Introduction
Dental caries affects oral health of different groups of a society. Reduction of pH in dental plaque and saliva can lead to dental caries [1]. Increased concentration of fermentable carbohydrates after consumption of sweets and beverages accompanied by low buffering capacity of saliva may cause continuous drop in salivary and inter-proximal plaque pH. Low pH of the oral cavity provides a suitable environment for cariogenic bacteria. A pH of 5.5 or less provides a favorable condition for enamel decalcification and further decay, which will influence tooth function and esthetics [2,3].

In 1940, Stephen was the first one to show that 2-5 minutes after a single sucrose dose, salivary pH drops and the condition lasts for 10 minutes; after 20-60 minutes it returns to its initial pH value, depending on the salivary characteristics or caries prevention methods that a person uses [1]. The more sweets are consumed, the less there are possibilities for returning to the baseline pH, and the greater is the risk for caries development [1,2]. Athletes, especially the professional ones, are among the most frequent consumers of different types of soft drinks and energetic acidic sweet drinks; since they must prevent dehydration during their heavy exercises, losing body fluids and facing imbalance of electrolytes [4-7]. Excessive consumption of sweet drinks causes low pH and increases the possibility of caries and subsequent tooth loss. As the result, masticatory disability, pain, discomfort and esthetic problems ensue [8] which may impair participation on national or international competitions [9].

Different caries preventive methods have been suggested for increasing the pH after consumption of sweet foods, e.g., tooth mineralizing products such as fluoride or calcium-phosphate containing varnishes, mouthwashes, and Xylitol chewing gums [1]. Fluoride varnishes have extensively been used over 40 years in Dentistry, the most common type of which is 5% sodium fluoride varnish [10]. Some studies show that varnishes allow an increase in both fluoride and pH levels of saliva [11-21]. In addition to fluoride varnish, other types of varnishes such as ones containing tri-calcium phosphate (TCP) has been proposed to increase salivary pH and therefore to reduce caries risk [12].

The aim of this study was to assess and compare the effect of fluoride and TCP varnishes on salivary and plaque pH among the professional athletes who consume soft drinks. The null hypothesis was that TCP varnish could minimize pH drop in saliva and in inter-proximal plaque.

Can Fluoride or Tri-calcium Phosphate Varnishes alter Salivary and Plaque pH in Athletes who Consume Soft Drinks?

Abstract
Background: Plaque and saliva pH are the main factors that facilitate the caries process. Consumption of acidic soft drinks is one of the factors responsible for pH changes in the oral cavity. Athletes commonly consume soft drinks. The purpose of this study was to evaluate the effects of two types of varnishes (fluoride and tri-calcium phosphate, TCP) on plaque and saliva pH of professional athletes who consume soft drinks.

Methods: In this clinical study, 40 professional athletes aged 18-30 years were first randomly divided into two groups: Fluoride varnish (Sultan®, USA) and TCP varnish (3M®, ESPE, USA). At the first session, the baseline pH of plaque and saliva was measured using a plaque indicator kit (GC, USA) and pH meter (Hana, model AZ 8686, Italy). Then, the varnishes were applied. After 3 weeks, pH value of the participants was examined and varnishes were applied again, following by pH measurements at weeks 6 and 12. The data were analyzed using Repeated Measures ANOVA.

Results: Applying fluoride varnish or TCP varnish did not cause any significant difference in saliva and plaque pH during the assessment periods (p>0.05). However, higher buffering capacity was observed among the athlete who had low pH at the baseline (p<0.05).

Conclusion: Neither of the varnishes caused changes in plaque and saliva pH in this study. But the buffering capacity increased in athletes with low baseline pH.

Keywords: Fluoride Varnish; Tri-Calcium Phosphate; Saliva pH; Plaque pH; Athletes; Soft Drinks
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Materials and Methods

In this clinical trial, after approval of the ethics committee of research council of the Dental Faculty, 40 professional athletes (33 males, 7 females) of the Olympic Federation, who signed the informed consent and met the inclusion criteria, participated. The inclusion criteria were: consumption of sweet drinks more than three times daily, age 18 years or older, being cooperative, having no systemic diseases, no periodontal problems, no orthodontic retainers or night guards, not being on antibiotics three weeks before or during the study, not taking medications affecting salivary secretion and not smoking.

The procedure of the trial was explained to the participants and they were asked not to brush their teeth, apply dental floss or mouthwash two days before the experiment and not to drink or eat two hours before pH measurement. A questioner handed over to the participants who contained questions about the type of sport, type of sweet drinks that each participant consumes and the period of daily workout. The validity and reliability of the questioner has been evaluated in a pilot study.

10 ml of unstimulated saliva was extracted with a pipette from each participant, Saliva pH was measured by a pH meter (Hana, model 8321, Italy), which was calibrated each time before the measurement. The inter-proximal plaque pH measurement was done with plaque sampling from the distal surface of the first molar using a special applicator available in GC plaque indicator kit (GC America, USA) (Figure 1). After cleaning teeth by using gauze, participants were randomly allocated to two groups for application of varnishes: Group 1(n=20): Fluoride varnish (5% NaF, Sultan® , USA), and Group 2 (n=20): Tri-Calcium Phosphate varnish (TCP) (3M® , ESPE, USA). Participants were blinded to the type of varnish to be applied.

Both varnishes affected the buffering capacity of saliva and plaque pH of the participants who had low pH (less than 5) at baseline (p<0.05) (Figure 2 & 3). As it is shown in Figure 1 in participants with lower baseline plaque pH more improvement occurred at the end. Also salivary pH was raised in participants with lower baseline pH. There was no significant relationship between the questioner items in two study groups (p<0.05).

Results

7 of the participants were woman and 33 were man. There were no differences in plaque and salivary pH between the genders. In both groups, there was no significant difference in plaque pH within the time periods (p=0.98) (Table 1). Salivary pH difference was also insignificant in all follow-ups (p=0.068) (Table 2).

Table 1: The mean of plaque pH (SD) in different groups and time periods.

|                  | Baseline pH | 3rd week | 6th week | 12th week |
|------------------|-------------|----------|----------|-----------|
| Fluoride varnish | 6.3(0.25)   | 6.3(0.30)| 6.4(0.20)| 6.4(0.23) |
| TCP varnish      | 6.3(0.25)   | 6.3(0.36)| 6.4(0.20)| 6.5(0.14) |

Table 2: The mean saliva pH (and SD) in different groups and time periods.

|                  | Baseline pH | 3rd week | 6th week | 12th week |
|------------------|-------------|----------|----------|-----------|
| Fluoride varnish | 7.0 (0.27)  | 6.8 (0.45)| 6.9 (0.29)| 7.0 (0.23)|
| TCP varnish      | 6.7 (0.44)  | 6.8 (0.49)| 6.9 (0.21)| 6.9 (0.20)|

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Citation: Banava S, Sabernezhad M, Sisko Honkala (2016) Can Fluoride or Tri-calcium Phosphate Varnishes alter Salivary and Plaque pH in Athletes who Consume Soft Drinks?. J Dent Health Oral Disord Ther 4(3): 00112. DOI: 10.15406/jdhodt.2016.04.00112
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Discussion

Prevention of caries and erosion in individuals with high caries risk is a major goal in public health settings. Professional athletes, due to their physical activities, regular exercise and sweating during their workout, need to drink high-calorie beverages to counteract their dehydration and balance their body electrolytes [5-7]. This could cause pH changes in the oral environment which consequently result in tooth decay and erosion due to the high acidity of the beverages [5]. Several studies have shown that consumption of soft or energy drinks can lead to an increased incidence of dental caries and erosion [4-7]. Hence, proper methods of caries prevention accompanied by remineralizing measures may be beneficial in these groups.

In this study the effect of two materials, fluoride and TCP varnishes, with tooth mineralizing potentials evaluated in professional athletes to decrease the incidence of caries and its consequences especially in the world competitions period. Numerous studies confirm the anti-caries effects of these products [15,16,22,23]. It has been shown that fluoride increases the structural strength of the tooth through incorporating the released calcium from hydroxyapatite and subsequent remineralization [15,16,23]. Therefore, it seems that plaque pH might be increased and the remineralization process accelerated [1,24].

There are controversies in the number of fluoride varnish applications in the literature [16,22,25]. It is recommended to apply the fluoride varnish every three hours for high caries risk patients and every six months for those with the low risks [22]. A study have suggested to apply fluoride varnish three times a week for one year as more effective than twice yearly [20]. However, this was not possible to implement in our study because it was difficult to get the athletes to attend the clinic weekly for varnish application. Also an earlier study indicated that application of fluoride varnish once in three months has weekly for varnish application. Also an earlier study indicated that application of fluoride varnish once in three months has

In Vivo studies are required to evaluate the higher application frequencies of both varnishes.

An interesting finding of the current study was the buffering effect of both varnishes in participants with lower baseline pH. It might be useful in the future studies to include only the athletes with saliva pH equal to or lower than 5 to evaluate the buffering potential of different varnishes. Future In Vitro and In Vivo studies are required to evaluate the higher application frequencies of both varnishes.

It is clear that in high-risk individuals, one application of both varnishes, which is often suggested in books and references, will have no significant impact on saliva and plaque pH. Consistency in the application of varnish seems to be more effective which requires further research to define the frequency of application and the effective intervals.

Conclusion

According to the limitations and circumstances of this research, it can be concluded that none of the varnishes raised the pH of plaque or saliva in professional athletes when applied twice within three weeks. As a supplementary finding, fluoride and TCP varnishes application increased the plaque and saliva pH in athletes with low baseline pH which certainly needs further investigations.

New findings:

a. Varnishes caused changes in plaque and saliva pH in this study.

b. Varnishes showed effective buffering capacity in subjects with low baseline pH.
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