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Original Article

Efficacy of dental health education and a novel mouthwash on periodontal health of navy personnel on a long ocean-going training mission

Guodong Wang[1*], Wei Li[1*], Yuan Liu[1], Xiaoqing Chen[1], Jiantao Huang[1], Yunfu Zhao[1], Yang Wu[1], Dalin Wang[2]

[1]Department of Stomatology, Changzheng Hospital, The Second Military Medical University, Shanghai 200003, China; [2]Department of Stomatology, Changhai Hospital, The Second Military Medical University, Shanghai 200003, China. [*]Equal contributors and co-first authors.

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Abstract: Purpose: The periodontal health status remains unknown among seafaring navy. We examined the periodontal health of 154 navy personnel and the effect of dental health education or dental health education plus a novel mouthwash on periodontal health. Trial design: Navy servicemen on a 201-day ocean-going mission were prospectively recruited and randomized to receive no intervention (group I, n=49), pre-seafaring education booklet and seminars (group II) (n=51), or dental health education plus mouth rinse twice per day (group III) (n=54). The debris index-simplified (DI-S), the calculus index-simplified (CI-S), and the sulcus bleeding index (SBI) were evaluated before and after the mission. Results: Compared with the baseline, the post-voyage DI-S score showed a median 22.5% increase (Q1, Q3: 0.00, 50.00%, P<0.001) in group I and a median 22.5% increase (Q1, Q3: -20.00, 66.67%; P=0.0265) in group II while no marked change was observed in group III (Q1, Q3: -16.67, 50% P=0.1233). The post-voyage CI-S score showed a median 36.67% increase (Q1, Q3: 11.11, 83.33%; P<0.0001) in group I and a median 33.33% increase (Q1, Q3: 0.00, 83.33%; P<0.0001) in group II, but no apparent change in group III (Q1, Q3: -25.00, 33.33%; P=0.3001). The post-voyage SBI scores showed a median 82.86% increase (Q1, Q3: 22.22, 200.00%; P<0.0001) in group I and a median 36.67% increase (Q1, Q3: -10.10, 150.00%; P<0.0001) in group II. By contrast, group III exhibited a median 58.33% reduction in post-voyage SBI scores (Q1, Q3: -83.33, -25.00; P<0.0001). Conclusion: Long seafaring mission adversely impacts the periodontal health of sailors and pre-voyage dental health education and the use of mouthwash during seafaring prevents decline in periodontal health in seafarers.

Keywords: Navy, sea mission, periodontal health, dental health education, debris index-simplified (DI-S), the calculus index-simplified (CI-S), sulcus bleeding index (SBI)

Introduction

Dental health of seafarers has become an important health issue with increasing popularity of sea cruises, sea commerce and navy activities [1]. Overall good dental health helps the combat readiness of the navy [2]. A retrospective analysis of 1,107 navy personnel showed that more than three quarters of the personnel exhibited gingivitis of varying severity [3]. A survey of 2711 US Army, Air Force, Navy, and Marine Corps recruits showed that more than half of US military recruits (61%) perceived a need for dental care, which was influenced by calculus, bleeding gums, level of decay [4]. The same study also found that education was a significant predictor of dental utilization prior to entering military service with the better educated recruits more likely seeking dental care. Periodontal diseases are also common in Chinese navy personnel [1] and this situation has not shown any apparent improvement over the recent years [2-4], compromising navy combat readiness. However, neither the prevalence of periodontal disease nor the periodontal health status among Chinese navy personnel has been well studied.

In this prospective randomized controlled study, we examined the periodontal health of 154 navy personnel before and after an ocean-going training mission for duration of 201 days

and further investigated the efficacy of dental health education or dental health education plus a novel mouthwash on the periodontal health of the navy personnel.

Subjects and methods

Subjects

In this prospective randomized control study carried out between July, 2012 and January 2013, soldiers on two destroyers of the Chinese PLA Navy on an ocean-going training mission for duration of 201 days were recruited for the study. A subject was included if the subject was in general good physical health and was competent to comprehend the study booklet. The study protocol was approved by the institutional review boards at the authors' affiliated institutions and written informed consent was provided by all study participants.

Study interventions

The subjects were randomized by the study investigators using a random table at an allocation ratio of 1:1:1 to the control group (n=49), the dental health education group (n=51), and the dental health education and intervention group (n=54). Dental health education was provided through dental health education booklet and seminars. The booklet and seminars provided information on proper method for brushing teeth, choice of toothpastes and the use of dental floss and common symptoms and signs of oral diseases. Subjects in the dental health education group and the dental health education and intervention group received dental health education; subjects in the latter group also rinsed their mouth with 10 mL mouthwash for 5 min twice per day. The main components of the mouthwash were lysostaphin, lysozymes, and chlorhexidine acetate.

Periodontal examination

Periodontal evaluation was performed the week before and after the ocean going mission. The dentists were blinded to the grouping of the study subjects. The index teeth were evaluated for the presence of debris, calculus, and gingival bleeding. The debris index-simplified (DI-S) was calculated by the formula:

DI-S = [(The total of the upper and lower buccal scores) + (The total of the upper and lower lingual scores)]/(The number of segments scored).

The calculus index-simplified (CI-S) was calculated using the formula:

CI-S = [(The total of the upper and lower buccal scores) + (The total of the upper and lower lingual scores)]/(The number of segments scored).

The sulcus bleeding index (SBI) was calculated using the formula:

CI-S = [(The total of the upper and lower buccal scores) + (The total of the upper and lower lingual scores)]/(The number of segments scored) [5].

The subjects were examined under artificial lighting using CPI probe as described previously [5]. Totally 28 teeth in the mouth were divided into six sections and six index teeth (No.16, 11, 26, 36, 31, and 46) were evaluated. In the absence of the first molar, the second molar was evaluated. The CPI probe was kept parallel to the long axis of the tooth, which was probed with a force <20 g disto-proximally from the lingual or buccal surface along the gingival margin. A total of six sites were probed and the site probed with the greatest force was scored. The evaluation was performed by 4 dentists with more than 10 years of dental experience and the dentists underwent Kappa concordance test with a good inter-rater agreement (Kappa >0.8).

Statistical analysis

Data were entered into the database by specifically designated staff. Normally distributed data was expressed in mean ± SD and analyzed using SAS 9.2 (SAS Institute, Cary, NC). Non-normally distrusted data were expressed as median (Q1, Q3). Categorical data were expressed using numbers and percentages. Differences in age among the three groups were analyzed by a one-way ANOVA. Data on place of residence was analyzed by Chi-square test and data on education received by Cochran-Mantel-Haenszel test followed by Fisher's least significant difference (LSD) test to determine Comparison of pre-seafaring and post-seafaring data within groups was made using Wilcoxon signed rank test and among the three groups using Kruskal-Wallis H test. $P<0.05$ was

Table 1. Demographic and baseline data of the study participants

Variables	Control (n=49)	Dental health education (n=51)	Dental health education plus mouthwash (n=54)	P
Male gender, n (%)	49 (100)	51 (100)	54 (100)	
Age				
Mean (SD)	25.63 (4.72)	26.67 (4.86)	26.61 (4.98)	0.4895
Range				
Residency before enlisting in the navy, n (%)				0.1676
Urban	20 (40.82)	12 (23.53)	16 (29.63)	
Rural	29 (59.18)	39 (76.47)	38 (70.37)	
Education status, n (%)				0.4006
College and above	9 (18.37)	5 (9.80)	12 (22.22)	
Polytechnic school	6 (12.24)	16 (31.37)	12 (22.22)	
High school/technical school	31 (63.27)	27 (52.94)	28 (51.85)	
Middle school	3 (6.12)	3 (5.88)	2 (3.70)	

considered to be statistically significant and if P≤0.05, Nemenyi test was used.

Results

Demographic and baseline data of the study subjects

A total of 154 male subjects were recruited from the two destroyers for the study. All subjects completed the study and were included in the data analysis. Their mean age was 26.3 years (range, 18-40 years). All study participants were of the male gender. The three groups were comparable in demographic and baseline characteristics (P>0.05 in all) (**Table 1**). No important harms or unintended side effects were observed during the study.

Debris index-simplified (DI-S) scores before and after the sea voyage

The mean baseline DI-S score was significantly higher in the control group than that of subjects receiving dental health education only (3.88±1.78 *vs*. 3.65±1.76; P<0.05) or those receiving dental health education plus mouthwash (3.88±1.78 *vs*. 3.17±1.75; P<0.05) (**Table 2**). The post voyage DI-S score was significantly increased in the control subjects (5.10±1.42; P<0.0001) with a median 22.5% increase (Q1, Q3: 0.00, 50.00%). A significant increase in the post voyage DI-S score was also observed in subjects receiving dental health education only (4.16±1.79; P=0.0265) with a median 22.5% increase (Q1, Q3: -20.00, 66.67%). By contrast, no marked change in the post voyage DI-S score was found in the subjects receiving dental health education plus mouthwash (3.59± 1.63; P=0.1233) with a median 0% increase (Q1, Q3: -16.67, 50%). These findings demonstrate that dental health education plus mouthwash attenuates the worsening of DI-S scores in seafaring subjects.

Calculus index-simplified (CI-S) scores before and after the sea voyage

The median baseline CI-S score was significantly higher in the control group than that of subjects receiving dental health education only (5.43±3.38 *vs*. 4.55±3.74; P=0.0361) or those receiving dental health education plus mouthwash (5.43±3.38 *vs*. 3.83±2.89; P=0.0361) (**Table 3**). The post voyage CI-S score was significantly increased in the control subjects (8.24±3.39; P<0.0001) with a median 36.67% increase (Q1, Q3: 11.11, 83.33%) and in the subjects receiving dental health education only (6.53±3.76; P<0.0001) with a median 33.33% increase (Q1, Q3: 0.00, 83.33). On the other hand, there was no apparent change in the post voyage CI-S scores of subjects receiving dental health education plus mouthwash (3.89±2.39; P=0.3001) with a 0.00% increase (Q1, Q3: -25.00, 33.33%). Furthermore, there was a statistically significant difference in the mean changes of CI-S scores before and after sea voyage between the dental health education plus mouthwash group and the dental health education group (Nemenyi test, P=

Table 2. Debris index-simplified (DI-S) scores before and after the sea voyage

Variables	Control (n=49)	Dental health education (n=51)	Dental health education plus mouthwash (n=54)
Debris index-simplified (DI-S)			
Before voyage			
Mean (SD)	3.88 (1.78)	3.65 (1.76)	3.17 (1.75)
Range			
Median	4.00	4.00	3.00
Q1, Q3	3.00, 5.00	2.00, 5.00	2.00, 4.00
After voyage			
Mean (SD)	5.10 (1.42)	4.16 (1.79)	3.59 (1.63)
Range			
Median	5.00	4.00	4.00
Q1, Q3	4.00, 6.00	3.00, 5.00	2.00, 5.00
Difference between before and after voyage			
Mean (SD)	1.22 (1.52)	0.51 (2.09)	0.43 (1.87)
Range			
Median	1.00	1.00	0.50
Q1, Q3	0.00, 2.00	-1.00, 2.00	-1.00, 1.00
Percentage change in DI-S (%)			
Mean (SD)	57.61 (112.88)	33.39 (80.95)	47.48 (125.79)
Range			
Median	22.50	22.50	0.00
Q1, Q3	0.00, 50.00	-20.00, 66.67	-16.67, 50.00
Intragroup *P* value	<0.0001	0.0265	0.1233

0.0007) and between the dental health education plus mouthwash group and the control group (Nemenyi test, P<0.0001). However, no statistically significant difference was found between the dental health education group and the control group (Nemenyi test, P= 0.3902). The findings indicate that dental health education plus mouthwash significantly prevents increase of CI-S scores in seafaring subjects.

Sulcus bleeding index (SBI) scores before and after the sea voyage

We further examined gingival bleeding in the study subjects. We found no statistical difference in the baseline SBI scores among the three groups (P>0.05) (**Table 4**). We observed a significant increase in the post voyage SBI scores in the control subjects (9.29±3.62; P<0.0001) with a median 82.86% increase (Q1, Q3: 22.22, 200.00%) and in subjects receiving dental health education only (5.84±4.50; P<0.0001) with a median 36.67% increase (Q1, Q3: -10.10, 150.00%; P<0.0001). By contrast, subjects receiving dental health education plus mouthwash experienced a significant reduction in the post voyage SBI scores (1.91±1.92; P<0.0001) with a median 58.33% reduction (Q1, Q3: -83.33, -25.00; P<0.0001). There was a statistically significant difference in the mean changes of CI-S scores before and after sea voyage between the dental health education plus mouthwash group and the dental health education group (Nemenyi test, P<0.0001) and between the dental health education plus mouthwash group and the control group (Nemenyi test, P<0.0001). A statistically significant difference was also found between the dental health education group and the control group (Nemenyi test, P=0.040). The findings suggest that health education plus mouthwash significantly decreases gingival bleeding in seafaring subjects.

Moreover, we calculated the number of teeth with gingival bleeding before and after sea voyage. No statistical difference was noted in the number of teeth with gingival bleeding among the three groups before the sea voyage (P=0.0794) (**Table 5**). The number of teeth with gingival bleeding was noticeably increased in

Table 3. Calculus index-simplified (CI-S) scores before and after the sea voyage

Variables	Control (n=49)	Dental health education (n=51)	Dental health education plus mouthwash (n=54)
Calculus index-simplified (CI-S)			
Before voyage			
Mean (SD)	5.43 (3.38)	4.55 (3.74)	3.83 (2.89)
Range			
Median	5.00	4.00	3.00
Q1, Q3	3.00, 7.00	2.00, 6.00	2.00, 6.00
After voyage			
Mean (SD)	8.24 (3.39)	6.53 (3.76)	3.89 (2.39)
Range			
Median	9.00	6.00	4.00
Q1, Q3	7.00, 10.00	3.00, 9.00	2.00, 5.00
Difference between before and after voyage			
Mean (SD)	2.82 (2.54)	1.98 (2.38)	0.06 (2.47)
Range			
Median	2.00	2.00	0.00
Q1, Q3	1.00, 4.00	0.00, 4.00	-1.00, 1.00
Percentage change in CI-S (%)			
Mean (SD)	88.37 (143.87)	76.42 (122.53)	13.51 (67.60)
Range			
Median	36.67	33.33	0.00
Q1, Q3	11.11, 83.33	0.00, 83.33	-25.00, 33.33
Intragroup *P* value	<0.0001	<0.0001	0.3001

the control group (P<0.0001) and the dental health education group (P=0.0294) post the sea voyage while it markedly decreased in the dental health education plus mouthwash group (P=0.0188). There was a significant difference in the mean difference between before and after the voyage between the control group and the dental health education group (Nemenyi test: P=0.0043) and the dental health education plus mouthwash group (Nemenyi test: <0.0001) and between the dental health education group and the dental health education plus mouthwash group (Nemenyi test: P= 0.0271). These findings indicate that gingival bleeding worsened in the control subjects and dental health education helped alleviated the worsening of gingival bleeding while dental health education plus mouthwash group improved gingival bleeding in the seafarers.

Discussion

The prevalence of periodontal disease and the periodontal health status among Chinese navy personnel has been not been fully addressed. In this prospective randomized controlled study, we demonstrated that the control subjects or subjects who received dental health education only had significantly increased post voyage DI-S, CI-S and SB-I scores and a higher number of teeth with gingival bleeding compared with the baseline data, indicating that the seafaring mission had a significantly adverse impact on the periodontal health status of the seafarers. Periodontal diseases are also common in Chinese navy personnel [1] and may compromise navy combat readiness. Seafarers on long seafaring missions are faced with food supplies that lack varieties, which may be further constrained by insufficient consumption of fruits and vegetables at the late stage of the mission, leading to inadequate uptake of vitamins and micronutrients. Seafarers are also faced with constrained living space and a monotonous lifestyle over an extended period of time, which may lead to psychopathological disturbances in these sailors [5]. These psychopathological changes in turn may adversely affect the periodontal health status of the sailors.

Table 4. Sulcus bleeding index (SBI) scores before and after the sea voyage

Variables	Control (n=49)	Dental health education (n=51)	Dental health education plus mouthwash (n=54)
Sulcus bleeding index (SBI)			
Before voyage			
Mean (SD)	5.08 (4.38)	3.82 (3.71)	4.00 (4.08)
Range			
Median	4.00	3.00	2.50
Q1, Q3	1.00, 8.00	1.00, 6.00	1.00, 6.00
After voyage			
Mean (SD)	9.29 (3.62)	5.84 (4.50)	1.91 (1.92)
Range			
Median	9.00	6.00	1.50
Q1, Q3	7.00, 12.00	2.00, 10.00	0.00, 3.00
Difference between before and after voyage			
Mean (SD)	4.20 (2.71)	2.02 (3.94)	-2.09 (3.72)
Range			
Median	4.00	2.00	-1.00
Q1, Q3	2.00, 6.00	0.00, 4.00	-4.00, 0.00
Percentage change in SBI (%)			
Mean (SD)	161.40 (213.60)	106.54 (215.83)	-31.29 (115.06)
Range			
Median	82.86	36.67	-58.33
Q1, Q3	22.22, 200.00	-10.10, 150.00	-83.33, -25.00
Intragroup *P* value	<0.0001	0.0001	<0.0001

Dental health education has been shown to improve periodontal health status. D'Cruz and, Aradhya showed that an dental health education program significantly lowered mean plaque index and gingival index scores among 13 to 15 years old school children over a 9-month period [6]. Our data showed that subjects who received dental health education only had comparable post voyage DI-S and CI-S scores to the control subjects but a marked reduction in post voyage SBI scores versus the controls. These findings indicate that long seafaring mission adversely impacted on the periodontal health status of the sailors and dental health education alone failed to attenuated the worsening of periodontal health status except gingival bleeding, suggesting the inadequacy of relying on dental health education alone for improving periodontal health of seafarers on long seagoing missions. This may be due to the fact that dental health education was only given once before the seafaring mission. Shenoy and Sequeira showed that dental health education at more regular intervals improved periodontal health than dental health education at less regular intervals [7]. DI-S and CI-S scores reflect oral hygiene and higher DI-S and CI-S scores may predispose the sailors to the development of periodontal diseases. On the other hand, gingival bleeding is a manifestation of periodontitis and dental health education significantly alleviated gingival bleeding. We demonstrated here that dental health education alone may alleviate the worsening of gingival bleeding in the seafarers while the additional of mouth wash not only alleviated but significantly improved gingival bleeding in the seafarers. Therefore, for improvement of the overall periodontal health of the sailors, more regular dental health education during the seafaring mission and the use of effective mouth wash may be recommended.

The mouthwash used in the current study contained lysostaphin, lysozymes, and chlorhexidine acetate. Lysostaphin and lysozymes can rapidly destroy peptidoglycans on the bacterial wall and have potent bactericidal effects. An

Table 5. Number of teeth with gingival bleeding before and after sea voyage

Variables	Control (n=49)	Dental health education (n=51)	Dental health education plus mouthwash (n=54)
Before voyage			
Mean (SD)	3.16 (2.11)	2.55 (2.01)	2.28 (1.91)
Range			
Median	3.00	2.00	2.00
Q1, Q3	1.00, 5.00	1.00, 4.00	1.00, 4.00
After voyage			
Mean (SD)	4.88 (1.09)	3.18 (2.11)	1.74 (1.67)
Range			
Median	5.00	3.00	1.50
Q1, Q3	4.00, 6.00	1.00, 5.00	0.00, 3.00
Difference between before and after voyage			
Mean (SD)	1.71 (1.74)	0.63 (1.95)	-0.54 (1.65)
Range			
Median	1.00	0.00	0.00
Q1, Q3	0.00, 3.00	0.0, 2.00	-2.00, 0.00
Intragroup *P* value	<0.0001	0.0294	0.0188

earlier study showed that a mouthwash containing lysozymes failed to significantly inhibit plaque regrowth [8] while no mouthwash containing lysostaphin has been reported. The current study demonstrated that subjects who received dental health education plus mouthwash in the seafaring mission had significantly lower post voyage DI-S, CI-S, and SBI scores compared with the control subjects or subjects who received dental health education only. In addition, subjects who received dental health education plus mouthwash also had a noticeably lower number of teeth with gingival bleeding post voyage compared with the rest of the subjects. Subjects who received dental health education plus mouthwash had comparable DI-S and CI-S scores to the pre-voyage scores, indicating that the lysostaphin mouthwash inhibited the formation of calculus and the buildup debris. More importantly, a noticeable reduction in gingival bleeding was seen in the subjects who received dental health education plus mouthwash with a median 58.33% reduction in post voyage SBI scores. The number of teeth with gingival bleeding was also markedly reduced post voyage. These findings indicated that the lysostaphin mouthwash was effective in reducing gingival bleeding. Chisick *et al.* found that calculus, bleeding gums, level of decay impacted on the need for dental care by military recruits [9]. Our findings demonstrated that dental health education plus mouthwash significantly protected periodontal health status of the sailors on long seafaring missions.

The study has certain limitations. The study only included only male subjects and the results may be biased by gender. Furthermore, the subjects were navy servicemen who are generally in good health compared to the general population. Therefore, the study results may not be applicable to the population at large.

In conclusion, long seafaring mission adversely impacts on the periodontal health of sailors and pre-voyage dental health education and the use of mouthwash during seafaring prevent decline in periodontal health in seafarers.

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Disclosure of conflict of interest

None.

Address correspondence to: Dr. Yang Wu, Department of Stomatology, Changzheng Hospital, The Second Military Medical University, 415 Fengyang Road, Shanghai 200003, China. Tel: 86-21-81885944; E-mail: wuyang1980339@163.com; Dr. Dalin Wang, Department of Stomatology, Changhai Hospital, The Second Military Medical University, Shanghai 200003, China. Tel: 86-21-81873221; E-mail: wang_dento@163.com

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