signs and symptoms is still uncertain and can be determined only by longitudinal surveys in the non-patient population encompassing all age groups. As Magnusson et al[13] have pointed out, longitudinal epidemiologic investigations can also shed light on risk factors for the development of TMD signs and symptoms.

In this study, the fluctuating nature of TMD symptoms was investigated in an adult Japanese population with a self-administered questionnaire. The participants were requested to answer the same questionnaire that they had answered 4 years earlier, and the answers from the 2 surveys were compared. The aims of this study were: *(1)* to investigate the natural course of TMD symptoms in an adult Japanese non-patient population and *(2)* to investigate the relationship between strongly hypothesized risk factors and the precipitation and perpetuation of symptoms.

Materials and Methods

Subjects and Questionnaire

The subjects selected for this study were the same 672 adults (304 males and 368 females with a mean age of 49.7 ± 15.0 years) who participated in a previous study.[6] The subjects were randomly selected from the voter's list of Okayama City, Japan (target population). All subjects had already answered a self-administered questionnaire, and the same questionnaire was sent to them 4 years after the first survey. At the second survey, however, the questionnaire failed to reach 58 subjects as a result of a change of address (n = 51), serious disease or senility (n = 5), or death (n = 2). Of the remaining 614 subjects (accessible population), 367 (166 males and 201 females with a mean age of 53.1 ± 14.2 years) returned the questionnaire (respondents), for a return rate of 59.8%. Each questionnaire covered 8 major categories, with a total of 36 questions: *(1)* food and nutrition (8 questions), *(2)* history of dental treatment (3 questions), *(3)* oral and postural habits (7 questions), *(4)* history of extrinsic trauma (2 questions), *(5)* mental health (5 questions), *(6)* daily activities (2 questions), *(7)* histories and symptoms of TMD (7 questions), and *(8)* general health (2 questions). Information about general health was collected by means of a list of symptoms or illnesses, and other questions were asked in a dichotomous fashion. All questions concerning food and nutrition, history of dental treatment, and daily activities were not analyzed in this study. Furthermore, 6 of 7 questions concerning oral and postural habits, 1 of 2 questions concerning extrinsic trauma, 4 of 5 questions concerning mental health, 3 of 7 questions concerning histories and symptoms of TMD, and 1 of 2 questions concerning general health were also not analyzed. These questions were intentionally added to the questionnaire as "dummy" questions with the intent to direct the respondents' attention to their general health, rather than to TMD problems alone.

Analytic Procedures

The only data analyzed in this study came from the 367 subjects who completed both questionnaires. Fluctuation of TMD symptoms was assessed by comparing 6 pairs of answers between the first and second surveys. Information about 4 TMD symptoms and 2 symptoms in the adjacent regions was obtained from the following 6 questions: *(1)* TMJ pain (do you have pain or an unpleasant feeling around your jaw joint(s)?), *(2)* limitation of mouth opening (do you have any difficulty in opening your mouth?), *(3)* TMJ noise (are you aware of your jaw making sounds?), *(4)* headache, *(5)* neck pain, and *(6)* shoulder stiffness. Headache, neck pain, and shoulder stiffness were included in a list of symptoms or illnesses along with the request, "please check all of the following which you frequently experience."

Based on the fluctuation patterns, the following 4 measurements were calculated to estimate epidemiologic outcomes of TMD symptoms: *(1)* symptom-maintaining rate, *(2)* symptom remission rate, *(3)* symptom-emerging rate (incidence), and *(4)* symptom-free rate. The *symptom-maintaining rate* is the ratio of the number of subjects with a symptom in both surveys to the total number of subjects, and the *symptom-free rate* is the ratio of the number of subjects without a symptom in both surveys to the total number of subjects. The *symptom remission rate* is the ratio of the number of subjects in whom a symptom disappeared during the 4-year period to the total number of subjects, and the *symptom-emerging rate* (incidence) is the ratio of the number of subjects in whom a symptom appeared during the 4-year period to the total number of subjects. The authors also calculated

Table 1 Comparison of Frequency of TMD Symptoms and Risk Factors Between the Target Population and Respondents

	Target population (n = 672) (%)	Respondents (n = 367) (%)*	*P* value
Mean age (y)	49.7 ± 15.0	53.1 ± 14.2	< 0.001
Gender			
Male	304 (45.2)	166 (45.2)	> 0.99
Female	368 (54.8)	201 (54.8)	
TMD symptoms			
TMJ pain	75 (11.1)	44 (12.0)	0.68
Limitation of mouth opening	93 (13.8)	48 (13.1)	0.73
TMJ noise	170 (25.2)	89 (24.2)	0.71
Headache	181 (26.9)	105 (28.6)	0.56
Neck pain	80 (11.9)	55 (15.0)	0.16
Shoulder stiffness	330 (49.1)	195 (53.1)	0.21
Risk factors			
Clenching habit	158 (23.5)	110 (30.0)	0.02
Extrinsic trauma	194 (28.8)	95 (25.9)	0.31
Sleep disturbance	170 (25.3)	135 (36.8)	0.0001
Family history of TMD	38 (5.7)	23 (6.3)	0.68

*Values taken from first survey.

the percentage of subjects without symptoms at the second survey who had symptoms in the first survey, as well as the percentage of subjects without symptoms in the second survey who did not have symptoms in the first survey.

The authors tested whether the hypothesized risk factors were actually related to the perpetuation or precipitation of the TMD symptoms. As a result of the previous reports in which candidate risk factors for TMD pathogenesis were determined,[1,3,5,6,10,11,16–24] 6 factors were hypothesized as risk factors for TMD (age, gender, clenching habit, history of extrinsic trauma, sleep disturbance, and family history of TMD). Respondents were asked to estimate these risk factors as follows: *(1)* clenching habit (do you often clench your teeth?), *(2)* history of extrinsic trauma (have you ever been in an accident or received a "blow" or injury to any part of your head or face?), *(3)* sleep disturbance (do you have any trouble sleeping?), and *(4)* family history of TMD (are there any persons in your family who have jaw sounds or difficulty in opening their mouth?). A respondent was regarded as having the risk factor when the answer at the first survey was "yes" and as not having the risk factor when the answer at the first survey was "no."

Statistical Analysis

The statistical differences of age and sex distribution between subjects with and without TMD symptoms or risk factors were tested with the Chi-square test. To evaluate how strongly each risk factor was associated with precipitation or perpetuation of TMD symptoms, relative risk (RR) was calculated by means of 2 × 2 contingency tables.[25] Relative risk for precipitation was defined as the ratio of subjects with TMD symptoms and risk factors to subjects with TMD symptoms and without risk factors. Although gender and a family history of TMD are considered predisposing factors for TMD, in this study, these factors were regarded as having precipitated a TMD symptom if the symptom appeared between the first and second surveys. Relative risk for perpetuation was defined as the ratio of subjects who reported TMD symptoms in both surveys and had risk factors to subjects who reported TMD symptoms in both surveys and did not have risk factors.

The statistical significance of RR was estimated with confidence intervals. To calculate confidence intervals for RR, the formula

$$RR^{(1 \pm z/\sqrt{\chi^2})}$$

was used.[25] If the null value of an estimate (1.0 for RR) was not contained within the confidence interval, the estimate was considered significant. Because of the large number of statistical tests, the Bonferroni correction was applied to protect against Type I error. The significance level was set at $\alpha = 0.0083$ (0.05/6) for analysis of the reported frequencies of TMD symptoms and $\alpha = 0.0125$ (0.05/4) for analysis of the reported frequencies of risk factors. An alpha of 0.01 was chosen as the level of significance for analysis of relative risk. An alpha of 0.05 was chosen for the level of significance for mean age and male/female ratio analyses.

Results

Frequencies of TMD Symptoms and Risk Factors

Table 1 shows the distribution of age, gender, TMD symptoms, and risk factors in the target population and the respondents. The mean age of the respondents was significantly higher than that of the target population (Student's *t* test, $P < 0.001$). However, there was no statistically significant difference in gender distribution between the target population and the respondents. There were

also no statistical differences in frequencies of TMD symptoms and risk factors (at the time of the first survey) between the target population and the respondents, except that the sleep disturbance frequency was higher in respondents than in the target population. With regard to self-reported frequencies of TMD symptoms, the frequencies of TMJ noise, headache, and shoulder stiffness were relatively higher than those of TMJ pain, limitation of mouth opening, and neck pain in both the respondents and the target population.

Tables 2 and 3 show the distribution of TMD symptoms and risk factors in terms of gender and age, respectively. Headache was reported more frequently by females than males, whereas extrinsic trauma was reported more frequently by males than females in both the first and second surveys. Shoulder stiffness was reported more frequently by females at the first survey. There were no statistical differences in reported frequencies of both TMD symptoms and risk factors in different age groups, except for TMJ noise at the second survey.

Fluctuation of TMD Symptoms

For all TMD symptoms, the percentage of subjects without symptoms at the second survey who had reported symptoms at the first survey was much higher than the percentage of subjects with symptoms at the second survey who had not reported symptoms at the first survey (Table 4). More than half of the subjects who reported TMJ or neck pain at the first survey did not report these symptoms at the second survey. Temporomandibular joint noise and shoulder stiffness were not reduced as often as the other symptoms between the first and second survey. However, the symptom remission rates of TMD symptoms were similar to the symptom-emerging rates (incidence), with the exception of TMJ noise and shoulder stiffness. The incidence of TMJ noise was double the symptom remission rate. The symptom-free rates for all TMD symptoms, except for shoulder stiffness, were the highest among the 4 rates calculated in this study.

Risk Factors for Perpetuation and Precipitation of TMD Symptoms

The relative risks of precipitation of TMD symptoms ranged between 0.40 and 3.30. Of the 36 relative risks calculated, 2 showed a significant association (Table 5). The incidence of TMJ noise among subjects under 40 years of age was 3.3 times that of subjects over 40 years of age ($P < 0.01$). The relative risk of developing limited mouth opening among subjects with a history of extrinsic trauma was 2.85 times that of subjects without such a history ($P < 0.01$). Subjects with a history of trauma also had a risk of developing TMJ pain that was 2.14 times higher than for subjects without trauma, but the relative risk was not significant at the 95% confidence interval (0.94–4.89). Gender, clenching habit, sleep disturbance, and a family history of TMD were not significantly associated with the precipitation of TMD symptoms.

The relative risks of perpetuation of TMD symptoms ranged between 0.50 and 2.81 (Table 6). Of the 36 relative risks calculated, only 1 showed a significant association. The relative risk of perpetuating TMJ pain among females was 2.81 times that of males ($P < 0.01$). Age, clenching habit, history of extrinsic trauma, sleep disturbance, and family history of TMD were not significantly associated with the perpetuation of TMD.

Discussion

Data Collection

One of the primary disadvantages of mailed questionnaires is that the return rate is often quite low. Realistically, researchers can expect return rates between 30% and 60%. Response rates between 60% and 80% are usually considered excellent.[25] In this study, the return rate (59.8%) was just below 60%, which, together with a fairly large survey sample, suggests study validity. However, the non-respondents might have introduced some bias into the results, since the respondents' age was higher than that of the original participants, ie, of the target population. Thus, the significantly higher frequency of sleep disturbance in the respondents may have been influenced by the slightly older respondent population. On the other hand, because there were no statistically significant differences in gender ratio and frequencies of TMD symptoms between the target population and the respondents, we believe that the findings obtained from this survey can be meaningfully interpreted while maintaining consideration of the final respondents' demographic characteristics.

All the data were collected through a written questionnaire, ie, without clinical examination. The reliability of individual questions as well as the content and construct validity are all concerns for survey researchers. The item reliability was confirmed in a pilot study of a small sample from

Table 2 Comparison of Frequencies of TMD Symptoms and Risk Factors in Respondents with Respect to Gender

	First survey (n = 367)			Second survey (n = 367)		
	Male (n = 166)	Female (n = 201)	*P*	Male (n = 166)	Female (n = 201)	*P*
TMD symptoms						
TMJ pain	19	25	0.79	15	26	0.21
Limitation of mouth opening	29	19	0.02	26	25	0.40
TMJ noise	45	44	0.25	44	66	0.17
Headache	28	77	< 0.0001	30	70	0.0003
Neck pain	27	28	0.53	30	32	0.58
Shoulder stiffness	74	121	0.003	75	102	0.29
Risk factors						
Clenching habit	59	51	0.03	39	46	0.84
Extrinsic trauma	59	36	0.0001	52	33	0.0009
Sleep disturbance	54	81	0.12	42	72	0.04
Family history of TMD	7	16	0.14	7	19	0.052

Table 3 Reported Frequencies of TMD Symptoms and Risk Factors with Respect to Age

	Age						
	20–29	30–39	40–49	50–59	60–69	70+	*P*
First survey (n = 367)							
n	6	45	59	92	93	72	
TMD symptoms							
TMJ pain	2	5	12	9	12	4	0.08
Limitation of mouth opening	1	7	11	10	13	6	0.58
TMJ noise	3	18	16	20	20	12	0.04
Headache	2	13	13	39	23	15	0.03
Neck pain	0	4	9	14	17	11	0.58
Shoulder stiffness	3	21	28	53	49	41	0.74
Risk factors							
Clenching habit	0	12	14	34	30	20	0.27
Extrinsic trauma	3	16	15	21	19	21	0.28
Sleep disturbance	3	10	20	33	32	37	0.04
Family history of TMD	0	2	4	6	7	4	0.94
Second survey (n = 367)							
n	2	25	52	88	85	115	
TMD symptoms							
TMJ pain	0	3	6	9	12	11	0.96
Limitation of mouth opening	0	6	8	15	12	10	0.43
TMJ noise	1	14	28	24	23	20	< 0.0001
Headache	1	8	17	30	23	21	0.09
Neck pain	0	4	5	22	16	15	0.10
Shoulder stiffness	2	15	24	50	37	49	0.12
Risk factors							
Clenching habit	0	4	12	20	26	23	0.40
Extrinsic trauma	0	8	11	25	21	20	0.41
Sleep disturbance	0	7	10	22	31	44	0.04
Family history of TMD	0	2	7	10	4	3	0.05

Number = no. of respondents who answered "yes" at the first or second survey.

Table 4 Fluctuation Pattern of TMD Symptoms (%)

Symptom	Symptom-maintaining rate	Symptom remission rate	Symptom-emerging rate (incidence)	Symptom-free rate
TMJ pain	5.5	6.6 (54.8)*	6.1 (6.9)†	81.8
Limitation of mouth opening	7.8	5.5 (41.3)*	6.9 (8.0)†	79.8
TMJ noise	19.3	5.6 (22.4)*	12.9 (17.2)†	62.3
Headache	18.9	9.9 (34.3)*	8.5 (11.9)†	62.7
Neck pain	6.3	8.5 (57.4)*	9.8 (12.5)†	74.5
Shoulder stiffness	37.8	15.3 (28.9)*	10.7 (22.8)†	36.2

*Parentheses = Percentage of subjects without symptom at the second survey who showed symptom at the first survey.
†Parentheses = Percentage of subjects with symptom at the second survey but without symptom at the first survey.

Table 5 Risk Factors for the Precipitation of TMD Symptoms (Relative Risk)

TMD symptom	Female	Age under 40	Clenching habit	History of extrinsic trauma	Sleep disturbance	Family history of TMD
TMJ pain	0.93	0.62	1.23	2.14	1.49	0.95
Limitation of mouth opening	0.77	0.86	0.79	2.85*	1.33	0.68
TMJ noise	1.37	3.30*	0.89	0.55	1.22	0.40
Headache	1.54	1.49	1.35	1.07	1.08	2.42
Neck pain	1.29	0.64	1.42	1.42	1.17	1.24
Shoulder stiffness	1.20	1.60	0.77	1.48	1.47	1.10

*$P < 0.01$.

Table 6 Risk Factors for the Perpetuation of TMD Symptoms (Relative Risk)

TMD symptom	Female	Age under 40	Clenching habit	History of extrinsic trauma	Sleep disturbance	Family history of TMD
TMJ pain	2.81*	0.94	0.71	0.78	1.29	1.60
Limitation of mouth opening	1.32	1.08	1.10	0.79	1.21	1.90
TMJ noise	1.33	1.06	0.88	1.06	0.98	1.33
Headache	1.11	1.02	0.58	1.42	1.13	0.74
Neck pain	0.50	0.57	0.57	1.31	1.88	1.26
Shoulder stiffness	0.90	1.06	1.07	1.10	0.94	0.95

*$P < 0.01$.

the target population. Also, the validity of questions regarding TMJ noise and limitation of mouth opening has been found acceptable when compared to findings obtained prior to this survey from a clinical examination of a different adult population.[26] However, the validity of questions regarding other TMD symptoms and risk factors was not ensured prior to data collection, since it is difficult to validate such questions. Pain and stiffness can be measured only subjectively, and self-reporting is the only direct way to determine how much a subject is actually suffering from TMD. Also, there is no agreement on how TMD risk factors, except for age and gender, should be defined or measured. However, owing to the easily understood questions related to the risk factors and the results of the preliminary tests on reliability and validity, we presume that we measured most of what we intended to measure and that the results of the survey can be generalized.

Symptom Fluctuation

This study clearly shows that TMD symptoms (self-reported) in a non-patient population fluctuated over a 4-year period, as has been previously reported.[10–16] Almost half of the subjects who responded positively at the first survey did not report TMJ pain (55%), limitation of mouth opening (41%), and neck pain (57%) at the second survey. The symptom that showed the least reduction during the 4 years was TMJ noise; nevertheless, 22% of subjects who responded positively at the first survey did not report it at the second survey. A clear fluctuation in subjectively reported joint sounds has also been reported in longer follow-up studies.[27] These results suggest that although some of the fluctuations may be explained by the fact that some individuals received treatment for their conditions during the 4-year period, many TMD symptoms, even TMJ noise, may disappear spontaneously. Thus, the natural fluctuation of TMD symptoms should be taken into consideration prior to treatment planning of TMD.

Symptom Incidence

It is very important to measure the incidence of a disorder or disease to estimate the risk of developing the disease. Nevertheless, the number of epidemiologic studies designed to measure the incidence of TMD symptoms is limited. Wänman[16] reported that the incidence of TMD symptoms during a 10-year follow-up period in subjects from age 17 to age 28 was 6% in both sexes. The incidence of TMD symptoms in this study ranged from 6.1% for TMJ pain to 12.9% for TMJ noise, and the overall symptom incidence was 12.8%. Despite the shorter follow-up period in the current study, the incidence in this study was double that in Wänman's study, although both surveys were based on a questionnaire. Interestingly, the incidences during the 4 years were almost equal to the rates at which the symptoms disappeared, except for TMJ noise. This indicates that, except for TMJ noise, the number of subjects who were aware of TMD symptoms neither increased nor decreased in the non-patient adult population,[28] a finding that has also been reported previously.[11,29] Only the number of respondents with TMJ noise increased significantly (from 89 to 110) during the 4 years (see Table 3), confirming that, regardless of the subject's age, the prevalence of TMJ noise increases with age.[11–14,27–30]

Symptom Risk Factors

Risk factors for TMD can be classified as predisposing, precipitating, or perpetuating.[31] Individually, risk factors may serve any or all of these roles. To fully understand the etiology of TMD, each role should be investigated separately. In this study, therefore, the risk of each factor to precipitate or perpetuate TMD symptoms was calculated separately. No risk factor was associated with both a precipitating and perpetuating role leading to a specific TMD symptom, suggesting that the risk factors that precipitate TMD symptoms might be different from those that perpetuate TMD symptoms. Gender was not found to be related to the precipitation of any self-reported TMD symptoms, but females had a significantly higher risk (2.81:1) of perpetuating TMJ pain than males. This indicates that TMJ pain lasts longer in females than in males, although there are no differences in the symptom prevalence between females and males. The number of subjects with pain will be larger if the pain is of long duration, so the observed predominance of females who report TMJ pain in cross-sectional epidemiologic studies[5,6,10,18] could be partly explained by the long-standing nature of the pain in females. Wänman[16] also reported in his 10-year longitudinal study that males and females had different natural courses for TMD symptoms.

Subject age was significantly related only to the onset of TMJ noise. Indeed, during the 4-year period, subjects aged 40 and under had a 3.3-times higher risk of developing TMJ noise, compared to subjects age 41 and over. In support of this finding, higher frequency of TMJ noise among the younger generation has also been reported in cross-sectional epidemiologic studies.[1,6,18] These results suggest, therefore, that youth could represent a significant risk factor for the development of TMJ noise.

It has been stated frequently that extrinsic trauma to the face/neck region is an important risk factor leading to TMD, because patients with TMD more often report a history of trauma than subjects without TMD.[19,20,32,33] In several cross-sectional clinical studies, it has been further observed that trauma was significantly associated with TMD symptoms, eg, difficulty in mouth opening, pain on movement, TMJ crepitation, and TMJ pain, as well as non-TMD symptoms such as higher facial and headache pain ratings, more frequent daily recurrent headache, neck pain, ear-related symptoms, sleep disturbances, occupational and avocational disability, and dizziness.[19,23,32,34]

Despite several of the positive associations, there was no consensus in these studies that any individual TMD or non-TMD symptom was significantly associated with a history of trauma. In an epidemiologic study of a general population, Locker and Slade[18] found no association between a history of trauma to the jaw and the presence of one or more symptoms of TMD. The conflicting results suggest that the exact role of trauma in the etiology of TMD is as yet not fully understood. One of the reasons for the controversy is that these studies could not identify a history of trauma separately as a predisposing, precipitating, or perpetuating factor, since the studies were not longitudinal. Because this longitudinal study was able to assess TMD risk factors for their precipitating or perpetuating roles, we could estimate the RR for each factor in precipitating and perpetuating TMD symptoms. This study demonstrated that individuals with a history of extrinsic trauma had risks of precipitating TMJ pain and limited mouth opening that were 2.14 times and 2.85 times greater, respectively, than in persons without trauma. The RR of 2.85 was significant ($P < 0.01$). However, a history of trauma did not significantly perpetuate any TMD symptoms. This suggests that while individuals who experience external trauma to the head or face experience TMJ pain or limitation of mouth opening more frequently, the symptoms usually resolve.

The present study attempted to delineate certain precipitating and perpetuating factors for TMD. In addition, the reader is cautioned that the assumption that a risk factor is responsible for a symptom that arises following the presence of the risk factor may be incorrect in some cases, and the risk estimates are probably lower than what we have reported. However, the possible roles of those factors in the etiology of TMD should be further explored by future research utilizing multifactorial and interaction statistics that include not only the subjects' symptoms but also clinical findings to offer more insight regarding precipitating and perpetuating factors for TMD.

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