Temporomandibular Disorders in Scuba Divers—An Increased Risk During Diving Certification Training

Özmen Öztürk, MD, Mustafa Tek, DDS, PhD,† and Hüseyin Seven, MD**

Abstract: The design of a diving regulator's mouthpiece increases the risk of a temporomandibular disorder (TMD) in scuba divers. The total weight of a diving regulator is reflected directly on the temporomandibular joint, causing articular and periarticular disorders. In the current study, the prevalence of TMD in scuba divers triggered during diving certification training is investigated. We also aimed to determine the factors that lead to TMD during diving training and clarify the observation that there is an increased incidence of TMD in inexperienced divers. The study was held between 2006 and 2011. Ninety-seven divers were referred with the complaint of pain around temporomandibular area. The divers were classified according to their diving experience. Symptoms and signs of TMD were graded. Fourteen divers were diagnosed with TMD. Temporomandibular disorder was seen more frequently in inexperienced divers than in experienced divers ($P = 0.0434$). The most prevalent symptom was an increased effort for mouthpiece gripping. Temporomandibular joint tenderness and trigger point activation were the mostly seen physical signs. Thirteen divers had an improvement with therapy. The increased effort for stabilizing the mouthpiece is a recognized factor in TMD development. Attention must be paid to an association of scuba diving with TMDs, especially in inexperienced divers having a scuba certification training.

Key Words: Temporomandibular joint, temporomandibular disorders, myofascial pain dysfunction syndrome, diving, recreation

(*J Craniofac Surg* 2012;23: 1825–1829)

Diving with "self-contained underwater breathing apparatus" (scuba) is one of the leading recreational sports with an increasing number of performers.[1] In the last decade, scientific investigations in the field of recreational and professional scuba diving focused on improving the technology of diving equipment with the aim of increasing underwater comfort and exercise capacity of divers and maintaining a simultaneous decrease in the health problems associated with the technical insufficiencies.[2] A diving regulator is one of the most essential components of scuba hardware. Despite prominent advancements in the technology of a regulator, the design of a regulator's mouthpiece has a long-standing standard, which is a recognized factor increasing the risk of a temporomandibular disorder (TMD) in divers.[2–4]

A regulator controls the pressure of air supplied to the diver, and a typical regulator consists mainly of 2 stages (air calibrating stations) (Fig. 1). The first stage, stabilized on top of the diving tank, reduces the pressurized air of the diving tank to an intermediate pressure. Compressed air flows from the first stage to the second stage through a flexible low-pressure hose. The second stage of a regulator consists of a demand valve combined with a mouthpiece. After an equalization of air to the ambient hydrostatic pressure, the demand valve of the second stage serves air to the respiratory tract through the airway passage of the mouthpiece. The mouthpiece is gripped between the upper and lower teeth by compression. The vestibular shield of the mouthpiece is dimensioned to extend into the buccal vestibule (Fig. 2). Whereas lips surrounding the vestibular shield of the mouthpiece create an airtight and watertight seal, palatal flange and interdental bite platforms reinforce the stability of the mouthpiece (Fig. 2).

The total weight of a regulator's second stage and the low-pressure hose is reflected directly on the temporomandibular joint (TMJ) and the mandibular musculature with overload and occlusion imbalance.[2–4] The compression force spent by the upper and lower jaws for stabilizing the mouthpiece causes articular and periarticular problems of the TMJs.[2–5] While the conventional design of a mouthpiece is known to play a role in increasing the tendency of damage in TMJs, myofascial pain is a complaint enunciated by many divers.

Although divers attending to an otolaryngologist with the complaint of temporomandibular pain are initially suspected of having otic barotrauma, otitis externa, or barodontalgia, a TMD has to be evaluated as a probable diagnosis. In this study, the prevalence of TMD in divers is investigated during scuba diving certification training. We also aimed to determine the related factors that lead to a TMD triggered during scuba training and clarify the observation that there is an increased incidence of TMD in inexperienced divers.

MATERIALS AND METHODS

A prospective study was conducted to determine the prevalence of TMD in divers during scuba diving certification training. The study was held in a period of 5.5 years (approximately 6 diving seasons), between April 2006 and November 2011.

The divers having a previous diagnosis of TMD, degenerative arthritis, trigeminal neuralgias, dental infections, episodic type headaches, and a history of a previous operation of the TMJ and mandible were excluded from the study. The divers using standard regulators and mouthpieces provided by the technical department of the diving club were included into the study.

From the *Department of Otorhinolaryngology, School of Medicine, Istanbul Medipol University, Istanbul; and †Department of Oral and Maxillofacial Surgery, Faculty of Dentistry, Abant İzzet Baysal University, Bolu, Turkey.

Received August 9, 2012.
Accepted for publication August 25, 2012.

Address correspondence and reprint requests to Özmen Öztürk, MD, Istanbul Medipol Universitesi, Istanbul Medipol Hastanesi, Kulak Burun Bogaz Departmanı, Haydarpasa Harem Yolu, Kosuyolu Kadikoy 34718. Istanbul, Turkey; E-mail: oozturk@medipol.edu.tr

The authors report no conflicts of interest.

ISSN: 1049-2275
DOI: 10.1097/SCS.0b013e3182710577

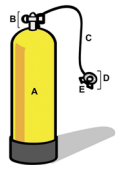

FIGURE 1. Scuba equipment. Diving tank and the regulator are the most important components of SCUBA equipment (A, diving tank; B, first stage of the regulator; C, flexible low-pressure hose; D, second stage of the regulator; E, mouthpiece).

The registered scuba trainees of the Turkish Divers Club (Türk Balıkadamlar Kulübü [TBK]), Istanbul attended the study. The diving club conducted SCUBA certification courses and performed routine trips in the Marmara, Aegean, and Mediterranean seas, and the sample of patients came from the educational activities in the club pool and the diving points of the previously mentioned locations.

In Turkey, diving certification for recreational scuba is issued by Confédération Mondiale des Activités Subaquatiques (CMAS) in association with the Turkish Underwater Sports Federation. The CMAS has a star system for grading the SCUBA divers according to the experience level, that is, CMAS 1 star (CMAS*), CMAS 2 stars (CMAS**), and CMAS 3 stars (CMAS***).

In Turkey, a diving season usually starts in the middle of April and terminates at the end of November, and a total of 9 diving certification courses (6 CMAS*, 2 CMAS**, and 1 CMAS***) are programmed in TBK during this period. Each diving course consists of a 3-week training period irrespective of the level of CMAS certification. In each course period, 12 training dives (4 dives in the pool and 8 dives in the open sea) are completed. In the current study, whereas CMAS* divers were accepted to be in the inexperienced group (group A), divers with CMAS** and CMAS*** certificates were evaluated in the advanced and experienced group (group B).

The divers were referred by the director of the course to the first investigator when a health problem related to diving had been suspected. During the study period of 5.5 years, 482 divers were certified by TBK and had their CMAS*, CMAS**, or CMAS*** certificates. Ninety-seven divers (20.1%) classified according to their CMAS certificate degrees (CMAS* [n = 59] and CMAS** [n = 36], CMAS*** [n = 2]) were referred to the first investigator with the main complaint of pain around the temporomandibular and auricular area.

After a general otolaryngologic history taking, the symptoms related to a TMD (S1: dull or aching pain of the jaw during chewing, biting, yawning, and regulator's mouthpiece gripping [in the course of diving and/or postdive activities]; S2: restricted jaw movements; S3: toothache and sensitivity of teeth without any sign of dental infection; S4: otalgia without a sign of ear infection; S5: headache; S6: clicking, popping, or grating sound during jaw movements; S7: tinnitus; S8: vestibular dysfunction; S9: an increased effort spent for holding the mouthpiece and a feeling of jaw tiredness; S10: loss of sensitivity of the face and lips) were routinely questioned. For the classification of these symptoms, a 10-degree visual analog scale (VAS, graded from 0–9 [eg, "grade 9" represented the most severe complaint level of a symptom]) was used.

During a routine otolaryngologic examination, physical signs (PSs) related to TMD (PS1: a decrease in the range of TMJ movements; PS2: a deviation during the mouth opening; PS3: TMJ tenderness and trigger point activation with palpation of the definite muscle and/or TMJ; PS4: occlusion problems) were evaluated. The severity of PSs were graded (0, no PS detected; 1, mild-intensity PS; 2, moderate-intensity PS; 3, severe-intensity PS).

After a definite diagnosis of TMD, a conservative approach was the initial therapeutic approach. The divers were informed about the factors that lead to TMD and myofascial pain. Soft diet, moist heat application to increase the circulation around the tense jaw muscles, isometric jaw exercises (eg, massage of painful muscles, muscle stretching, gentle isometric tension exercises against resistance), relaxation techniques, correction of body posture in the course of diving and/or postdive activities, providing a proper sleeping position, and elimination of parafunctional habits (eg, clenching or teeth grinding in the course of diving and/or postdive activities, and lip or cheek biting) were advised. Isometric muscle exercises were practiced in the presence of a technician from the dentistry clinic. A muscle relaxant (eg, thiocolchicoside 2 × 4 mg/d orally) and an anti-inflammatory agent (eg, acemetacin 2 × 60 mg/d orally) were routinely used.

During the medical and conservative therapy, scuba divers with TMD were advised to refrain from the diving activities and postpone the training. When recommended by the first investigator and the course director, the trainer suspended the course and continued the training in the following training program. Scuba divers with TMD were strongly advised to use "thermoformable mouthpieces for a customized personal usage." For divers who were not able to incur expenditure for a customizable mouthpiece, self-reconstruction of a standard mouthpiece proper to the jaw structure was advised. The divers were assisted by the first investigator during molding or self-reconstruction procedure of the mouthpieces.

During the consequent dives, the divers were advised to change their behavior of gripping the mouthpiece. The patients were followed up with the conservative approach for a period of 1 month until the start of a consequent scuba-diving course.

The patients with no improvement after a conservative approach were evaluated by magnetic resonance (MR) imaging of TMJs, in both closed- and open-mouth positions, for a possible anterior disk replacement with or without reduction, inflammation in the retrodiskal area, or a subluxation of the joint. The patients were consulted with the oral surgeon from the Department of Oral and Maxillofacial Surgery. After examining the patients and MR imaging, if it was deemed to be necessary by the oral surgeon, stabilization splint was prepared and used for a period of minimum 6 weeks.

All of the data obtained were coded and entered in Prism 5 for Mac OS X Version 5.0d (GraphPad Software, San Diego, CA). Appropriate statistical analysis with a 2-tailed *t* test was performed for data that followed a Gaussian distribution. Fisher exact test was used for the comparison of the prevalence of TMD between the CMAS experience groups. A significance level of $P < 0.05$ was chosen to define statistical significance.

This report was approved by the ethics committee of Istanbul Medipol University, Faculty of Medicine, in 2010 and carried out in accordance with the Declaration of Helsinki. Informed and full consent has been received from the divers for sharing and publishing the data of this study.

An additional approval was also taken from the ethical board of the diving club, TBK, in 2007. The first investigator is a

FIGURE 2. Regulator mouthpiece. Mouthpiece of the second stage is a factor in TMJ disorders (A, vestibular shield; B, interdental bite platform; C, palatal flange; D, connector tube to the demand valve of the second stage; arrows, air passing from the demand valve of the second stage to the respiratory tract of the diver through the airway of the connector tube).

registered diving instructor of TBK and works as a medical consultant in the club's scientific committee.

RESULTS

In the current study, 14 divers were diagnosed with TMD. There were 9 male (64.3%) and 5 female (35.7%) patients, ranging in age from 18 to 44 years (mean, 26.5 years). Fourteen divers were classified according to their experience levels: 12 divers were CMAS* (85.7%), and 2 divers (14.3%) were CMAS**. Temporomandibular disorder was not detected in any CMAS*** diver. Among the referred patients (n = 97), it was found that TMD was seen more frequent in group A (CMAS* divers, n = 12) than in group B (CMAS** and CMAS***divers, n = 2) ($P = 0.0434$).

The most prevalent complaints were "an increased effort spent for holding the mouthpiece during a dive causing a feeling of jaw tiredness (S8)," "dull or aching pain of the jaw during chewing, biting, yawning, and mouthpiece gripping in the course of diving and/or postdive activities (S1), and "restricted jaw movements" (Table 1). The symptoms were scored according to VAS grades (Table 1). When mean VAS scores of symptoms were compared between group A (CMAS* divers) and group B (CMAS** and CMAS***divers), no statistically significant difference was found ($P = 0.3819$). When both groups were counted together, the highest mean VAS score was for "an increased effort spent for holding the mouthpiece during a dive causing a feeling of jaw tiredness (S8)" (Table 1). In association with these complaints, "TMJ tenderness and trigger point activation with palpation of the definite muscle and/or TMJ (PS1)" and "a decrease in the range of TMJ movement (PS1)" were the mostly seen PSs (Table 1).

In the course of therapy, 11 divers (78.6%) had an improvement of symptoms with conservative approach and/or medical treatment. Nine divers (64.3%) of this subgroup postponed their training and had no recurrence of symptoms during the consequent training program. Two divers (14.3%) of this subgroup had to continue on their training, but reported an improvement of symptoms during the course of training. All divers used thermoformable customized mouthpieces, whether the training course was postponed or not, and acted upon the recommendations of the course director and the first investigator.

In the remaining 3 scuba divers (21.4%) (patients 5, 8, and 9 in Table 1), no improvement was detected during the follow-up period with the continuation of conservative treatment approach. Magnetic resonance imaging showed unilateral anterior disk replacement with reduction in all patients of this subgroup (n = 3, 21.4%) (Fig. 3). In these patients, the medical and conservative treatment was supported with a stabilization splint. Using a splint provided an improvement after an average usage period of 4.2 months (range, 3–7 months).

The average duration of follow-up is 14 months (range, 6–28 months; up to 2 diving seasons), with no recurring TMD complaints in 13 patients. Temporomandibular disorder symptoms recurred in 1 patient (patient 5 in Table 1) in the following diving season. Despite complaints of a TMD, the patient continued on diving and was followed up conservatively. This patient's treatment was accepted as ineffective, and the success rate of the current study was determined as 92.85% (n = 13).

DISCUSSION

There are various external factors that place undue strain on TMJ and masticatory muscles. Scuba divers constitute a distinct population with an increased risk of TMD and myofascial pain dysfunction syndrome (MPDS). The use of a diving regulator's mouthpiece leads to microtrauma of the TMJ, chronic hyperactivity of the masticatory muscles, and a structural temporomandibular instability.[2–5] The tension created by a springing low-pressure regulator hose has to be countervailed all through the diving activity. The duration of scuba diving is an additional factor increasing the mandibular masticatory muscle fatigue and overexertion on TMJs.[1] Most dives last at least 30 minutes, and most divers perform at least 2 dives per day.

The divers bite interdental bite platforms of the mouthpiece to stabilize the whole second stage.[2] Upper and lower incisors, canines, and premolar teeth serve as a reinforcement frame during interdental bite platform compression. To accomplish proper positioning of the mouthpiece, the gripping is facilitated by anterior protrusion of the mandible with masticatory muscle strain.[1,2,4] The anatomic and functional characteristics of the masticatory musculature have limitations in carrying the total weight of the second stage of the regulator in this position.[2,3] Anterior disk displacement during mouthpiece gripping causes a lack of posterior support and an uneven loading on TMJ and masticatory muscles.[2] The direction of the joint load and the application point of the biting force move the point of pressure to the retrodiskal structures and the periarticular muscles, which are rich in neurovascular elements (Fig. 4).[1,5] Individual

TABLE 1. Demographics of the Scuba Divers With VAS Scores of Symptoms and Physical Signs

Patient	Sex	Age, y	CMAS	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	PS1	PS2	PS3	PS4
1	F	31	*	6	5	0	2	3	0	0	0	7	0	2	0	2	0
2	M	19	*	5	5	0	2	2	2	0	0	5	0	2	0	1	0
3	M	18	*	8	6	2	3	4	0	0	0	8	1	3	1	3	1
4	M	31	*	4	5	0	1	2	0	0	0	6	0	2	1	2	1
5	F	24	*	7	7	0	0	4	3	0	0	8	2	3	2	3	2
6	M	21	*	6	4	0	1	1	0	0	0	6	0	1	1	1	0
7	M	33	*	5	6	0	2	0	2	0	0	4	1	2	0	1	0
8	F	22	*	8	9	2	4	5	2	0	2	7	1	3	1	2	1
9	M	28	*	7	6	1	2	3	3	0	0	7	0	2	1	2	0
10	M	21	*	5	3	0	2	0	0	0	0	3	0	1	0	1	0
11	M	26	*	6	5	0	0	3	3	0	0	5	1	2	0	2	0
12	F	22	*	6	6	0	1	4	1	0	0	3	0	2	0	2	0
13	F	44	**	5	5	0	1	0	0	0	0	3	0	2	0	2	0
14	M	31	**	6	3	0	0	2	1	0	0	4	0	1	0	2	0

Demographics of the SCUBA divers with a definite TMD, VAS scoring of TMD symptoms (on a scale from 0–9), and TMD physical signs (on a scale from 0–3). See text for definitions of symptom and PS abbreviations.

F indicates female; M, male.

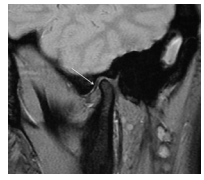

FIGURE 3. Anterior displacement of TMJ disk in a diver. Sagittal oblique T2-weighted gradient-echo MR image (closed-mouth position) shows an anteriorly displaced disk (arrow) in a diver with TMD.

anatomic differences, joint laxity, degenerative joint disorders, joint disk displacement, capsulitis, inflammation of the periarticular muscles, and occlusion problems aggravate TMD with MPDS.[5]

An increased incidence of TMD is observed during the scuba diving certification courses. The unroutine diving activities performed by the trainees during a diving training increase physical and psychological stress. In Turkey, sea temperatures change between 15°C and 24°C during a diving season.[6] Diving in this temperature interval is accepted as "cold-sea diving" by most scuba divers. Physical (eg, cold, factors associated with depth and duration of dive, poor sports conditioning) and psychological stress (eg, lack of diving experience, problems of adaptability to the hydrostatic environment, incompetence in using and manipulating diving equipment, and anxiety of failure in training) causes a significant increase in TMJ parafunctional activity during diving.[3,7] In conditions of stress, as are frequently encountered during a training dive, the tendency is to clench the teeth tightly with an increased physical straining on mandibular masticatory muscles and an uneven loading on TMJs.[7,8] Anxiety and physical straining are routinely seen during a diving training, which are more prominent in inexperienced divers. In the current study, TMD was seen more frequently in CMAS* divers (n = 12) than in CMAS** and CMAS***divers (n = 2). The incidence of TMD is increased in patients with postural abnormalities.[9] Divers routinely maintain the prone position and extend the head during diving. The postural strain during diving may aggravate a TMD.[2,10]

The signs and symptoms of TMD include pain in the TMJs, muscles of mastication, preauricular areas, and ears; TMJ clicking or crepitus; asymmetric and impaired TMJ mobility; headache and facial pain; malocclusion; deviation or limitation in jaw movements; eustachian tube dysfunction, tinnitus, and nausea.[3,10–12] In the current study, "pain of the jaw during chewing, biting, yawning, and mouthpiece gripping (in the course of diving and/or postdive activities)," "an increased effort spent for holding the mouthpiece during a dive with jaw tiredness," and "restricted jaw movements" were the most prevalent symptoms.

Temporomandibular disorders are best evaluated with MR imaging.[13] The articular disk is evaluated in both closed- and open-mouth positions. The presence of a displaced disk is a critical sign of TMD. Rupture of retrodiskal layers and TMJ effusion must also be sought. In the current study, MR imaging was evaluated when a patient had no improvement with a conservative approach. Unilateral anterior disk displacement with reduction was detected in all patients (n = 3) of this subgroup.

The testing of various mouthpieces with electromyographic assessments of the masseter muscle showed different levels of muscle tension.[14] Customized mouthpieces, acting like stabilization splints, are held in the mouth with less muscle activity,[15] and "specially manufactured mouthpieces for divers with TMD" or "thermoformable mouthpieces" provide a significant advantage over conventional club-type mouthpieces.[16]

Researchers explore the factors crucial in the mouthpiece manufacture (eg, assess the effectiveness of the materials and determine the structural specifications) and incorporate them into second stages of diving regulators. It is recommended that a mouthpiece must have an interdental bite platform with a thickness of less than 4 mm and a width less than 8 mm, the thickness should not exceed the interocclusal gap, the bite platform should be positioned further posteriorly between canine and premolar teeth, and the intraoral labial screen should extend in the labial and buccal area in accordance with the sulcus of the mouth and must not extend more than 2 mm behind the biting blocks.[8,15,17] The mouthpiece must be reconstructed from silicone rather than rubber.[15,17] The total weight of the second stage may be reduced by applying special alloys during the manufacture. Full-face masks without a mouthpiece may be used and advised for professional divers with a TMD. Divers are advised to try their mouthpieces before buying.[18]

Conservative approach should initially be tried for the treatment. Different classes of drugs (eg, nonsteroidal anti-inflammatory drugs, steroids, muscle relaxants, and antianxiety agents) may be prescribed.[4,12,19] Heat, exercise therapy including active and passive jaw movements, correction of body posture during diving and postdive activities, and relaxation techniques relieve myofascial pain in TMDs.[9,19] If an outcome with a relief in pain intensity and a decrease in the duration of symptoms are not detected, stabilization splint therapy is advised.[4,19] In the current study, the divers (n = 3) with an anterior disk displacement had splint therapy conducted.

Diagnosing TMD is important from an aspect of subaquatic health. Temporomandibular disorder is assumed to cause eustachian tube dysfunction and labyrinthine dysfunction and an increased risk of otic barotrauma.[10] When the TMJs are overstrained by gripping the mouthpiece for an extended period, venous and lymphatic return from the TMJs and middle ear may be blocked, causing an edema and blockade of the eustachian tube, leading to a possible otic barotrauma.[10]

Temporomandibular disorders and MPDS cause discomfort during underwater activities, impede the performance of the diver during diving training, and may force the diver to abort the diving activity.[3] The resultant painful TMD and MPDS reinforce the emotional alterations of a diver, which may induce unexpected subaquatic risks (eg, a lower threshold for nitrogen narcosis, underwater panic, and decompression sickness). A TMD pain from repeated mouthpiece usage can commonly be mistaken as barodontalgia, eustachian tube dysfunction, and otic barotrauma.[1,2,10]

CONCLUSIONS

The effort for stabilizing the mouthpiece of the second stage of a diving regulator is a recognized factor in TMD development. The training for diving certification causes an increase in the prevalence

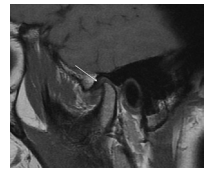

FIGURE 4. A demonstration of the temporomandibular disk of the first investigator with MR imaging during mouthpiece gripping. The anterior disk displacement is seen more often than it is expected. A demonstration was performed by the first investigator, who had no symptoms related to TMD. The mean of the last 100 dives of the first investigator was measured by using UWATEC Smart TRAK 2.0.8.0 software of the diving computer Aladin 2G (both Johnson & Johnson Outdoors, Henggart, Switzerland) and was found to be 41 minutes. According to this diving time, the first investigator gripped a conventional mouthpiece with the second stage of the regulator attached for 41 minutes. After detaching the mouthpiece from the demand valve of the second stage of the regulator, the TMJ of the first investigator was evaluated by MR imaging, with the mouthpiece compressed between the upper and lower teeth. Sagittal oblique T1-weighted MR image shows an anterior disk displacement of mild severity during mouthpiece biting.

of TMD with anxiety intensifying during scuba diving certification training Attention must be paid by otolaryngologists to an association of diving with TMD especially in inexperienced divers. Further research is necessary to investigate an efficient mouthpiece useful in reducing the risk of developing TMD in recreational and professional diving.

ACKNOWLEDGMENTS

The authors thank TBK (Turkish Divers Club) for close cooperation, Ilker Gurbuz (registered diving instructor of TBK) for graphic design of Figures 1 and 2, and Hasan Catalca, PhD, from Istanbul Medipol University, School of Health Sciences, for statistical supervision.

REFERENCES

1. Brandt MT. Oral and maxillofacial aspects of diving medicine. *Mil Med* 2004;169:137–141
2. Hobson RS. Temporomandibular dysfunction syndrome associated with SCUBA diving mouthpieces. *Br J Sports Med* 1991;25:49–51
3. Aldridge RD, Fenlon MR. Prevalence of temporomandibular dysfunction in a group of SCUBA divers. *Br J Sports Med* 2004;38:69–73
4. Koob A, Ohlmann B, Gabbert O, et al. Temporomandibular disorders in association with SCUBA diving. *Clin J Sport Med* 2005;15:359–363.
5. Balestra C, Germonpré P, Marroni A, et al. CUBA diving can induce stress of the temporomandibular joint leading to headache. *Br J Sports Med* 2004;38:102
6. Office of Navigation, Hydrography and Oceanography (ONHO). Physical oceanographic activities. http://www.shodb.gov.tr/osinografi/physical.htm
7. Hurst TL, Tye EA, Byrd C. Snorkel or SCUBA diver's denture. *J Prosthet Dent* 1986;55:597–599
8. Hobson RS. Airway efficiency during the use of SCUBA diving mouthpieces. *Br J Sports Med* 1996;30:145–147
9. Nicolakis P, Erdogmus B, Kopf A, et al. Effectiveness of exercise therapy in patients with myofascial pain dysfunction syndrome. *J Oral Rehabil* 2002;29:362–368
10. Pinto OF. Temporomandibular joint problems in underwater activities. *J Prosthet Dent* 1966;16:772–781
11. Herb K, Cho S, Stiles MA. Temporomandibular joint pain and dysfunction. *Curr Pain Headache Rep* 2006;10:408–414
12. Speck JE. The temporomandibular joint pain dysfunction syndrome. *Can Fam Physician* 1988;34:1369–1374
13. Katzberg RW, Bessette RW, Tallents RH, et al. Normal and abnormal temporomandibular joint: MR imaging with surface coil. *Radiology* 1986;158:183–189
14. Ingervall B, Warfvinge J. Activity of orofacial musculature during use of mouthpiece for diving. *J Oral Rehabil* 1978;5:269–277
15. Mack PJ, Hobson RS, Askell J. Dental factors in SCUBA mouthpiece design. *Br Dent J* 1985;158:141–142
16. Matsui R, Ueno T, Ohyama T. Fabrication of a custom diving mouthpiece using a thermoforming material. *J Prosthet Dent* 2004;92:392–394
17. Goldstein GR, Katz W. Divers' mouth syndrome. *N Y State Dent* 1982;10:523–525
18. Hobson RS, Newton JP. Dental evaluation of SCUBA diving mouthpieces using a subject assessment index and radiological analysis of jaw position. *Br J Sports Med* 2001;35:84–88
19. Clark GT, Seligman DA, Solberg WK, et al. Guidelines for the treatment of temporomandibular disorders. *J Craniomandibular Disord* 1990;4:80–88

