Office and ambulatory blood pressure in patients with craniomandibular disorders

Tereza Cristina de Abreu, Maria Nilner, Thomas Thulin and Danila Vallon

Department of Stomatognathic Physiology, Centre for Oral Health Sciences, Lund University, Malmö, and Department of Internal Medicine, University Hospital, Lund, Sweden

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To assess the physiologic response to daily life stress in patients with craniomandibular disorders (CMD), office and ambulatory blood pressure and heart rate were studied in 25 female patients and 25 controls. Significant differences ($p < 0.05$) were found between the groups for heart rate before the clinical examination and that in the patient group when compared before and after the clinical examination. Higher values were found for mean daytime systolic and diastolic blood pressure in the control group compared with the patient group ($p < 0.05$). The mean number of systolic blood pressure ≥ 140 mmHg during 24 h and daytime was significantly higher ($p < 0.05$) in the control group than in the patient group. In this study the CMD patients with muscular diagnosis were not more stressed than healthy subjects in the daily activities as evaluated by ambulatory blood pressure measurements.
□ *Heart rate; stress*

Maria Nilner, Department of Stomatognathic Physiology, Centre for Oral Health Sciences, Lund University, S-214 21 Malmö, Sweden

The literature presents multiple factors influencing the development of craniomandibular disorders (CMD), and some studies give support to the theory that indicates emotional stress as an etiologic factor, especially in CMD of muscular origin (1–3).

The pathophysiologic effects of stress are likely to depend on interaction of at least three factors: the nature of the environmental stressor, its perception by the individual personality, and the individual's physiologic susceptibility (4, 5). For arterial hypertension there is a hypothesis that predicts that repeated exposure to acute stress, with transient elevations of blood pressure (BP), will eventually produce a sustained elevation of the BP (6, 7).

It is well known that muscular exercise promotes increased BP and heart rate. Increases in BP have also been found in experimental studies during isometric clenching and dynamic jaw exercises (8). Results from studies in normotensive and hypertensive subjects have shown that static clenching may result in increased systolic and diastolic BP (9, 10). If isometric contraction of small muscle groups influences BP, then it seems that subjects experiencing this type of reaction for various periods might experience concurrent and possibly significant elevations of BP. In patients with decreased cardiac function, Mitchell & Wildenthal (11) have emphasized the risks generated by isometric exercise.

Patients seeking treatment for CMD very often present with hyperactivity of the masticatory muscles and the habit of clenching (isometric contraction) or grinding (dynamic exercise) their teeth (12). Stress, which can lead to increased BP and heart rate (13), is often mentioned as an etiologic factor of CMD (12). The aim of this study was therefore to measure and evaluate the BP and heart rate in a clinical situation and during 24 h in patients with CMD of muscular origin and in controls.

Table 1. Age distribution, smoking habits, and body mass index (BMI) (kg/m^2)

	Patients ($n = 25$)	Controls ($n = 25$)
20–34 years	11	11
35–49 years	7	7
50–64 years	7	7
Smokers	11	5
BMI*	23 ± 3	21 ± 2

* Values are shown as mean ± SD.

Subjects and methods

The patient group consisted of 25 female patients (39 ± 14 years old) from the Department of Stomatognathic Physiology, fulfilling the diagnostic criteria for CMD of muscular origin (14). All subjects had symptoms of pain, tiredness in the face region, or a decreased range of movements. The control group consisted of 25 women (39 ± 14 years old) not seeking care for CMD symptoms, among dental patients and the staff of the same school, without acute or chronic pain considered in need of treatment. They were matched with the CMD patients for age. The age distribution, smoking habits, and body mass index (BMI), calculated in accordance with Thomas et al. (15) are shown in Table 1.

The exclusion criteria of the study, for patients and controls, were the presence of symptomatic degenerative joint disease of the temporomandibular joint (TMJ), generalized arthritis, previous surgical intervention in the TMJ, or known psychiatric illness. Patients with pain originating from other structures, such as teeth, periodontium, jaw bone, sinuses, and ears were also to be excluded from the study, as were patients undergoing medical treatment of hypertension or heart disease or using drugs that could affect the BP. The reasons for invited subjects not to be included in the study are given in Table 2.

The study included a history and a clinical examination of the stomatognathic system. Measurements of BP and heart rate were taken before and after the clinical examination, and information of diagnosis given. Furthermore, ambulatory BP and heart rate monitoring was performed during a period of 24 h. The procedures were performed in the same manner in the two groups.

Invitation to the study

The participants received written information about the study and were also told that their participation was on a volunteer basis. The results concerning the BP were not given to the participants until all examinations had been completed. The patients and controls were informed that if any evidence of hypertension was found, they would be given an opportunity to discuss the results with a physician.

History

Questions about symptoms of CMD, such as localization, severity, frequency, and time of onset, were included in a questionnaire modified in accordance with Carlsson et al.

Table 2. Reasons for not participating in the study*

	Patients ($n = 10$)	Controls ($n = 25$)
Not interested in participating	3	13
CMD of muscular diagnosis in need of treatment		6
Generalized joint disease	3	1
Symptomatic osteoarthrosis of TMJ	2	1
Medication for blood pressure	1	1
Frequent and severe headaches (migraine)		1
Pain from the teeth (pulpitis)	1	
Technical problems		2

* CMD = craniomandibular disorder; TMJ = temporomandibular joint.

(16). A visual analogue scale was also used to evaluate the symptoms (17). The participants' general health with regard to migraine, sinusitis, and psychiatric and neurologic diseases was evaluated subjectively. Diseases originating from the joints, muscles, craniocervical region, and stomach were registered, as were hypertension and heart and renal disease. Questions on medication and some general psychosocial questions (16) were included in the questionnaire.

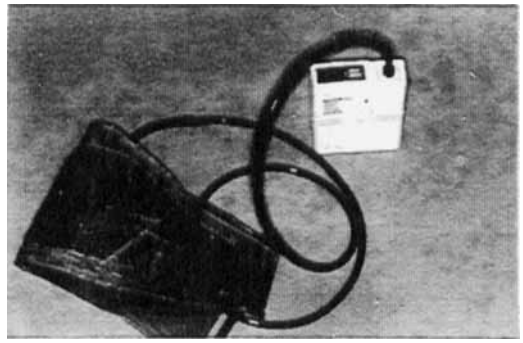

Fig. 1. Equipment for ambulatory blood pressure measurements.

Clinical examination

A standardized clinical examination procedure was performed in both groups in accordance with Krogh-Poulsen (18). The examination included the registration of mandibular movements, deviation, and presence of pain. Tenderness to palpation of the lateral and posterior part of the TMJ and the presence of tenderness in the masticatory muscles were noted. Only muscle and joint tenderness in association with a pain reflex were considered. The method errors in these procedures have been evaluated (19). A stethoscope was used to listen for joint sounds. At this stage the patients were informed of the clinical findings and diagnosis. Diagnoses were established in accordance with the criteria of WHO (20) and McNeill (14). Myofascial pain (ICD no. 729.1) was diagnosed in all the patients, and myositis (ICD 728.81) in three patients.

Office blood pressure and heart rate

The BP and heart rate were measured before and after the clinical examination of the stomatognathic system. The first recording was made after 5 min of rest in a dental chair and calculated as the mean of two measurements. The room temperature was approximately 21°C. The back of the chair was lowered to a supine position, and the participant had her right arm extended and level with the heart. A sphygmomanometer and a stethoscope were used to measure BP. Systolic and diastolic BP were determined to the nearest 5 mmHg. Diastolic BP was measured in accordance with Korotkoff phase V (21). A cuff size corresponding to the circumference of the right arm was chosen (22). Information about this examination was given to the participants in advance. The heart rate was measured by counting the radial pulse during 15 sec and then multiplied by 4. After the clinical examination of the stomatognathic system and information about the diagnosis, the subjects' BP and heart rate were registered once again with the same procedure as in the first recording. All BP and heart rate measurements were taken by one observer (T. de Abreu). Mean office BP and heart rate were calculated from the measurements before and after the clinical examination.

Ambulatory blood pressure and heart rate

The participants received a monitor that recorded their BP and heart rate every 20 min during the daytime and every 60 min during the night. The daytime was defined as from 0600 h to 2300 h, and the nighttime from 2300 h to 0600 h. The cuff was applied around the subject's arm and connected to the monitor (Fig. 1). Some practical information about the ambulatory BP system was also given to the participants. The equipment was normally used on working days only. The subjects were instructed to cease activity and keep their arm still during the ambulatory measurements. For each hour of the 24-h recording the individual mean systolic and distolic BP and heart rate were calcu-

Table 3. Reported symptoms and oral parafunctions

	Patients ($n = 25$)	Controls ($n = 25$)
Symptoms		
Feeling of tiredness in face or jaw	22	2
Pain or tiredness in face, head, or jaw after waking up in the morning	19	3
Headaches (more than once a week)	17	4
Pain in facial region	16	
TMJ* sounds	11	6
Difficulties or pain at opening wide	11	1
Tenderness in the teeth	9	2
Pain in ear region	9	
TMJ locking or luxation	6	2
Difficulties at chewing	6	
Oral parafunctions		
Grinding/clenching teeth or pressing tongue	21	10

* TMJ = temporomandibular joint.

lated. The number of measurements for systolic BP $\geq$ 140 mmHg and for diastolic BP $\geq$ 90 mmHg (peaks) was also estimated.

The ambulatory BP equipment used in this study was the SpaceLabs Inc. model 90207 (Redmond, Wash., USA). This equipment has been validated against both invasive and non-invasive methods with good agreement (23, 24). The data were registered and printed in a computer at the Department of Internal Medicine, University Hospital, Lund.

Statistical analysis

Differences in the variables analyzed, with regard to BP and heart rate values, between the two groups and intra-individual differences in the groups were checked with Student's t test for paired data. Two-tailed tests were performed, and $p < 0.05$ was considered statistically significant. Chi-square analyses were also used for other differences between the groups.

Results

History and clinical examination

The symptoms and oral parafunctions reported by the subjects in the study are presented in Table 3. A feeling of tiredness in the face or jaw (88%) was the commonest symptom found in the patient group. Pain or tiredness in the face, head, or jaw after waking up in the morning (76%) and headaches (more than once a week) (68%) and pain in the facial region (64%) were also very common among the patients. The corresponding figures in the control group were very low throughout. Twenty-one patients (84%) reported parafunctional habits of clenching/grinding teeth or pressing tongue, and four patients were not aware of any parafunctions but reported symptoms in the morning. Fifteen control subjects (60%) did not report any parafunctions, one having occasional moderate symptoms in the morning.

The severity of symptoms registered by 25 patients and 8 control subjects are presented in Fig. 2. The statistical median of the symptoms reported by the patients were moderate in severity and several times a week in frequency. The symptoms evaluated by the visual analogue scale showed a mean of 46 $\pm$ 23 mm in the patient group and a mean of 2 $\pm$ 8 mm in the control group. Five patients reported having the symptoms for less than 6 months, 6 patients for 6 months to 1 year, and 14 patients for more than 1 year. In the control group, eight subjects

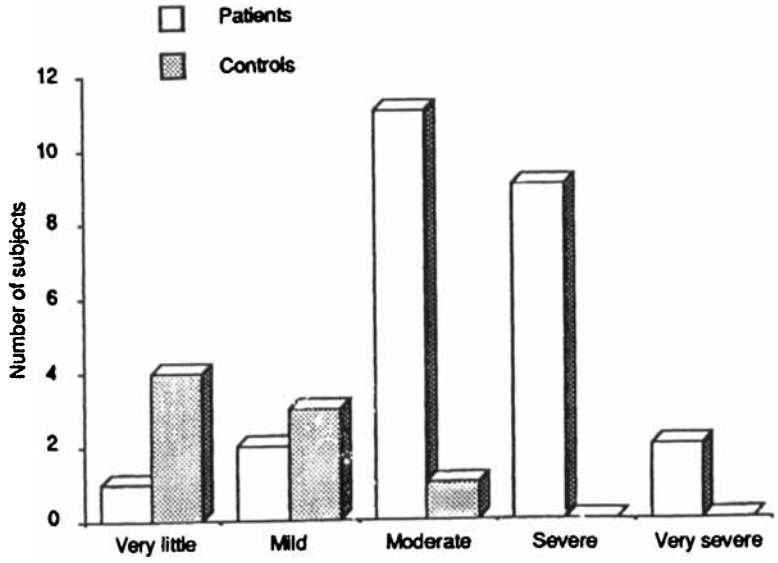

Fig. 2. Severity of the reported symptoms in 25 patients and in 8 controls

reported having minor symptoms for more than 2 years.

With regard to medication, 12 patients and 2 control subjects were using analgesic and/or anti-inflammatory drugs, and 4 patients and 2 controls reported using medication containing estrogen. None of the participants abused alcohol.

The general health status according to a questionnaire in the 2 groups showed 17 patients and 12 controls with neck, shoulder, and/or back pain. With regard to the psychosocial questions, the patients considered themselves as more stressed, nervous, or tense (chi-square = 5.13; $p < 0.05$).

The clinical signs of CMD in accordance with the clinical examination are shown in Table 4. The mean number of tender muscles was 12 in the patient group and 3 in the control group out of a total of 22 examined muscles sites (chi-square = 204; $p < 0.001$). Muscles tender to palpation and TMJ clicking were the commonest signs.

Blood pressure and heart rate

The mean systolic and diastolic BP and heart rate values before (I) and after (II) the clinical examination are shown in Tables 5 and 6, respectively. When the BP I was com-

Table 4. Clinical signs of mandibular dysfunction

	Patients ($n = 25$)	Controls ($n = 25$)
Muscles tender to palpation	25 (12*)	15 (3*)
TMJ† clicking	12	4
Pain on movement	10	
Reduced movement capacity‡	3	1
TMJ crepitus	3	2
Deviation on opening > 2 mm	1	

* Mean number of tender muscles.
† TMJ = temporomandibular joint.
‡ Maximum mouth opening < 40 mm and/or horizontal movements < 5 mm.

Table 5. Systolic (SBP) and diastolic (DBP) blood pressure before (I) and after (II) the clinical examination

	Patients ($n = 25$)	Controls ($n = 25$)	p value
SBP I	110 ± 14	114 ± 14	NS
SBP II	112 ± 15	114 ± 17	NS
p value	NS	NS	
DBP I	65 ± 11	66 ± 11	NS
DBP II	67 ± 10	67 ± 10	NS
p value	NS	NS	

Values are shown as mean ± SD (mmHg); NS = not statistically significant.

Table 6. Heart rate before (I) and after (II) the clinical examination

	Patients ($n = 25$)	Controls ($n = 25$)	p value
Heart rate I	72 ± 8	68 ± 6	$p < 0.05$
Heart rate II	68 ± 6	68 ± 7	NS
p value	$p < 0.05$	NS	

Values are shown as mean ± SD (beats/min); NS = not statistically significant.

pared with the BP II in the two groups, no differences were found. Furthermore, the groups did not differ with regard to systolic or diastolic BP. However, the patients had higher heart rate values than the controls before the clinical examination ($p < 0.05$). The heart rate values in the patient group were higher before than after the clinical examination ($p < 0.05$).

The mean values for office and ambulatory BP and heart rate are shown in Tables 7 and 8, respectively. Comparisons between patients and controls were made for the office and for the ambulatory BP and heart rate measurements. Significant differences ($p < 0.05$) were found for the mean daytime systolic and daytime diastolic BP, with higher values in the control group. No other differences were found for the measurements between these groups.

Table 8. Office and ambulatory heart rate

	Patients ($n = 25$)	Controls ($n = 25$)	p value
Office	70 ± 6	68 ± 6	NS
24 h	77 ± 6	77 ± 9	NS
Day	78 ± 7	79 ± 10	NS
Night	67 ± 7	64 ± 8	NS

Values are shown as mean ± SD (beats/min); NS = not statistically significant.

Lower values ($p < 0.001$) were found when the systolic and diastolic BP and heart rate at the office were compared with the corresponding ambulatory values during the daytime in the two groups (Tables 7 and 8).

The mean number of measurements during the periods of 24 h, daytime, and nighttime were determined and compared between the two groups. The mean number of systolic BP ≥ 140 mmHg during 24 h and the daytime were significantly higher ($p < 0.05$) in the control group than in the patient group. When the systolic BP ≥ 140 mmHg was considered together with the diastolic BP ≥ 90 mmHg, similar differences were found. No differences between the groups

Table 7. Office and ambulatory systolic (SBP) and diastolic (DBP) blood pressure

	Patients ($n = 25$), SBP/DBP	Controls ($n = 25$), SBP/DBP	p value, SBP/DBP
Office	111/66 ± 14/10	114/67 ± 16/10	NS/NS
24 h	117/73 ± 8/7	122/76 ± 8/6	NS/NS
Day	119/75 ± 8/7	124/78 ± 9/6	$p < 0.05/p < 0.05$
Night	107/63 ± 8/6	106/61 ± 8/5	NS/NS

Values are shown as mean ± SD (mmHg); NS = not statistically significant.

were found for the nighttime number of peaks, and no peaks for the diastolic BP were registered in the two groups during this period (Table 9).

Discussion

Blood pressure tends to increase with different patterns in accordance with sex and age (25). It was therefore important to match the patient group with the control group in these respects. Of the subjects invited to participate as controls, eight had minor symptoms of the CMD. These findings are in agreement with other studies, which show that a large percentage of a population has signs and symptoms of the CMD (26).

The body mass index, which can be related to diastolic BP in obese women (27), showed no significant difference between the groups in this study and was considered within normal values, which are around 25 kg/m^2.

The patients included in this study showed frequencies of signs and symptoms similar to those in other patient studies (12, 28), presenting with muscles tender to palpation and TMJ clicking as the commonest signs. The severity of symptoms, as judged by the patients, was in accordance with the level of severity of pain found among CMD patients (12).

Muscular hyperactivity has been presented as an etiologic factor in patients with CMD, but the individuals are not always aware of the oral parafunctions (29). In the present study nearly all the patients reported oral parafunctions, and the four other patients reported symptoms in the morning. The patients presented with a high mean number of tender muscles. Forty-four per cent of the subjects in the control group were assumed to have the habit of clenching/grinding their teeth or pressing their tongue, but very few muscles tender to palpation were found in this group.

Life stressors have been considered factors predisposing to CMD because they are regarded as important to muscular hyperactivity (30). The answers to the general psychosocial questions used in this study showed that stressful life events were found equally in the two groups. However, the CMD patients regarded themselves as

Table 9. No. of measurements and systolic (SBP) and diastolic (DBP) blood pressure peaks

	Patients ($n = 25$)	Controls ($n = 25$)	p value
24 h			
No. of measurements	47.16 ± 7.19	43.36 ± 7.18	NS
SBP ≥ 140 mmHg	2.32 ± 3.34	4.56 ± 6.83	$p < 0.05$
DBP ≥ 90 mmHg	3.60 ± 6.60	5.16 ± 4.57	NS
SBP ≥ 140 mmHg and DBP ≥ 90 mmHg	1.36 ± 2.63	2.20 ± 3.04	$p < 0.05$
Daytime			
No. of measurements	40.12 ± 7.04	39.32 ± 7.32	NS
SBP ≥ 140 mmHg	2.24 ± 3.21	4.52 ± 6.66	$p < 0.05$
DBP ≥ 90 mmHg	3.60 ± 6.60	5.16 ± 4.57	NS
SBP ≥ 140 mmHg and DBP ≥ 90 mmHg	1.36 ± 2.63	2.20 ± 3.04	$p < 0.05$
Nighttime			
No. of measurements	7.04 ± 0.93	7.04 ± 0.79	NS
SBP ≥ 140 mmHg	0.08 ± 0.28	0.04 ± 0.20	NS
DBP ≥ 90 mmHg	0	0	NS
SBP ≥ 140 mmHg and DBP ≥ 90 mmHg	0	0	NS

Values are shown as mean ± SD; NS = not statistically significant.

stressed, nervous, or tense more often (68%) than the controls (36%). This difference could also be supported by the number of patients (44%) and controls (20%) who were smokers, as this behavior may reflect some anxiety.

The evaluation of the BP measurements before and after the clinical examination showed no differences in the two groups. Blood pressure analysis of CMD patients with muscular diagnosis and of healthy controls showed no differences in their BP in the clinical situation. These findings could be explained by the distribution of subjects by age, which shows that 44% of the subjects were younger than 35 years and 72% younger than 50 years, a rather young population. The BP at the ages of 20–40 years is very stable, and increase in BP at these ages is not common (22).

Environmental stress of a psychologic nature has been proposed as one etiologic factor in CMD of muscular origin. The emotional consequences of stress can be studied by recording the BP variability. The ambulatory BP monitoring techniques can therefore be used to study the role of environmental stress (5). The comparisons between the two groups showed a significant difference in daytime systolic and diastolic BP. The results showed higher mean values for controls than for patients, which may indicate that CMD patients with muscular disorders are not more stressed than controls.

The significant difference between office and ambulatory daytime measurements could be expected, considering that peace, rest, and warmth tend to lower the BP. The environment in which the BP is measured is important. This entails a need for standardized procedures for BP recordings. Repeated BP measurements during standardized conditions constitute an important part of the investigation when hypertension is suspected (22). The lower standard deviations during the ambulatory measurements can be explained by the difference in the number of recordings.

The patients' heart rate was significantly higher before the clinical examination than after, when information about the diagnosis had been given. This was not true for the controls, which could mean that patients are more anxious in the clinical setting when they do not know what diagnosis will be presented to them. The pain and fear that may accompany any physical disorder will certainly cause a certain amount of anxiety in the patient. This is particularly true when the pain is of unexplained origin and concentrated to a relatively important area of the body such as the face and oral cavity (31). Tachycardia has also been reported to occur in anxious and nervous persons (22).

The heart rate before the clinical examination was also found to be higher among patients than among controls. However, differences in heart rate values between the groups were not found when the ambulatory measurements were evaluated. Thulin & Werner (32) found higher heart rate in the recumbent position and during exercise in subjects with higher BP level than in normals, but no difference was found outside the clinic on a continuous 24-h electrocardiogram. These findings suggest that the patients might have been hyperreactive when exposed to the psychic stress of being examined at the clinic.

A parallelism has been shown between mean values of arterial BP and heart rate for both normotensives and hypertensives (33). In the present study differences in heart rate were found before the clinical examination in patients and between the groups. The clinical significance of the statistical difference at the level of $p < 0.05$ found in the patient group may be questioned, since this increase in mean heart rate was not large enough to reflect an increase in the mean BP.

Patients with CMD have been found to have a higher anxiety level than control subjects (34), but they were well within the limits of normal values (35). A clear difference in anxiety level has been observed between patients and controls before CMD treatment but not after (36). If anxiety levels return to normal values when a patient is free of symptoms, it is more likely that an anxiety increase is the result of the symptoms. This confirms the notion that CMD patients, who have pain, are more anxious than control

subjects, but whether the anxiety is the cause of the CMD or the result of it is not clear (35). These findings are in agreement with the findings of Marbach et al. (37), who stated that the level of anxiety manifested by idiopathic facial pain (IFP) patients was similar to that of other individuals undergoing treatment. He concluded that the anxiety perceived in the IFP patient is a function of being a patient and not of having the IFP syndrome.

In animal models, prolonged exposure to certain kinds of stress has been directly related to the onset of sustained hypertension (38). It is clear that behavioral stress can lead to a substantial transitory increase in BP and heart rate in man (13). Mancia et al. (39) have shown that a peak pressor response with an immediate rise in systolic and diastolic BP can occur during the first 4 min after an alarm reaction, and by the 10th min most of the increase can have disappeared. He has also shown that a second repeated stress situation did not change the average size of the earlier pressor response. To achieve suppression of the alarm reaction, repeated stress situations may be needed. There was also concomitant tachycardia, which was only slightly correlated to the rise in BP.

In this study, although the recordings did not reflect minute-to-minute changes, the 20-min recording periods could have allowed a good number of variations, which might be regarded as accurate and reliable (40). So, if the CMD patients were more exposed or more reactive to stressful situations, this would have been shown by a higher number of peaks.

It is suggested that psychologic and/or physical stress experienced by an individual leads to an increased activity in the masticatory muscles (41, 42). The reactivity of the CMD patients to stress situations has been demonstrated as muscular hyperactivity, but it was not possible to show an increased BP reactivity due to possible daily life stressors in this group of patients with CMD of muscular origin.

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