Article

Differences in Oral Health Status in Elite Athletes According to Sport Modalities

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Abstract: Oral health status may affect physical and sports performance. The purpose of this study was to assess the oral health status and oral health habits of elite athletes according to the performed sports type. A sample of 186 elite athletes divided into individual sports ($n = 74$; 53 men and 21 women; 24.9 ± 9.3 years) and team sports ($n = 112$; 97 men and 15 women; 24.5 ± 4.8 years) participated in the study. The decayed, missing, and filled teeth index (DMFT), the oral health impact profile (OHIP), and the diet assessment of caries risk (DACR) were evaluated to assess their oral health status. Athletes in individual modalities had a lower number in total teeth, healthy teeth, and restoration index ($p < 0.05$). Furthermore, this group showed a greater number of missing ($p < 0.001$) and decayed teeth ($p < 0.05$) and a greater DMFT index ($p < 0.001$). A relationship between sports modality and prevalence of malocclusions ($p < 0.01$), periodontal plaque ($p < 0.05$), and the habit of consuming energy drinks ($p < 0.05$) was also highlighted. Elite athletes who compete in individual sports presented a worse oral situation.

Keywords: sports dentistry; athletes; sports discipline; oral health

1. Introduction

Success in sport depends on multiple factors that combine to achieve optimal performance. Neglecting any aspect involved in the training processes could lead to sports failure [1]. Maintaining proper oral hygiene is considered an important variable in maintaining a general health status [2,3].

Recent studies have highlighted the growing interest that dental health is currently achieving in sports, especially when dealing with professional and elite sports [4–6]: usually, athletes tend to have many oral problems like frequent intake of carbohydrates and acidic sports drinks, dry mouth, and little knowledge about oral health are some of the reasons that explain the high prevalence of oral diseases in this group [7].

Dental health may play a relevant role in sports performance, so adequate prevention could allow athletes to maintain their training and competition routines, without suffering interference in their sports planning due to the occurrence of some dental discomforts [1,7]. For this reason, the improvement of dental status assessments should be highly recommended in the medical follow-up of athletes [8].

Research conducted at top-level international competitions highlights the importance that oral health monitoring is gaining in elite sport. During the Olympic Games, the care and maintenance of oral health has become increasingly important: in Athens 2004, dental care was the second most demanded health service [9], while during the Olympic Games of Beijing 2008, close to 1600 dental treatments were carried out [10]. Additionally, during the London 2012 Olympic Games, 30% of all medical emergencies presented by athletes were induced by oral diseases [11,12].

Interest in oral health in sport has increased, due to the significant prevalence of oral disorders among athletes, acquiring a more preventive approach [13,14]. As a consequence, oral examinations and oral health status are taken into account in athletes eligible to participate in the Olympic Games, with the purpose of creating dental awareness and avoiding possible problems during competition [6].

In the field of professional sports, the evaluation of oral health has increased due to its relationship with athletes' general physical condition: both caries and periodontal disease can be infectious foci and may degenerate into heart problems due to the huge number of bacteria that are located at the gingival level and can access the bloodstream, affecting other body regions [15,16].

Many joint and muscle injuries are the consequence of dental foci and/or periapical infections: if this happens, athletes may suffer asthenia expressed as muscle fatigue, joint inflammation, joint pain, or tendon injuries with late recovery [17,18].

On the other hand, the absence of teeth due to trauma and/or diseases entail other consequences, such as digestive disorders with a higher energy expenditure and slower digestion, being a disadvantage in sports competition [19]. Craniomandibular disorders are also frequent among elite athletes due to the habit of bruxism usually induced by stress during competition or training: bruxism not only affect the temporomandibular joint (TMJ) or teeth (wear), but may also cause head, neck, and back muscle pain [20].

In an experiment with highly proficient marksmen, performance was found to be significantly better when the mandible was in symmetric centric relation, as compared with intercuspal or lateral occlusion, an effect primarily attributed to postural stabilization [21]. In this context, recent studies investigated the performance of golf professionals while using stabilizing splints: Kwon et al. (2010) and Pae et al. (2013) observed significant improvements in driving distance and club head speed when the oral appliances were being used [22,23]. Professional soccer and volleyball teams reported significant oral health problems associated with reduced performance [24–26]. Moreover, previous studies reported differences in oral status between athletes and the control group [24,27,28].

However, to our knowledge, there are no studies that have analyzed differences in oral health between team and individual sports. It may be speculated that a more institutionalized attention to dental status is paid by the medical service of sport teams in comparison with athletes who train individually: sometimes the athlete voluntarily decides to visit or to not visit the dentist, but this is often overlooked, due to many factors such as fear, lack of time, training schedules, etc. The features of the different sports modalities could also influence the athlete's oral status. In this sense, long-term endurance sports duration may present the highest risk, since they require large carbohydrate intake due to the extraordinary degree of glycogen breakdown during exercise. This intake, which is done throughout the day and during exercise in the form of gels, bars, or energy drinks may significantly increase the risk of tooth decay and erosion [29]. In this respect, the objective of this study was to evaluate the state of oral health and oral health habits in elite athletes according to the type of sport practiced, evaluating different individual and team sports.

2. Materials and Methods

2.1. Subjects

A total of 186 athletes participated in this study (mean age 24.74 ± 6.96). The athletes were divided into two groups according to the practiced sports type, individual (fencing, tennis, table tennis, athletics, rowing, canoeing, cycling, cross-country skiing, alpine skiing, judo, triathlon, karate, trail running, paddle, badminton, orienteering, bicycle motocross, swimming, rhythmic gymnastics, climbing, and taekwondo) or team (volleyball, basketball, ice hockey, handball, soccer, and water polo). Among the participants, 74 athletes (53 men and 21 women) competed in individual sports while 112 athletes (97 men and 15 women) in team sports. This study was carried out on a population of 271 elite athletes from the community of Aragon (Spain). The sample represents a confidence level = 95% with

a margin of error = 6%. All the athletes participated voluntarily in the research were informed about the aim of the study and gave their written informed consent. A code was assigned to each participant for the collection and treatment of the data in order to maintain their anonymity. This research was carried out according to the Helsinki Declaration ethic guidelines updated at the World Medical Assembly in Fortaleza (Brazil) in 2013. The Clinical Research Ethics Committee of the Department of Health and Consumption of the Government of Aragon (Spain) approved the research project (code: 11/2015). The population sampling consisted of consecutive cases and it was defined according to the criteria established by the World Health Organisation (WHO) [30]: sampling was carried out with the purpose of providing information about two population groups, individual and team sport athletes. Athletes belonged to the capital city and many urban centers, small towns, and rural areas with the purpose of being representative of the geographical area in which the study was carried out (Aragón, Spain). The inclusion criteria to participate in the study were the following: (a) age between 18- and 35-years old, (b) to be recognized as an elite athlete, (c) to participate in national and/or international sports competitions, (d) to have given written informed consent, (e) to carry out a weekly training of at least 5 h, and (f) to present good general health. The following were considered as exclusion criteria: (a) pregnancy, (b) breastfeeding, (c) not having done training during the last 31 days, and (d) not having participated in any of the phases of the study.

2.2. Procedures

Oral examinations were carried out by a single examiner who previously received instructions for performing oral examinations and completion of the registration forms. Training and calibration days were carried out with the supervision of a dentist with more than 10 years of professional experience. During the training protocol the examiner observed twice a group of 10 subjects, allowing an interval of at least 30 min between exams to maintain consistency. When comparing the results of the two tests, the examiner was able to estimate the extent and nature of the variability of diagnosis. Intraexaminer concordance was assessed. Simple agreement percentage was used in the analysis (coincident diagnoses/total diagnoses × 100), observing an acceptable consistency with less than 3% error. An oral health assessment was performed through a dental examination using the WHO standardized protocol for adults (Version 2013) [31]. All the athletes were evaluated in the same examination area, which respected the requirements of the WHO protocol (i.e., supply, furniture, lighting, etc.) [31].

The oral health status was evaluated using the decayed, missing, and filled teeth index (DMFT) to evaluate the presence of caries, absent, and/or filled teeth and the restoration index (IR) obtained by dividing the number of filled teeth by the DMFT index × 100 [32]. The prevalence of malocclusions was also determined following the angle guidelines [33] due to the potential influence of dental occlusion disturbance on postural stability and competitive athlete performance, as already reported in the context of gun shooting, golfing, and running [24,25,34,35]. In order to assess the impact that oral needs have on athletes, the oral health impact profile (OHIP) questionnaire was used in its abbreviated and Spanish version (OHIP-14sp) [36]. Fluorosis was recorded according to the Dean's index criteria. Enamel defects were assessed using the modified developmental defects of the enamel index (DDE). Dental erosion was classified according to its severity and the modified CPI index was used for evaluating athletes' periodontal status [30]. It was inquired about certain habits such as teeth clenching (bruxism), oral respiration, extractions due to any other reason, tooth fracture (trauma), or the last dental check-up. The relationship between nutritional habits, caries risk, and athletes' oral health status alteration was evaluated using the diet assessment of caries risk (DACR). The DACR is a tool designed by the University of Iowa, to effectively identify those specific dietary behaviors that affected the risk of cavities. Key areas included in this tool for the dietary assessment of caries risk regards the number of dietary exposures (meals and/or snacks) in terms of timing, quantity and frequency, and duration, and the manner of sugared beverage intake [37]. Since the questionnaire was

not available in Spanish, we first proceeded to its linguistic and cultural adaptation to be later used in the population under study. The questionnaire was adapted using the reverse translation technique [38]. In order to ascertain the perception that the athletes had about their oral situation, they were trained to express it on a numerical index from 1 (totally dissatisfied) to 10 (totally satisfied), giving a score adapted to that index.

2.3. Statistical Analysis

Data were processed using IBM SPSS 25.0 Statistics pack for Macintosh (IBM Corp., Armonk, NY, USA). Variables were analyzed for normal distribution using the Kolmogorov–Smirnov tests, and the homogeneity of the variances was analyzed with the Levene test. For the quantitative variables, the Student's *t* test for independent samples was applied. For the categorical variables, the Chi-square test was used together with the Yates correction. A $p < 0.05$ difference was considered as statistically significant. The categorical variables were expressed in percentages and the quantitative variables in mean ± standard deviation.

3. Results

Table 1 reports the characteristics of the participants in each group.

Table 1. Participant's characteristics.

		Individual Sports (*n* = 74)	**Team Sports (*n* = 112)**
Age (years)		24.99 ± 9.33	24.57 ± 4.82
Gender (%)	Men	71.6	86.6
	Women	28.4	13.4
Dental self-evaluation (points)		7.95 ± 1.33	7.73 ± 1.21
Last dental check-up (months)		19.16 ± 13.47	19.59 ± 14.42

Table 2 reports the total number of teeth and the number of healthy, decayed, absent, and filled ones. In addition, it shows the results obtained in DMFT, IR, and OHIP-14sp. The athletes practicing individual sports modalities showed a lower number of healthy teeth and a lower IR index ($p < 0.05$). In addition, these athletes had a higher number of decayed teeth, missing teeth, and a higher DMFT index compared to team sports athletes ($p < 0.05$).

Table 2. The number of total and healthy teeth, the oral health status according to the DMFT, IR indexes, or OHIP-14sp questionnaire.

	Individual Sports (*n* = 74)	**Team Sports (*n* = 112)**	***t*-Value**	***p*-Value**
Total teeth number (*n*)	28.55 ± 1.91	30.14 ± 1.93	−5.501	<0.001
Healthy teeth (*n*)	23.85 ± 3.47	25.74 ± 3.64	−3.525	0.001
Decayed teeth (*n*)	2.18 ± 2.02	1.55 ± 1.95	2.093	0.038
Missing teeth (*n*)	3.50 ± 1.87	1.83 ± 1.94	5.785	<0.001
Filled teeth (*n*)	2.17 ± 2.39	2.58 ± 2.84	−1.032	0.287
DMFT	8.12 ± 3.56	6.10 ± 3.63	5.413	<0.001
IR	25.23 ± 24.38	43.10 ± 35.57	−3.418	0.001
OHIP-14sp	7.41 ± 3.76	7.04 ± 4.57	1.045	0.262

DMFT: decayed, missing, and filled teeth index; IR: restauration index; OHIP-14sp: oral health impact profile questionnaire (Spanish version).

Table 3 shows the number of teeth that suffered extractions, trauma, and fluorosis. There were no significant relationships between groups.

Table 3. Percentage of teeth that suffered extractions, trauma, and fluorosis.

		Individual Sports (*n* = 74)	Team Sports (*n* = 112)	X^2	*p*-Value
Extractions (%) *	Yes	13.5	13.4	0.612	0.529
	No	86.5	86.6		
Trauma (%)	Yes	10.8	17.0	1.167	0.340
	No	89.2	83.0		
Fluorosis (%)	Yes	5.4	2.7	0.926	0.439
	No	94.6	97.3		

X^2: chi-squared value; * due to caries or any other reason.

Table 4 reports the prevalence of malocclusions according to the sports modality. A significant relationship was observed between the type of sports modality and the prevalence of malocclusion.

Table 4. Prevalence of malocclusion according to the sports modality.

	Individual Sports (*n* = 74)	Team Sports (*n* = 112)	X^2	*p*-Value
Class I (%)	39.2	52.7		
Class II (%)	44.6	43.8	10.003	0.007
Class III (%)	16.2	3.6		

X^2: chi-squared value.

Table 5 reports the state of the gums, periodontal bleeding, periodontal plaque, dental erosion, and bruxism. There was a significant relationship between the sports modality and the presence of periodontal plaque (*p* < 0.05). Athletes practicing individual sports modalities presented a worse dental hygiene level with a higher percentage of periodontal plaque.

Table 5. Periodontal pockets, gingival bleeding, plaque, dental erosion, and bruxism.

		Individual Sports (*n* = 74)	Team Sports (*n* = 112)	X^2	*p*-Value
Periodontal pockets (%)	No	60.8	63.4	0.251	0.841
	Yes	39.2	36.6		
Gingival bleeding (%)	No	13.5	20.5	1.267	0.303
	Yes	84.5	79.5		
Plaque (%)	No	18.9	33.0	4.516	0.048
	Yes	81.1	67.0		
Dental erosion (%)	No	31.0	44.6	3.437	0.089
	Yes	68.9	55.4		
Bruxism (%)	No	32.4	40.2	1.043	0.360
	Yes	67.6	59.8		
Enamel (%)	Intact	86.4	87.5	0.213	0.840
	Abnormal	13.6	12.5		

X^2: chi-squared value.

Table 6 shows some results obtained from the DACR questionnaire. There were significant relationships between the sports modality and the frequency of energy/sugary drink intake (*p* < 0.05).

Table 6. Results obtained in the DACR questionnaire.

		Individual Sports (*n* = 74)	Team Sports (*n* = 112)	X^2	*p*-Value
Timing	Energy/sugary drink intake during meals (%)	21.6	8.0	6.360	0.028
	Energy/sugary drink intake during recovery (%)	47.3	58.8		
	Energy/sugary drink intake between meals (%)	31.1	33.9		
Quantity	Energy/sugary drink intake less than 0.35 l (%)	18.9	9.0	3.174	0.121
	Energy/sugary drink intake between 0.35 and 0.6 l (%)	73.0	79.5		
	Energy/sugary drink intake more than 0.6 l (%)	8.10	11.5		
Frequency	Energy/sugary drink intake once a day (%)	46.0	46.5	0.816	0.518
	Energy/sugary drink intake two-three times a day (%)	30.0	23.5		
	Energy sugary drink intake more than four times a day (%)	24.0	30.0		
Duration	Intake less than 15 min (%)	63.5	63.5	2.041	0.348
	Intake between 15 and 30 min (%)	24.5	17.8		
	Intake more than 30 min (%)	12.0	18.7		
Method	Liquid intake with straw (%)	68.9	79.5	2.567	0.250
	Liquid intake through its own package (%)	21.6	15.2		
	Liquid intake through its own package maintaining it in the mouth (%)	9.5	5.4		

X^2: chi-squared value.

4. Discussion

The purpose of this study was to evaluate the state of oral health and oral health habits in elite athletes according to the practiced sports modality. There is increasing evidence that elite or professional athletes present a poor oral health status, with consequences in well-being, training, and performance [1,13,26,28].

The OHIP-14 was aimed at capturing the impacts that oral conditions have on the athletes' quality of life. All the impacts measured by OHIP-14 were conceptualized as adverse outcomes and therefore the instrument measured the negative aspects of oral health [39]. The results achieved revealed that there were no significant differences in the score obtained in the OHIP-14 questionnaire according to the sport type: athletes considered that their oral status had no negative impact on their quality of life or performance, being quite satisfied with their oral situation. However, this self-perception was not completely in accordance with the results achieved by the clinical examination.

One of the most relevant results highlighted in this study regards the number of teeth present in the oral cavity, which differs depending on the sport type: a higher number of teeth have been found in athletes who compete in team disciplines. Likewise, a greater number of healthy teeth were found in athletes who practice team sports. It may be due to the fact that athletes who train individually often decides to visit or not the dentist without specific and institutionalized medical guidelines, and many factors such as fear, training schedules, geographical limitations/distance (i.e., for athletes training in rural areas, like climbers, trail runners, etc.), lack of economical support, etc., may negatively affect their awareness about oral health. The results obtained in the present study regarding team sports athletes are similar to those reported by Needleman et al. [11] in Olympic athletes and Gallagher et al. [13] in elite and high-performance athletes. In a recent survey on the oral

health status of the Spanish population, the cohort between 35 and 44 years old presented an average of 25.3 teeth in arch (on a maximum of 28, since the third molar was excluded from the analysis) [32]. These findings confirm the importance of monitoring, detecting, and promptly treating dentition in elite athletes, since its alteration can negatively affect chewing. Although many studies support the concept of reduced dental arch suggesting that a full dentition may not be necessary or desirable for all patients (thus questioning the need for replacement of missing molars, which are the most commonly affected by tooth decay and periodontal disease), other authors suggest that incorrect chewing, as a result of a deficit in the oral health status, can induce facial muscle overload and therefore produce an alteration in the digestion and absorption of nutrients, which may require higher nutritional energy expenditure [19,40–42].

Oral health status differed between groups and the number of decayed and missing teeth and DMFT index were higher in individual sports athletes. Previous studies reported that the incidence of caries in elite athletes was 75% [1] and 49.1% [13]. Likewise, Needleman et al. [11] reported that more than half of the athletes had dental caries (55.1%). A study carried out in soccer players revealed that 37% of them had active tooth decay [26]. Regarding the DMFT index, previous authors observed higher values in competitive soccer players compared to the inactive population [24,43]. However, Juliá-Sánchez et al. [44] obtained a lower DMFT index in anaerobic athletes compared to the control group. In a sample with characteristics similar to those of the present study, DMFT values ranging from 2.8 to 16.8 were reported [45]. Regarding individual endurance athletes, values of 6.2 were observed for swimmers and 11.6 for cyclists [46]. It should be noted that the results obtained in the present study achieved DMFT indexes superior to those reported in the Spanish youth population [47,48]. When comparing the restoration indexes (IRs), the sample analyzed presented lower values than the Spanish population (56.1%) [32].

Regarding periodontal plaque, it was observed that the prevalence was higher in athletes of individual sports modalities. Dental plaque accumulation may reflect a reduced awareness about oral health status and may be associated with the development of more destructive forms of periodontal diseases in later life. Different studies report a close relationship between exercise and physiological changes in the immune system: exercise may reduce the immune response depending on its type, duration, and intensity thus increasing susceptibility to certain infections, including periodontal disease [46,49,50].

Ashley et al. [1] reported that the prevalence of moderate irreversible periodontal disease was up to 15% and gingivitis up to 76% in elite athletes. Kragt et al. [6] reported a Dutch periodontal screening index score of 1.71 ± 0.73 in Olympic athletes, which was equivalent to the presence of dental plaque. Moreover, Gay Escoda et al. [24] reported an association between periodontal plaque and gingivitis. When comparing these results with the 2015 Spanish Oral Health Survey, it is evident that there is more prevalence of gingival/periodontal disease in athletes than in the general population [32].

Nutritional intake, including regular diet, sports drinks, and supplements, is an important determinant of oral health [7]. Athletes present a high risk of developing dental caries due to high and frequent carbohydrate intake [51]. Frequent consumption of sports drinks has been reported by 55–91% of athletes [28,51]. Long-term endurance sports require a large intake of carbohydrates, water, and electrolytes due to the high degree of glycogen breakdown and increased sweating during physical exercise. Currently, in all endurance sports, most of them practiced individually, such as for cycling or a triathlon, the consumption of gels and energy bars is highly extended, due to their easiness and rapid assimilation. These foods are characterized by their adherence to the tooth surface and they are rich in carbohydrates and citric acid [52]; their intake, which is carried out throughout the day and during exercise in the form of gels, bars, or energy drinks, may significantly increase the risk of tooth decay and erosion [51,53]. Therefore, Frese et al. [28] found a significant correlation between the incidence of caries and the hours of weekly training. Frequent consumption of carbohydrates causes a drop in pH in the oral environment that could lead to prolonged tooth demineralization and subsequent

caries development [28,53]. Commercially available sports drinks have a low pH and a buffering capacity of 43.0–56.5 (mmol/OH) [54]: dehydration and dry mouth during sports can increase the impact of carbohydrates on oral health by reducing the amount of saliva and, therefore, impairing its protective function [55].

Knowledge of food composition, the amount and frequency of food intake, and the way in which sugary drinks are consumed, can be an important factor for the development of preventive programs aimed at improving oral health status [56–58]. Regarding the intake of sugary drinks, all athletes confirmed using them, being more frequent among those who practice team sports during the recovery phases. The amount and frequency of ingestion constitute a moderate risk factor for the development of carious lesions [7,59]. Theoretically, the use of low-sugar or sugar-free bars or sports drinks should be advisable, although few data on their effectiveness on sport performance are available in the literature. Low-glycemic index versus a high-glycemic index sport nutrition bars consumed before a simulated soccer match were recently investigated revealing a lower carbohydrate oxidation rate and a modest improvement in performance (i.e., better agility and heading performance late in a simulated soccer match) [60]. However, other authors found no relationship between sports drink intake and oral health [61]. To reduce risk factors for developing oral diseases, it is essential to introduce preventive measures like promoting periodic oral assessment programs and the learning of correct oral hygiene procedures. In the present study, the mean with respect to the last visit to the dentist was around 19 months, far from what is recommended by the health authorities [31]. The better oral health results found in team athletes could be due in part to the fact that sports teams, having their own medical services, could predispose athletes to better access to primary care centers and induce greater awareness in the maintenance of oral health [62].

Regarding the prevalence of malocclusions, the present study highlighted a significant relationship between sports modality and malocclusion. Athletes in individual sports modalities presented a higher prevalence of classes II and III. The presence and influence of dental malocclusion has been studied in individual and team sports [24,63–65]. Using a similar methodology, Souza et al. [63] evaluated players between 13 and 20 years old classifying 89% of them in class I, 8% in class II, and 3% in class III. Similarly, after evaluating the Barcelona Football Club players, Gay Escoda et al. [24] reported that the prevalence of class I was 60%, while class II and III were 20%. Alterations in occlusion could significantly compromise performance, as they may interfere with chewing effectiveness and subsequent food digestion, impairing nutrient absorption. Other factors that may depend on occlusal alteration have also been proposed: loss of muscle balance, headache, temporomandibular joint problems, discomfort, or stress [66].

The training of an athlete necessarily implies the acquisition of coordinative abilities that allow him/her to control his/her motor actions. Balance participates in the proper execution of complex sports actions, being influenced by numerous factors including the stomatognathic system. A dental occlusion seems to differentially affect postural control depending on static versus dynamic conditions and on whether the eyes are open or closed. The main impact was previously observed to occur in dynamic conditions and with closed eyes. Maintaining balance (static and dynamic) is essential for an athlete, for a two reasons: first of all because athletes tend to have better balance and then because it seems to decrease the risk of sports injuries [67–69]. The influence of dental occlusion on body posture appears more pronounced in professional athletes than in the general population [65].

The present study presented the following limitations: (1) no distinction was made between sexes; (2) the nutritional intake of the participants was not analyzed; (3) there was no control group to compare results. The methodology of the present study should be repeated in a larger sample of athletes. Future research should also focus on the influence of oral status on athletes' performance and on the effect of preventive oral health examinations.

5. Conclusions

High-performance athletes who practice individual sports are prone to present a lower oral health status when compared to athletes who practice team sports. It is necessary to pay greater attention to athletes' oral health to improve their general health, their quality of life, and the potential influence it may have on sports performance. Dentists should actively participate in assessing the health status of athletes.

Furthermore, it is necessary that coaches, sports clubs, and federations understand the importance of promoting oral health preventive programs among athletes.

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