ANDREA BARROS TOLENTINO

Hipersensibilidade Dentinária Cervical: fatores de risco e protocolos de tratamento neural - estudo in vitro e clinico longitudinal

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“Faça o teu melhor, na condição que você tem,
enquanto você não tem condições melhores,
para fazer melhor ainda!!”

Mario Sergio Cortella

RESUMO

Tolentino AB. Hipersensibilidade Dentinária Cervical: fatores de risco e protocolos de tratamento neural - estudo in vitro e clinico [tese]. São Paulo: Universidade de São Paulo, Faculdade de Odontologia; 2022. Versão Corrigida.

A lesão cervical não cariosa (LCNC) é uma doença caracterizada pela perda mineral do tecido dentário na região cervical. A sua progressão pode levar a hipersensibilidade dentinaria cervical (HDC). Apresenta etiologia multifatorial através de mecanismos de: fricção como a escovação (frequência, força, direção e creme dental abrasivo); tensão com sobrecarga oclusal (bruxismo e má-oclusão) e, principalmente, o mecanismo de corrosão através de doenças gástricas, transtornos alimentares e hábitos dietéticos (ingestão de ácido). Nos últimos anos é notório observamos a mudança de estilo de vida da população, e com isso um aumento da prevalência de HDC. É uma condição clínica comum caracterizada por uma dor aguda e transitória que surge devido a túbulos expostos em resposta a estímulos. Impacta negativamente a saúde bucal e a qualidade de vida dos pacientes. Para facilitar o entendimento, essa tese apresenta um compilado em três capítulos. Capitulo 1: O objetivo foi avaliar o pH de bebidas esportivas, energéticas, fitness/funcionais e suplementos, e a capacidade de neutralizar o ácido pela adição de saliva artificial, em um estudo experimental; capitulo 2: Avaliar o pH de bebidas, alimentos e medicamentos disponíveis no mercado brasileiro e a capacidade de neutralizar o ácido pela adição de saliva artificial; e capitulo 3: Através de um estudo clínico longitudinal randomizado, avaliar diferentes protocolos de tratamento da HDC com laser de baixa potência, agente dessensibilizante, e sua associação. Após as análises dos resultados ressalta-se que bebidas esportivas são comumente recomendadas por outros profissionais com o objetivo principal de atingir as metas de cada atleta, seja amador ou profissional. No entanto, como podem ter impacto na saúde bucal e um trabalho multidisciplinar é necessário, além de orientações para os pacientes esportivos. A maioria dos alimentos e bebidas consumidas por brasileiros são ácidas, e os resultados fornecem a dentistas e pacientes informações relevantes sobre as características do potencial corrosivo das bebidas comercialmente disponíveis no Brasil, sendo necessário orientações dietéticas específicas para prevenir ou minimizar o desgaste precoce dos dentes. E por último, encontrou-se que protocolo dessensibilizante de três sessões foi eficaz na redução da HDC após 3 meses, independentemente do mecanismo de dessensibilização utilizado.

Palavras-chave: Saúde bucal. Hipersensibilidade dentinária. Laser de baixa potência. Nitrato de potássio. Desgaste dentário. Dieta ácida. Atletas.

ABSTRACT

Tolentino AB. Cervical Dentin Hypersensitivity: risk factors and neural treatment protocols - in vitro and clinical study [thesis]. São Paulo: Universidade de São Paulo, Faculdade de Odontologia; 2022. Versão Corrigida.

Non-carious cervical lesion (NCCL) is a disease characterized by mineral loss from dental tissue in the cervical region. With their progression they can lead to cervical dentin hypersensitivity (CDH). It has a multifactorial etiology through mechanisms: friction, such as brushing (frequency, force, direction and abrasive dentifrice); tension with occlusal overload (bruxism and malocclusion) and mainly the corrosion mechanism through gastric and eating disorders and dietary habits (acid ingestion). in the last few years, we have seen a change in population's lifestyle with an increase in the prevalence of CDH. It is a very common clinical condition characterized by an acute and transient pain that arises due to exposed tubules in response to stimuli. It negatively impacts the oral health and quality of life of patients. To facilitate the understanding, this thesis it is compiled in three chapters. Chapter 1: The aim of this chapter was to evaluate the pH of sports, energy, fitness/functional drinks and supplements, and the ability to neutralize acid by adding artificial saliva, in an experimental study; Chapter 2: To evaluate the pH of beverages, foods and medicines available in the Brazilian market and the ability to neutralize acid by adding artificial saliva; and chapter 3: Through a randomized longitudinal clinical study, to evaluate different protocols for the treatment of CDH with low power laser, desensitizing agent, and its association. After analyzing the results, it is can be observed that drinks from the sports world are commonly recommended by other professionals, with the main objective of achieving the goals of each athlete, whether amateur or professional. However, as they can have an impact on oral health, multidisciplinary work and guidelines for sports patients are necessary. Most foods and beverages consumed by Brazilians are acidic, and the results provide dentists and patients with relevant information about the corrosive potential characteristics of commercially available beverages in Brazil, requiring specific dietary guidelines to prevent or minimize early tooth wear. Finally, the proposed three-session protocol was found to be effective in reducing CDH after 3 months of follow-up, regardless of the desensitization mechanism used.

Keywords: Oral health. Dental hypersensitivity. Low power laser. Potassium nitrate. Tooth wear. Acid diet. Athletes.

SUMÁRIO

PREFÁCIO

Essa tese foi dividida em três capítulos:

Capítulo 1: *Analysis of sports, energy and fitness beverages and acid neutralizing capacity and its impact on Dentistry: an experimental study*.

Submetido para o *The Journal of Sports Medicine and Physical Fitness* (Fator de Impacto 1.637)

Capítulo 2: *pH mapping of beverages, medicines and foodstuffs consumed in Brazil and the acid neutralizing capacity: an experimental study*

Submetido para o *Brazilian Oral Research* (Fator de Impacto 1.633)

Capítulo 3: *Photobiomodulation therapy and 3% potassium nitrate gel on the treatment of cervical dentin hypersensitivity: a randomized clinical trial*

Submetido para o *Clinical Oral Investigations*. (Fator de Impacto 3.573)

1 INTRODUÇÃO

As Lesões Cervicais Não Cariosas (LCNC) são caracterizadas pela perda de estrutura dental na região de junção cemento-esmalte (região cervical), não relacionadas à presença de cárie, sendo comumente encontradas na rotina clínica odontológica). O início e a progressão das LCNCs possuem etiologia multifatorial, envolvendo um complexo de interações de mecanismos associando concentração de tensões, fricção mecânica e corrosão.(1–6)

A tensão é correlacionada ao acúmulo de tração/compressão provocado por forças mastigatórias e principalmente por parafunção, além da fadiga causada pelo dinamismo cíclico entre compressão e tração(1,4,7,8). A fricção é relacionada ao desgaste provocado por atrição, abrasão e pela movimentação de fluidos em contato com a superfície dentária(9–11). Por fim, a biocorrosão que se refere à degradação química, bioquímica e eletroquímica da estrutura dental, causada por ácidos endógenos e exógenos, agentes proteolíticos e efeitos piezoeléctricos da dentina.(1,4,12,13)

A degradação da estrutura dentária, provocado pela presença dos fatores etiológicos ou a presença de Recessão Gengival (RG) pode levar a exposição dos túbulos dentinários, possibilitando o aparecimento da Hipersensibilidade Dentinária Cervica (HDC) (1,4,14–16). Esta é caracterizada como uma sensação dolorosa, desconfortável e algumas vezes de difícil tratamento. O sintoma inicial é a dor aguda de rápido estabelecimento que desaparece quando o estimulo é removido. (17–19)

Diante do aumento do número de casos de HDC, aliados com as mudanças comportamentais da população em geral, faz-se necessário a adoção medidas preventivas, orientações e protocolos para controle da dor. Com relação aos tratamentos, há terapias efetivas para a oclusão dos túbulos dentinários e/ou o bloqueio da atividade neural. Como exemplos podem ser citados a aplicação de oxalato de potássio, cloreto de estrôncio, vernizes fluorados, fluoreto de sódio, lasers de alta e baixa potência, sistemas adesivos e procedimentos restauradores.(4,18,20–24)

O uso dos lasers para o tratamento da HDC vem ganhando espaço nas últimas décadas e fornece outra opção de tratamento possível e tornou-se interesse de pesquisa. O laser, ao interagir com o tecido, provoca reações teciduais diferentes, de acordo com seu meio ativo, comprimento de onda e protocolos e às propriedades ópticas do tecido alvo (24). Os lasers utilizados no controle da dor da HDC podem ser divididos em dois grupos: os lasers de alta potência: Er:YAG, Er,Cr:YSGG, Nd:YAG e CO_2(21,25,26), e os lasers de baixa potência: e gálio-alumínio-arseneto (GaAlAs) (diodos semicondutores) (25,27,28).

Agentes à base de potássio promoverão um aumento na concentração do íon potássio nas terminações nervosas, diminuindo a capacidade do nervo de conduzir estimulação sensorial, alterando seu potencial de ação.(19,22,24) Por outro lado, o laser irá interagir com o tecido, causando diferentes reações teciduais, de acordo com seu meio ativo, comprimento de onda, densidade de potência e propriedades ópticas do tecido alvo (24). Lasers de baixa potência, cuja ação se destaca como biomoduladores. As respostas promoverão a redução dos níveis de dor através da despolarização das fibras nervosas e da formação de dentina reparadora.(21,22,29,30)

Os ácidos responsáveis pela corrosão dentária e hipersensibilidade dentinaria, podem surgir de fontes intrínsecas (como distúrbios alimentares ou doença do refluxo gástrico esofágico) ou extrínsecas (medicamentos, bebidas e alimentos ácidos). O consumo frequente de dieta ácida está aumentando com a mudança do estilo de vida da sociedade e tem sido associado as desgaste dos dentes. (1,5,31–34) O potencial ácido de alimentos e bebidas ácidas está relacionado às suas propriedades físico-químicas, poder do hidrogênio (pH), acidez titulável, capacidade de tamponamento da saliva, concentração inorgânica de íons cálcio, fosfato, flúor e quelação mineral. (5,35–38) Devido a isso, são necessários mais estudos que possam embasar dentistas para uma melhor orientação e conscientização de profissionais da saúde e pacientes.

Além disso, é necessário buscar melhores tratamentos para o controle da dor. A literatura demonstra ensaios clínicos com resultados divergentes. Existe a necessidade de mais estudos controlados com ênfase na eficácia da terapia com laser de baixa potência e o gel dessensibilizante de ação neural no tratamento da HDC. Além disso, é importante comparar a eficiência dos sistemas laser com a dos agentes dessensibilizantes atualmente utilizados. Portanto, faz-se necessária a avaliação de protocolos de tratamento no controle da HDC ao longo do tempo, com evidências para suportar seu uso, e estabelecer medidas de prevenção e controle da dor para o desenvolvimento da HDC.

2 PROPOSIÇÃO

As informações sobre as bebidas consumidas pelos brasileiros são necessárias para que profissionais da saúde e do esporte possam orientar e conscientizar seus pacientes sobre os efeitos dos ácidos na cavidade oral. A literatura demonstra falta de ensaios clínicos e resultados divergentes quanto ao uso de lasers de baixa potência e gel dessensibilizante. Em virtude da necessidade de mais estudos, esses três trabalhos tiveram como objetivo:

Artigo 1. Determinar o pH de bebidas esportivas, energéticas e fitness/funcionais e a capacidade de neutralização ácida pela adição de saliva artificial.

Artigo 2. Determinar o pH de bebidas, condimentos e medicamentos consumidos pelos brasileiros e a capacidade de neutralização ácida pela adição de saliva artificial.

Artigo 3. Avaliar, por meio de um estudo clínico randomizado e controlado, a eficácia e longevidade de diferentes protocolos de tratamento para HDC com fotobiomodulação laser de baixa potência, agente dessensibilizante, e a associação entre laser de baixa potência e agente dessensibilizante.

5. Capítulo 1

Analysis of sports, energy and fitness beverages and acid neutralizing capacity and its impact on Dentistry: an experimental study.

Submetido para o *The Journal of Sports Medicine and Physical Fitness*

Analysis of sports, energy and fitness beverages and acid neutralizing capacity and its impact on Dentistry: an experimental study

Andrea Barros Tolentino, Livia Favaro Zeola, Paulo Vinicius Soares, Ana Cecilia Aranha

Abstract

Objective: To evaluate the pH of sports, energy, fitness/functional beverages and the capacity to neutralize acid by adding artificial saliva. Methods: 35 beverages commonly used in the sports world (isotonic drinks, teas, supplements, energy drinks) were evaluated. A calibrated pH meter was used to measure the pH of each beverage, in triplicate, immediately after it was opened at a temperature room of 25°C. To assess the pH neutralizing ability, 5 ml/min of artificial saliva was added until a pH of 5.5 (defined as the cut-off point) was reached in the tested solution. Results: Of the total, only 5 beverages had an initial pH greater than 5.5, the majority (n=17) had an initial pH lower than 4. It was found that protein-based supplements need low volumes of artificial saliva to reach a pH above 5.5, however, there is a resistance of energy supplements to being neutralized. Conclusion: Most drinks had an initial lower pH but energy, carbohydrate gel, lemon drinks had greater resistance to neutralization with artificial saliva. These beverages are commonly recommended by other professionals, with the main purpose of achieving the athlete’s goals. However, as they can have an impact on oral health, it is necessary to have a multidisciplinary work and guidelines for sports athletes’ patients.

Clinical Implications: The results provide dentists and sports professionals with information about the corrosive potential of some commercially available beverages. Specific dietary recommendations are needed to prevent early tooth wear.

Key-words: athlete; sport; dental erosion; acid diet; drinks; saliva

Introduction

In recent years it is possible to observe a greater stimulus to the practice of physical activities, sports and a healthier lifestyle. Many people have goals to win medals, competitions, lose weight, define the body, have mental and physical health. To achieve their goals, many individuals usually change their daily routine and need to introduce different dietary habits. Diet recommendations are individualized according to the type, duration, frequency and intensity of exercise and each person's goals. (1–5) So, there was an increase in the intake of energy, sports and functional beverages and, as a consequence, a greater risk of dental corrosion. (1,4,6–13)

Dental corrosion is defined as the irreversible acid dissolution of the surface tooth structure by chemical and electrochemical means, in the absence of microorganisms. With its progression, it can lead to exposure of dentinal tubules and, consequently, sensitivity in the teeth and, in the future, severe dental wear. (10,14–16) The etiology is multifactorial and can be caused by acids of extrinsic origin (acidic foods and drinks, medications) or intrinsic (gastric reflux, bulimia). (10,15,17–19) However, initial diagnosis is difficult and, therefore, it is necessary to know the interaction of the etiological factors responsible for the loss of dental tissue. The presence of liquids in the oral cavity with a hydrogenic potential (pH) lower than 5.5 can already result in the immediate softening of the tooth surface, making it quite susceptible to removal by abrasion and friction (eg brushing and bruxism).(10,14,20,21)

Incorrect oral hygiene habits, especially after drinking acidic beverages, can contribute to accelerated tooth wear and sensitivity. In addition, athletes who have parafunctional habits such as clenching their teeth during strenuous physical activities associated with an acidic diet can also lead to an overload of dental structures and premature aging of the oral cavity.(12,13,21–24)

Also, the diet of these individuals may be rich in products with high corrosive potential. The best known are sports drinks, for example isotonic drinks that have a pH below 5.5, considered the critical pH for tooth demineralization to occur. They are mainly used for rehydration and electrolyte replacement purposes during physical exercise.(3,6,17,25–27) pH is the primary indicator of the corrosive potential of a food or beverage and provides a measure of the initial concentration of hydrogen ions and no indication as to the presence of undissociated acid. pH is an important property to understand the dynamics of tooth wear. (28,29) However, the titratable total acidity is a more accurate measure of the total acid content of a beverage, being directly related to the acid concentration undissociated present in a solution. (30–32) The high titratable acidity of a drink increases the time that saliva needs to neutralize the acid (buffering capacity), increasing its demineralizing potential. That is, the higher the acid titration of a drink, the greater the amount of saliva needed to neutralize this acid. (30,33,34)

One of the most important biological protective factors for dental corrosion is saliva. (35–38) First, because it can neutralize the pH in the oral cavity and second, to rebalance the process of demineralization/remineralization that occurs during the contact of acids with the tooth. However, it is necessary to emphasize that during physical exercise there is a decrease in salivary flow and quality, leading to a decrease in the protective functions that saliva could have. (6,38–40) Individuals who practice physical activity and consume drinks or supplements before, during or after sport, have a higher risk of developing dental wear.(3,4,6,12,41,42)

Information about the beverages consumed by Brazilians is necessary so that health and sports professionals can advise, guide, and make their patients aware of the effects of acids in the oral cavity. Therefore, the aim of this study was to determine the pH of sports, energy and fitness/functional beverages and the acid neutralization capacity by the addition of artificial saliva.

Materials and methods

Thirty-five commercially available beverages were analyzed. (Table 1) A pilot study was carried out to establish the best data collection strategy. The analyses was performed at the Department of Restorative Dentistry at the School of Dentistry of the University of São Paulo (FOUSP). The beverage evaluation was performed in triplicate and the pH evaluation was performed immediately after the opening the beverage. Artificial saliva was used (0.213 g/l CaCl2 · 2H2O; 0.738 g/l KH2PO4; 1.114 g/l KCl; 0.381 g/l NaCl; 12 g/l Tris[43]) with pH at 8.0 with HCL.

The initial pH value of each beverage was measured using an electrode connected to a digital pH meter (K39-1014B – Kasvi, Paraná, Brazil). Before the beginning of each session, the electrode was calibrated with standard buffers of pH 4.0 and 7.0. To avoid contamination, the meter was rinsed with distilled water. All beverages were tested at room temperature and each one was opened following the instructions of each manufacturer. After opening the packages, 50 mL of the freshly opened beverage was dispensed into an identified glass beaker, under constant stirring with a non-heating magnetic stirrer (model) until a stable reading was obtained and the package was set aside and sealed or closed again. All beverages that required mixing with water were made according to the manufacturer's guidelines. Then, the initial pH value of the samples was measured immediately after opening.

Subsequently, the neutralizing capacity (NC) was estimated using a pipette by adding 5mL increments of saliva until reaching pH 5.5 (value considered cut-off point). All pH and BC measurements were performed in triplicate and an average result was obtained for each beverage. This procedure was repeated for all drinks. At the end, the amount of saliva necessary to raise the pH from the initial value to the established value of 5.5 was recorded. The results obtained were analyzed and compared in tables and graphs.

To evaluate the buffering capacity data, a graph was drawn with pH x mL added of salivary solution. The resulting curve allowed the comparison of different buffer capacities between the analyzed beverages.

Results

Table 1 shows the composition and initial pH of all beverages analyzed. Of the total, only 5 had an initial pH greater than 5.5, the majority (n=17) had an initial pH lower than 4. That is, taking only pH into account, in general, most of the sports/energy drinks/supplements are acidic.

Figure 1 shows the performance of pH after the addition of saliva in each of the beverages evaluated. It was found that protein-based supplements need low volumes of artificial saliva to reach a pH above 5.5, however, there is a resistance of energy supplements to being neutralized, which can be attributed to the high titratable acidity of these drinks.

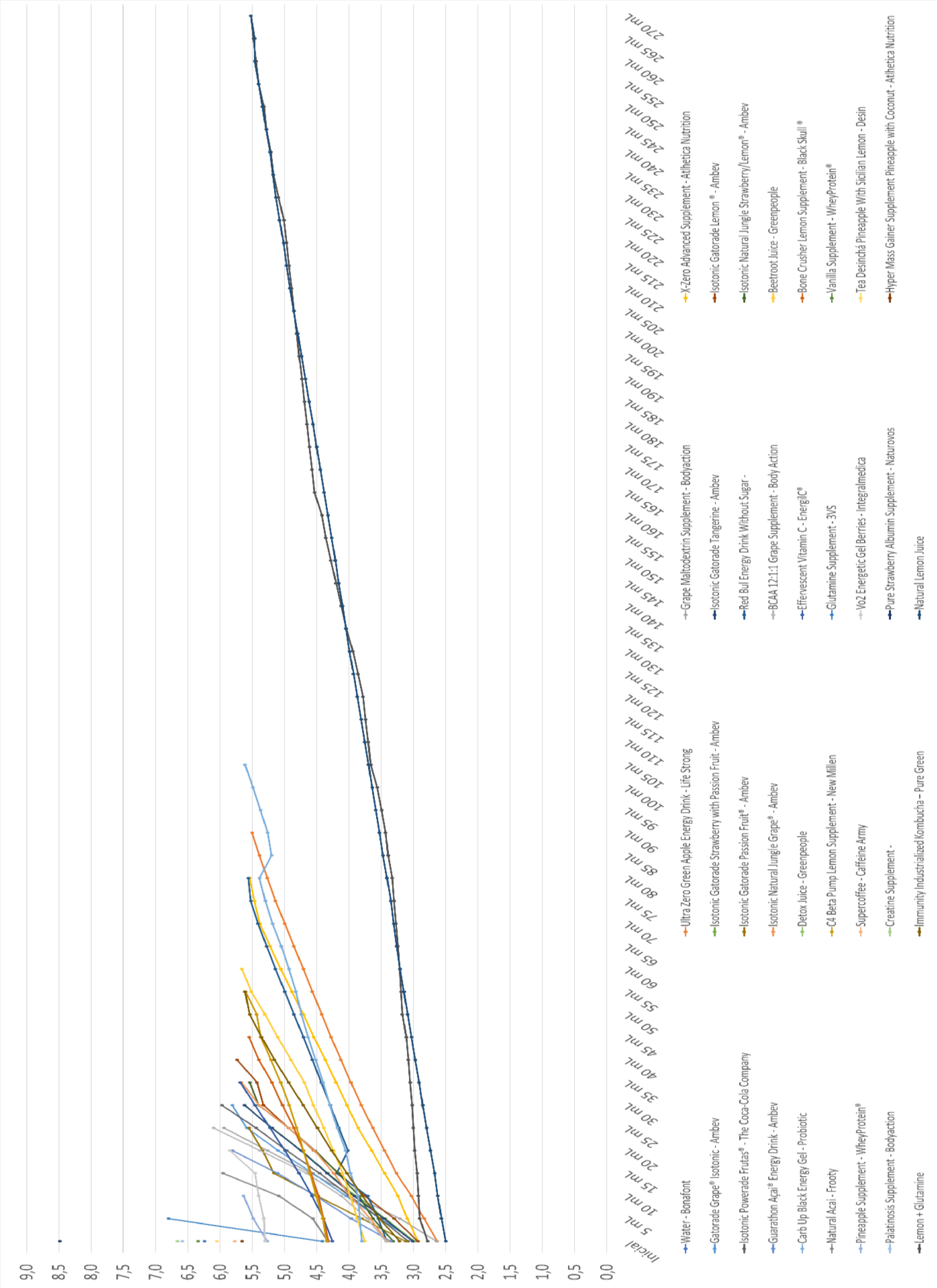
Table 1. pH and standard deviation of all beverages analyzed.

Drinks/Supplements/ /Energetics/Fitness	*Average pH/ Standard deviation*	*Amount of Saliva (mL)*	*Composition*
Water - Bonafont	6,45 (0,0047)	0 mL	Fluoridated mineral water. Bicarbonate; Nitrate; Potassium; Calcium; Sodium; Magnesium; Chloride; Barium; Sulfate; Fluoride
Natural Lemon Juice	2,50 (0,0047)	270 mL	Ascorbic Acid (Vitaminca C), Citric Acid, Folic Acid, Vitamin B6, Niacin, Riboflavin, Thiamine, Vitamin A, Zinc, Potassium, Magnesium, Calcium and Phosphorus
Lemon + Glutamine	2,78 (0,0125)	270 mL	Ascorbic Acid (Vitaminca C), Citric Acid, Folic Acid, Vitamin B6, Niacin, Riboflavin, Thiamine, Vitamin A, Zinc, Potassium, Magnesium, Calcium and Phosphorus + L-Glutamine.
Isotonic Gatorade Lemon ® - Ambev	3,04 (0,0047)	40 mL	Water, Sucrose, Maltodextrin, Sodium Chloride, Sodium Citrate, Monobasic Potassium Phosphate, Citric Acid Acidulant and Flavoring. Contains Sucrose.
Isotonic Powerade Frutas® - The Coca-Cola Company	3,10 (0,0374)	30 mL	Water, Sugar, Sodium Chloride, Potassium Citrate, Magnesium Chloride, Calcium Chloride, Potassium Phosphate, Vitamins B3, B6 and B12, Flavoring, Citric Acid Acidulant, Sucralose Sweetener, Disodium Calcium EDTA Sequestrant and Artificial Color Bright Blue FCF . Contains Sucrose.
Isotonic Gatorade Passion Fruit® - Ambev	3,12 (0,1105)	25 mL	Water, Sucrose, Maltodextrin, Sodium Chloride, Sodium Citrate, Monobasic Potassium Phosphate, Citric Acid Acidulant, Flavoring and Artificial Colors: Tartrazine and Twilight Yellow FCF. Contains Sucrose.
Isotonic Gatorade Strawberry with Passion Fruit - Ambev	2,99 (0,0216)	30 mL	Water, Sucrose, Maltodextrin, Sodium Chloride, Sodium Citrate, Monobasic Potassium Phosphate, Citric Acid Acidulant, Flavoring and Artificial Colors: Red 40 and Twilight Yellow FCF. Contains Sucrose.
Gatorade Grape® Isotonic - Ambev	2,97 (0,1725)	30 mL	Water, Sucrose, Maltodextrin, Sodium Chloride, Sodium Citrate, Monobasic Potassium Phosphate, Citric Acid Acidulant, Flavoring and Artificial Colors: Bordeaux S, Twilight Yellow FCF and Brilliant Blue FCF. Contains Sucrose.
Isotonic Gatorade Tangerine - Ambev	3,01 (0,0082)	30 mL	Water, Sucrose, Maltodextrin, Sodium Chloride, Sodium Citrate, Monobasic Potassium Phosphate, Citric Acid Acidulant, Flavoring and Artificial Color Twilight Yellow FCF. Contains Sucrose.
Isotonic Natural Jungle Grape® - Ambev	3,41 (0,2085)	35 mL	Water, organic tapioca, grape juice, organic coconut water, organic lemon juice, sea salt and natural flavors.
Isotonic Natural Jungle Strawberry/Lemon® - Ambev	3,31 (0,2398)	35 mL	Water, organic coconut water, organic tapioca, organic cashew juice, organic orange juice, organic lemon juice, salt, natural flavors. Gluten-free
Guarathon Açai® Energy Drink - Ambev	5,3 (0,0589)	20 mL	Water, sugar, natural guarana extract with artificial flavor, natural açaí extract, citric acid acidulant, potassium sorbate preservative, sodium benzoate preservative.
Ultra-Zero Green Apple Energy Drink - Life Strong	2,63 (0,0455)	90 mL	Carbonated Water, Taurine, Caffeine Inositol, Guarana Extract, Vitamins (B3, B5, B2, B6 and B12) Acidulant Citric Acid, Acidity Regulator, Potassium Citrate, Natural Green Apple Flavor, Sweeteners Sucralose and Acesulfame Potassium, Colors Artificial Yellow Tartrazine and Brilliant Blue.
Red Bul Energy Drink Without Sugar -	3,41 (0,0216)	75 mL	Water, carbon dioxide, taurine, glucuronolactone, caffeine, inositol, vitamins (B3, B5, B6, B2, B12), acidity regulator sodium citrate, flavoring, caramel coloring, artificial sweeteners sucralose and acesulfame K, stabilizer xanthan gum, artificially flavored
Carb Up Black Energy Gel - Probiotic	3,83 (0,0300)	105 mL	Maltodextrin, deionized water, waxy corn starch (waxy maize), taurine, glucuronolactone, caffeine, inositol, nicotinamide (niacin), calcium D-pantothenate (pantothenic acid), pyridoxine hydrochloride (vitamin B6), riboflavin (vitamin B2) , cyanocobalamin (vitamin B12), acidity regulators monosodium citrate and phosphoric acid, flavoring, preservatives of potassium sorbate and sodium benzoate and sweeteners sucralose and acesulfame potassium.
Vo2 Energetic Gel Berries - Integralmedica	5,3 (0,0000)	20 mL	Maltodextrin, filtered water, dextrose, fructose, monosodium phosphate, potassium phosphate, sodium chloride, sodium citrate (stabilizer), artificial flavor, sodium benzoate and potassium sorbate (preservative), citrus flavor (acidulant) and sucralose (sweetener)). Artificially scented.
Bone Crusher Lemon Supplement - Black Skull ®	4,32 (0,0125)	45 mL	Creatine monohydrate, L-arginine, taurine, anhydrous caffeine, maltodextrin, flavors, citric acid acidulant, silicon dioxide anti-wetting agent, sucralose sweetener, tartrazine yellow artificial

			color
Pineapple Supplement - WheyProtein®	5,27 (0,0471)	10 mL	Whey Protein Isolate (WPI), Hydrolyzed Whey Protein (WPH)), Thickener, Xanthan Gum, Natural Pineapple and Artificial Vanilla Caramelized Flavors, Artificial Sweeteners Sucralose and Acesulfame Potassium and Natural Reb A (Glycosides of steviol)
Vanilla Supplement - WheyProtein®	6,34 (0,0294)	0 mL	Whey Protein Isolate (WPI), Hydrolyzed Whey Protein (WPH)], Thickener Xanthan Gum, Flavourings, Artificial Sweeteners Sucralose and Acesulfame Potassium and Natural Reb A (Steviol Glycosides).
Creatine Supplement -	6,66 (0,0492)	0 mL	Monohydrate creatine.
BCAA 12:1:1 Grape Supplement - Body Action	3,42 (0,0624)	25 mL	L-Leucine, Maltodextrin, L-Valine, L-Isoleucine, Vitamin B6 (Pyridoxine), Citric Acid Acidulant, Sucralose and Acesulfame-K Sweeteners, Silicon Dioxide Antiwetting.
Glutamine Supplement - 3VS	4,41 (0,5249)	5 mL	L-Glutamine.
Grape Maltodextrin Supplement - Bodyaction	2,64 (0,1061)	25 ml	Maltodextrin, Dextrose, Citric Acid Acidulant. Guarana with Açaí: Identical Aroma to Natural Guarana with Açaí and Caramel Colorings, Bordeaux Red and Brilliant Blue. Orange with Acerola: Identical Aroma to Natural Orange with Acerola and Twilight Yellow Dye. Lemon: Identical Aroma to Natural Lemon. Wild Strawberry: Identical Aroma to Natural Wild Strawberry and Bordeaux Red Dye. Grape: Identical Aroma to Natural Grape and Colorings Bordeaux Red and Brilliant Blue
Palatinosis Supplement - Bodyaction	6,58 (0,0492)	0 mL	Isomaltulose (Palatinosis)
X-Zero Advanced Supplement - Atlhetica Nutrition	2,92 (01281)	80 mL	Carbonated Water, Arginine, Taurine, Microencapsulated Caffeine, Niacin (Nicotinamide), Coenzyme Q10, Citric Acid Acidulant, Flavorings, Artificial Sweeteners Sucralose and Acesulfame Potassium, Sodium Citrate Stabilizer, EDTA Sequestrant, Caramel IV Color and Sodium Benzoate Preservative.
Hyper Mass Gainer Supplement Pineapple with Coconut - Atlhetica Nutrition	5,65 (0,0330)	0 mL	Maltodextrin, Amylopectin Starch (Waxy Maize), Creatine Monohydrate, Whey Protein Concentrate, Whey Protein Isolate, Hydrolyzed Whey Protein, Pineapple and Vanilla Natural Identical Flavor, Sucralose Artificial Sweetener and Yellow Artificial Color Tartrazine.
C4 Beta Pump Lemon Supplement - New Millen	4,35 (0,0591)	55 mL	Taurine, Glucoronolactone, Caffeine, Inositol, BETA PUMP FORMULA (Grape Seed Powder (Vitis Vinífera), Zinc Bisglycinate, Calcium Bisglycinate, Magnesium Bisglycinate, Dehydrated Watermelon Pulp (Citrullus Vulgaris Extract)), Vitamin Mix [B9 (folic acid), C (ascorbic acid), B3 (nicotinamide), B5 (calcium pantothenate), B12 (cyanocobalamin), B6(pyridoxine), B1 (thiamine), B2 (riboflavin)], Artificial Flavors, Xanthan Gum (thickener), Citric Acid (acidulant), Artificial Colors Green Leaf and Sucralose (sweetener).
Pure Strawberry Albumin Supplement - Naturovos	8,49 (0,0050)	0 mL	Albumin (dehydrated pasteurized egg white), aroma identical to natural strawberry, coloring (titanium dioxide and ponceau red), acidulant (citric acid and ascorbic acid) and sucralose.
Supercoffee - Caffeine Army	5,77 (0,1061)	0 mL	Medium Chain Triglycerides (MCT), Alkaline Cocoa, Instant Coffee, Taurine, Choline, Microencapsulated Caffeine, Lyophilized Green Tea, Cinnamon, Black Pepper (Piperine), L-Carnitine, Ginger, Vitamin Complex: Vitamin B1 (Thiamine), Vitamin B3 (niacin), vitamin B5 (pantothenic acid), vitamin B6 (pyridoxine HCl), vitamin B9 (folic acid), vitamin B12 (methylcobalamin), chromium picolinate, flavorings, acidity regulator sodium bicarbonate, sweetener steviol.
Desinchá Pineapple With Sicilian Lemon - Desin	6,05 (0,2225)	0 mL	green tea, carqueja, green mate, mint, guarana, ginger, sage, rosemary, natural aromas of pineapple and Sicilian lemon.
Pure Green Immunity Industrialized Kombucha – Pure Green	2,36 (0,0368)	55 mL	Filtered water, Kombucha culture, organic green tea, passion fruit, ginger, organic crystal sugar, spirulina and turmeric.
Beetroot Juice - Greenpeople	3,75 (0,0236)	55 mL	Mixed juice of carrot, orange and beetroot.
Detox Juice - Greenpeople	3,88 (0,0510)	15 mL	Orange juice, apple juice, cabbage juice, carrot juice and pressed ginger juice.
Natural Acai - Frooty	4,33 (0,1109)	15 mL	Acai Pulp, Water, Sugar, Corn Glucose, Stabilizer (INS 466), Natural-Identical Guarana Flavor and Citric Acid (INS 330)
Effervescent Vitamin C - EnergilC®	4,25 (0,0249)	35 mL	Sorbitol, aspartame, macrogol, orange essence, twilight yellow #6, twilight yellow #6 aluminum lake, sodium carbonate, sodium bicarbonate, sodium benzoate, citric acid.

Fonte: autora

Figure 1. Changes in pH of acidic beverages during neutralizing titration with saliva to pH 5,5.



Fonte: autora

Discussion

To the best of our knowledge, this is the most comprehensive study on the pH of beverages related to sport and physical activity. The results are extremely relevant, since diet has a great impact on the onset and progression of dentin hypersensitivity and non-carious cervical lesions(10,34) which are an increasingly prevalent diseases in the clinical routine, closely associated with eating and drinking habits.

Many athletes have specific dietary needs to optimize physical performance.(1–4,6,12,44) and sports drinks are an example. They are designed to help athletes rehydrate during or after extensive training or competition as they lose water and electrolytes. (17,26,27) Replacement of water and minerals promotes adequate rehydration, which is important for delaying the onset of fatigue during exercise.

In view of the great amount and increasing number of amateur and professional athletes worldwide, the global sports nutrition industry has grown considerably in recent years with hundreds of products like amino acids, creatine, energy and endurance, isotonic and hydration, meal support and replacements, nitric oxide, post-workout shakes, pre-workout, protein and protein bars. (45,46) They are easy to consume and perhaps the reason why their use considerably increased. They can help improve stamina as well as help replenish glycogen levels which can aid in muscle recovery and strength. (47,48)

On the other hand, the increase in the intake of energy, sports and functional beverages has led to as a greater risk of dental corrosion and, as a consequence, dentin hypersensitivity (1,4,6–13) These condition can significantly interfere negatively in athletes' performance during training and sports competitions

For this reason, dentists should develop personalized preventive protocols. However, there is no ideal protocol regarding oral health recommendations for a specific group of patients such as athletes. First, the ideal is to know the lifestyle of the patient, identifying risk factors and then guide and make them aware of the necessary care.(1–3,12) As it is not an explored area, there are few studies analyzing sports, supplementary, energetic and functional beverages.

One of the most important biological protective factors for dental corrosion is saliva. (35–38) Two protective characteristics are flow rate and neutralizing capacity.

When present in the oral environment in normal conditions, the presence of saliva leads to the dilution of beverages. However, exercise leads to a significant loss of fluid through sweating, leading to dehydration.(39) As dehydration progresses, the salivary flow rate decreases and the resulting xerostomia leads to a slower rate of elimination of the corrosive beverage that is less dilute. In addition, saliva also has the ability to neutralize and buffer acidic substances. Calcium and phosphate in saliva can help fight against pH drop and encourage remineralization of the tooth surface. As a result, it has been proposed that adding calcium and phosphate to sports and soft drinks can reduce the corrosive nature of the drinks. The challenge of adding calcium and phosphate to sports drinks is in the taste. People prefer the taste of drinks with a lower pH and attribute a repulsive taste to those with an increased pH and calcium content. Palatability is a challenging issue. (49)

As previously reported, there is a consensus in the literature that a pH of 5.5 is critical for the initiation of tooth demineralization. Following this rationality, the authors of the present study evaluated the average amount of saliva that would be necessary to raise the initial pH of each drink to 5.5, which is considered as a safe value. Concerning the dynamics of dental corrosion, the initial pH is an important property. When the pH of a beverage is below the critical threshold, it is said to be undersaturated and, therefore, capable of causing demineralization of hard dental tissues. (50) Our results are consistent with the pH values of beverages reported by other researchers. (31,32,51,52)

The way in which acidic beverage affect the tooth will depend on a complex interaction of the following components: the chemical properties of the beverages: pH, titratable acidity and calcium and phosphate content; the physical properties of beverages; composition of the individual's saliva, salivary flow rate, buffering capacity, drinking habits, frequency of consumption and duration and time of exposure.

Beverages can be composed of acids such as malic, ascorbic, citric and phosphoric. They are responsible for the dissolution and softening of the tooth surface. Usually, they are added by manufacturers as flavorings and preservatives but result in a reduction in pH, decreasing enamel hardness and causing demineralization.(53,54)

It is important to emphasize that the type of acid influences the corrosive potential of a product. Sports drinks, energy drinks and supplements have citric acid added to improve flavor and shelf life. (55,56) In an aqueous solution, this acid appears in 3 different forms: H+ ions, acid anions (citrate) and undissociated acid molecules. (14) The citrate product has a chelating action, binding with calcium ions present in hard dental tissues and saliva, prolonging corrosive wear. (14) In the present study, it can be observed that many beverages that had citric acid in their composition had pH values lower than 4.0 and longer salivary neutralization times, such as isotonic drinks of various flavors, energy drinks and some supplements. This information is similar with other findings in the literature.(20,26,33,57)

When a beverage has high titratable acidity, saliva will need more time to neutralize the acid, increasing its demineralizing potential. Therefore, it is possible to observe beverages with different corrosive potential even with similar pH. This can be seen when we compare the Maltodextrin UVA Supplement (pH=2.64) and the Life Strong Ultra Zero Green Apple Energy Drink (pH=2.63). The latter requires 4 times more saliva to reach a pH of 5,5 than the first one. This may be related to the composition such as the presence of acids and taurine.

It is interesting to notice that during the analysis of the beverages with lower pH, the volume of saliva was insufficient for a rapid and significant change in the pH. One example is the lemon juice. If the pH of beverages influences the corrosive potential during the first consumption, it can be assumed the importance of analyzing pH and titrable acidity. After consumption, the titratable acidity will be responsible for the time that the saliva will keep the oral pH low. (30)

Of the total beverages analyzed, 6 of them required more than 60 mL of saliva, demonstrating a high degree of resistance to pH increasing, indicating high buffering capacity. From a conservative and hypothetical point of view, taking into account the average value of 2 ml/min of stimulated saliva(37) the results in graphic 1 show that it would take 52 minutes for the carbohydrate gel to reach a pH of 5.5.

Carbohydrates are consumed around or during training periods to reduce muscle protein breakdown and increase muscle protein synthesis. (58) They are the main fuel used by muscle exercise and are important in maintaining exercise and sports performance(48,59) When consumed with protein, fast-acting carbohydrates such as maltodextrin, glucose and dextrose can accelerate muscle protein synthesis.(60,61) Carbohydrate supplementation before and during training helps maintain muscle glycogen levels, leading to better performance, as well as faster recovery due to enhanced muscle glycogen resynthesis. (48) Among those carbohydrate beverages studied, the one with the lowest pH was Gatorade Grape flavor (2.92), with values similar to those found in other studies.(3,26,27,62,63) Although several in vitro and in situ studies demonstrate the power of isotonics in the degradation of tooth structure, a recent systematic review pointed out that there is no scientific evidence to support such information, requiring further clinical studies. (27)

Pre-workout supplements are designed to optimize nutrient delivery before exercise/training with the aim of increasing energy availability, promoting vasodilation and positively affecting exercise. (1,64,65) These are composed of a combination of ingredients that may include stimulants (eg caffeine), energy producing agents (eg creatine), agents that act as hydrogen ion buffers (eg beta-alanine), protein recovery nutrients (eg, amino acids), antioxidants, nitric oxide precursors (eg, arginine), and energy enhancers (eg, citrulline malate). (1,46,47,65,66) One of the most consumed pre workouts is Whey Protein, but as we can see, as it is derived from milk, it has a higher pH, and is easily neutralized, not becoming a problem for dental wear, but it is necessary to pay attention to caries. However, Bone Crusher pre-workout supplement has a pH lower than the critical 5.5, and requires a greater volume of saliva to neutralize it (45 mL).

The removal of a drink from the mouth also depends on the ability of the drink to adhere to the tooth surface.(67) In other words, a more viscous or sticky drink tends to stay longer in the surface of the tooth. An example is the famous carbohydrate gel, widely used by endurance sports athletes. The need for carbohydrates immediately, before and during exercise depends on the objective, duration and intensity of the exercise session. (1,66) In this study, Carb Up Gel does not even have a low pH (3.80) when compared to other beverages evaluated, but saliva had difficulties in neutralizing it, being one of the beverages that consumed a high amount of saliva (105 ml). Water consumption helps maintain salivary flow and neutral pH. If sports nutrition products (such as drinks, bars and gels) are consumed during exercise, then a practical recommendation for the athlete is to rinse the mount with water to reduce the risk of cavities and corrosion.(6,67)

To conclude, understanding the lifestyle and habits of patients helps us to provide individualized and more appropriate dental care. (1,12,46,56) The present study highlights the need to promote preventive programs for athletes in order to improve their knowledge about acidic beverages. Dentists must understand that the use of sports drinks and supplements are often necessary for the athlete to achieve their desired performance, and therefore, it is not our job to prohibit consumption. What we can do is to raise awareness together with the athlete and sports professionals (nutritionists, physical educators, sports doctors). Some actions to minimize aggressions can be the use such as the use of a straw whenever possible, prescription of a mouthwash with fluoride, prescription of toothpaste with fluoride, oral hygiene guidelines, reducing the time that the drink remains in the mouth, rinse the mouth before brushing, control parafunctional habits and more importantly, consult your dentist routinely. More clinical studies involving direct observation of dental surfaces should be performed to determine the strength of associations between dental corrosion and acidic beverages.

Conclusion

Considering the limitations of this in vitro study, most beverages had an initial pH below 4 and energy drinks, carbohydrate gel, lemon juice showed greater resistance to neutralization with artificial saliva. The consumption of these drinks is recommended by sports professionals for the athlete to achieve his goals, but they can have an impact on oral health. Multidisciplinary work and guidelines are necessary to minimize tooth alterations in athletes.

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4. Capitulo 2

pH mapping of beverages, medicines and foodstuffs consumed in Brazil and the acid neutralizing capacity: an experimental study

Submetido para o *Brazilian Oral Research*

pH mapping and buffering capacity of Brazilian beverages, medicines and foods. An experimental study.

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Abstract

Objective: To evaluate the pH of beverages, foods and medicines available in the Brazilian market and the ability of these products to neutralize acid by adding artificial saliva. Methods: 90 products highly consumed by Brazilian population were evaluated. The groups were divided into: Group 1. Carbonated Drinks; Group 2: Fruit Juices; Group 3: Alcoholic Beverages; Group 4. Waters; Group 5: Teas; Group 6: Sauces/Condiments; Group: Others. A calibrated pH meter was used to measure the pH of each beverage, in triplicate, immediately after opening and after 15 minutes, at room temperature. To assess the pH neutralizing ability, 5 ml of artificial saliva were added every 1 min until reaching a pH of 5.5 (defined as the cut-off point) in the tested solution. Results: Of the total of all analyzed samples, 10% had a pH lower than 3; 51.11% pH between 3 and 4; 31.11% pH between 4 and 5.5; and 10% pH greater than 5.5. The drinks with the lowest pH values were: lemon juice (2.3), cola soda (2.38), cola soda (2.47), artificial grape juice (2.72) and carbonated water (2.92). It was found that 10% of the samples required saliva volumes greater than 100 ml, with natural lemon juice, salad dressing and ketchup being the most resistant products to reach a pH of 5.5. Conclusion: The results provide dentists and patients with relevant information on the corrosive potential of commercially available beverages by evaluating pH and buffering capacity. Specific dietary recommendations are necessary to prevent premature tooth wear.

Key-Words: dental erosion, pH, acid diet, beverages, drinks, saliva.

Introduction

In recent years there has been a change in the lifestyle and behavior of society and concomitantly, an increase in the consumption of acidic beverages and foods. (1–3) Acids present in foods, fruit juices, soft drinks, teas and energy drinks represent an important etiological factor for non-carious cervical lesions (NCCL) and tooth wear (TW), and consequently, for cervical dentin hypersensitivity (CDH). (2,4–8) It is a multifactorial disease with interaction between the mechanisms of corrosion, stress, attrition and abrasion. (1–3) Multicenter studies and systematic reviews shows a prevalence ranging from 17.7% to 97.9%. (3–7) Currently, it is a relevant and worrying situation for scientists and clinicians.

The consumption of acids has led to an increase in studies that investigate the influence of diet on the prevalence of tooth wear, and there is already some evidence that carbonated drinks and citrus fruits can have an impact on dental corrosion..(4,5,8–10) The corrosive potential of beverages is influenced by several physicochemical characteristics, such as: type of acid, concentration of hydrogen ions (pH), titratable acidity, concentration of calcium and phosphate, temperature, buffer capacity, frequency and contact time. It is accepted that the pH for enamel dissolution is 5.5, although wear is more evident in beverages with a pH below 4. (1,11–13)

The pH value provide only a measure of the initial concentration of hydrogen ions. On the other hand, the titratable acid content is the amount of base needed to bring a solution from an acidic pH to a neutral pH. The greater the titratable acidity of a liquid, the greater its buffering capacity. The buffering capacity of a substance is related to its resistance to changes in pH. It is considered that the greater the buffering capacity is, the more potentially corrosive the product will be. (14–16)

Saliva is one of the most important biological issue considered by researchers in reducing oral caries. Saliva has the potential to protect and clean the oral environment, maintaining teeth and the entire mucosa, antibacterial and antiviral activities and, most importantly, in flavor and digestibility. Saliva also has a proven and irrefutable role in oral pH balance as well as remineralization. It also has the ability to neutralize acids in the mouth.(16–19) Thus, saliva is one of the most important factors for the prevention and development of dental corrosion. Among the functions of saliva, buffering capacity should be highlighted as it corrects changes in the pH of the oral cavity, that is, it is important for the protection of oral tissues against dental corrosion through acidic foods and beverages. (18,20–22)

As prevention is the most effective way to reduce the occurrence of dental corrosion, it is extremely important for the dentist and the patient to identify the factors involved. Due to the high incidence and prevalence of this disease, the amount of literature has growing considerably, however, there are still many doubts and, as far as we know, there are no studies in Brazil with the variety of studied drinks and foods commercially available in the country.

Given this knowledge gap and considering the need of dentists and patient to the corrosive characteristics of beverages available for consumption, this study aims to determine the pH of commercially available beverages in Brazil and the acid neutralizing capacity by the addition of artificial saliva.

Methods

Ninety beverages commercially available in Brazil were analyzed (Table 1). The analyzes were performed at the Laboratory of Restorative Dentistry of the School of Dentistry of the University of São Paulo (FOUSP). Groups were divided into: Group 1. Carbonated Drinks; Group 2: Fruit Juices; Group 3: Alcoholic Beverages; Group 4. Waters; Group 5 Teas; Group 6: Sauces/Condiments; and Group 7: Others.

Tabela 1. Composition of all analyzed samples

Groups	Composition
Group 1 - Carbonated Drinks	
Pepsi Cola	Phosphoric acid, citric, acid and flavours
Coca Cola Normal - Coca-Cola Company	Carbonated water, sugar, kola nut extract, caffeine, caramel IV coloring, phosphoric acid acidulant and natural flavoring
Coca Cola Zero - Coca-Cola Company	Phosphoric acid, citric acid and flavours
Coca Cola Caffeine - Coca-Cola Company	Carbonated water, sugar, kola nut extract, caffeine, caramel IV coloring, phosphoric acid acidulant and natural flavoring
Schweppes Citrus - Coca-Cola Company	Carbonated water, concentrated apple, orange and grapefruit juices, acidity regulators citric acid and sodium citrate, natural flavor, sweeteners sodium cyclamate, sodium saccharin, conservative potassium sorbate, artificial coloring tartrazine.
Guarana Antarctica	Carbonated water, guarana extract, citric acid acidulant, sweeteners, aspartame and potassium acesulfame, sodium benzoate preservative, flavoring and caramel coloring IV.
Sprite - Coca-Cola Company	Carbonated Water, Sugar, Lemon Juice Concentrate, Natural Flavor, Citric Acid, Sodium Benzoate and Potassium Sorbate Preservatives.
Guarana Jesus - Coca-Cola Company	Carbonated water, sugar, guarana extract, citric acid and tartaric acid acidulants, flavoring, preservatives sodium benzoate and potassium sorbate, EDTA sequestrant, disodium calcium and amaranth and twilight yellow FCF dyes.
H2O2 Lemon - YES	Carbonated water, concentrated lemon juice, vitamins: B3, B5 and B6, flavoring, citric acid acidulant, preservatives: sodium benzoate and potassium sorbate, sweeteners: aspartame and acesulfame potassium, disodium calcium EDTA sequestrant.
Fanta Grape - Coca-Cola Company	Carbonated water, sugar, grape and lemon juices, synthetic flavor identical to natural, acidulant citric acid, acidity regulator sodium citrate, preservatives sodium benzoate and potassium sorbate, artificial colors amaranth, brilliant blue FCF and tartrazine.
Fanta Orange - Coca-Cola Company	Carbonated Water, Sugar, Orange and Apple Juices, Natural Identical Synthetic Flavor, Acidity Regulators Citric Acid and Sodium Citrate, Sodium Benzoate and Potassium Sorbate Preservatives, Stabilizers Sucrose Acetate Isobutyrate and Sodium Dioctyl Sulphosuccinate and Yellow Artificial Color Twilight FC.
Tonic Water - Antarctica	Carbonated water, sugar, quinine, flavoring, acidulants: citric acid and tartaric acid and preservatives: sodium benzoate and potassium sorbate.
Lemon Flavored Carbonated Water - Crystal	Carbonated water and natural flavors in lemon flavors

Sparkling Water - Crystal	Water and carbon dioxide
Group 2 - Juices	
Natural Lemon Juice	Ascorbic Acid (Vitaminca C), Citric Acid, Folic Acid, Vitamin B6, Niacin, Riboflavin, Thiamine, Vitamin A, Zinc, Potassium, Magnesium, Calcium and Phosphorus
Dell Valle Nutri Grape	Water, Grape Juice Concentrate, Sugar, Apple Juice Concentrate, Vitamin C, Zinc, Vitamin A, Natural Flavor, Acidity Regulator Citric Acid and Xanthan Gum Stabilizer
Peach Dell Valle Nutri	Water, Peach Pulp, Citric Acid Acidulant, Natural Flavor, Xanthan Gum Thickener, Ascorbic Acid Antioxidant And Artificial Sweeteners Sucralose And Acesulfame K.
Yakult apple	Concentrated apple juice, water, citric acid acidulant and natural apple flavor
Dell Valle Nutri Mango,	Water, mango pulp, sugar, apple juice concentrate, vitamin C, zinc, vitamin A, acidity regulator citric acid, natural flavor and stabilizer xanthan gum
Orange Ades Soy	Water, Soybean Extract, Inverted Liquid Sugar, Orange Juice, Concentrate, Sugar, Maltodextrin, Vitamins (C, B3, B6, B2, Folic Acid and B12) and Minerals (Iron and Zinc), Stabilizers Pecithin and Guma Guar, Acidulant Citric Acid, Flavourings, Malic Acid Acidity Regulator, Urucum and Turmeric Colors and Sucralose Sweetene
Whole Grain Orange	Orange juice with pulp.
Pineapple Ades	Water, Soy Extract, Sugar, Pineapple Juice Concentrate, Malto Dextrin, Vitamin E Minerals (b1, B2, B3, B6, B12, C, Folic Acid, Iron And Zinc), Acidulants Citric Acid And Malic Acid, Stabilizers Citric Pectin, Guar Gum And Calcium Chloride, Flavoring, Annatto And Carmine Color, Sweetener And Artificial Sucralose.
Apple Ades Max Soy	Water, Soybeans, Inverted Liquid Sugar, Apple Juice Concentrate, Sugar, Maltodextrin, Vitamins C, B3, B6, B2 and B12, Zinc Mineral, Stabilizers Pectin and Guar Gum, Citrus Acid, Flavoring, Malic Acid Acidity Regulator and Sweetener Sucralose
Grape Ades Soy	Water, Soybean Extract, Sugar, Concentrated Grape Juice, Inverted Liquid Sugar, Maltodextrin, Vitamins (C, B3, B6, B2, Folic Acid and B12) and Minerals (Iron and Zinc), Stabilizers Pectin and Guar Gum, Acidulant: Citric Acid, Flavoring, Carmine Color, Malic Acid Acidity Regulator and Sucralose Sweetener.
Natural Orange	Water, calories, protein, fat (saturated fatty acid, monounsaturated fatty acid, polyunsaturated fatty acid, cholesterol, carbohydrates, calcium, phosphorus, iron, potassium, sodium, vitamin A, (retinol equivalent), thiamine, riboflavin, niacin and ascorbic acid (vitamin C)

Peach Soy Ades	Water, soy extract, invert sugar, peach juice, sugar, maltodextrin, vitamins (B2, B3, B12, C, folic acid) and minerals (iron and zinc), stabilizers, citrus pectin and guar gum, citric acid acidifier, regulator malic acid acidity, flavoring (flavor identical to natural peach), annatto and carmine dyes and sucralose sweetener.
Guava – Da Fruta	Water, guava pulp and sugar, acidulant and antioxidant.
Cashew – Da Fruta	Water, Cashew Juice Concentrate, Apple Juice Concentrate, Acidulant, Citric Acid, Natural Coloring, Anthocyanin, Flavoring and Anti-foam.
Group 3 - Alcoholic/Energy Drinks	
Absolut Pure Vodka	Water and a special wheat
Pure Cachaça 51	Distillate from fermented must obtained from sugar cane juice and water.
Cachaça Ice 51 Passion Fruit	Carbonated water, sugar, sugar cane alcoholic distillate, sugar cane spirit, citric acid, natural passion fruit flavor, natural citric flavor, malic acid, sodium citrate, benzoate sodium, tartrazine yellow dye and twilight yellow dye.
Pilsen Heineken beer	Water, malt and hops.
Brahma Pilsen beer	Water, malt, corn and hops
Pilsen Skol beer	Water, malt, corn and hops
Pilsen Budweiser beer	Water, malt, rice and hops
Carbenet Sauvignon Red Wine	Blend of Cabernet Franc (red) and Sauvignon Blanc (white) grapes
White Wine	Fermented grapes and preservative
Red Label Whiskey	Aged single malt alcohol distillate, unmalted cereal alcoholic distillate, water and caramel color.
Liquor Stock Coffee	Water, alcohol, sugar, natural coffee extract and coloring.
Wild Catuaba	Dry Red Wine, Potable Ethyl Alcohol, Sugar, Apple Juice, Apple Syrup, Fermented Apple Compound With Catuaba Extract, Guarana And Marapuama, Sugar Caramel, Acidulant Ins 330, Stabilizer Ins 332ii, Conservatives Ins 202 And Ins 211 And Water
Terra Nova Moscatel sparkling wine	Moscato Grapes (Vitis Vinifera)
Red Bull Energy Drink	carbonated water, sucrose, glucose, taurine, caffeine, vitamins (B3, B5, B6, B2, B12), citric acid acidulant, acidity regulators: sodium bicarbonate and magnesium bicarbonate, flavorings, caramel coloring
Group 4 - Water	
Coconut Water - Obrigado	Water, sugar, coconut milk, mineral calcium, salt, vitamins C, B3, E, B5, B6, B1, A, H, D and B12, stabilizers xanthan gum and guar, natural coconut flavor

Water - Bonafont,	Fluoridated mineral water
Water - Crystal	Fluoridated mineral water
Water - Ibirá.	Vanadic Fluoridated Mineral Water
Group 5 - Tea	
Matte Tea - Lion	Water, sugar, aqueous extract of mate (Ilex paraguariensis St. Hil), acidity regulator citric acid and antioxidant ascorbic acid.
Matte Tea - Dr. Oetker	Roasted mate tea (Ilex paraguariensis St. Hil), leaves and stems.
Chamomile Tea - Lion	Floral Chapters of Chamomile (Matricaria recutita, L.)
Chamomile Tea - Dr. Oetker	Chamomile (Matricaria recutita L.) - floral capitula
Tea with Lemon - Lipton	Water, sugar, black tea extract, concentrated lemon juice, citric acid acidulant, preservatives: potassium sorbate and dimethyl dicarbonate, acidity regulator sodium citrate, antioxidant ascorbic acid and flavoring
Pineapple Tea with Sicilian Lemon - Desinchá	Green tea, carqueja, green mate, mint, guarana, ginger, sage, rosemary, natural aromas of pineapple and Sicilian lemon
Group 6 - Sauces/Condiments	
Premium Shoyu Sauce - Sakura	Water, salt, soy, corn, sugar, glucose syrup, caramel coloring and potassium sorbate conservative
Tarê Sauce - Sakura	Soy sauce (water, salt, soy, corn, sugar, caramel coloring and potassium sorbate preservative), water, sugar, sake, glucose syrup, modified starch, caramel coloring, acidulant, lactic acid, flavor enhancer, monosodium glutamate, conservative potassium sorbate and xanthan gum thickener
Tomato Sauce - Heinz	Tomato, Sugar, Onion, Modified Starch, Salt, Vegetable Oil, Yeast Extract, Garlic, Parsley, Basil, Oregano, Thyme, Sage and Flavor Enhancer Monosodium Glutamate
Pepper Sauce - Aztec	water, ground red pepper, alcohol vinegar, salt, crystal sugar. additive: conservative sodium benzoate ins 211
Worcestershire sauce - Gota	Alcohol Vinegar, Salt, Sodium Benzoate Conservative Natural Meat Flavor, Brown Sugar, Natural Fried Onion Flavor, Caramel Color, Pepper Flavor, Roasted Oak Extract, Soybean Flavor, Natural Compound Extract and Worcestershire Sauce Flavor
Ready Rose Sauce - Hikari	Water, vegetable oil, sugar, vinegar, tomato pulp, powdered milk, salt, monosodium glutamate flavor enhancer, aroma identical to natural onion and ketchup, lactic acid acidulant, xanthan gum thickener, potassium sorbate preservative, EDTA sequestrant and BHT and BHA antioxidant
Ketchup - Heinz	tomato, sugar, vinegar, salt, onion and natural aroma.
Mustard - Heinz	water, vinegar, mustard, salt and natural dyes turmeric and paprika.
Extra Virgin Olive Oil - Borges	Extra virgin olive oil extracted from olives.

Group 7 - Others	
Roasted Coffee - Três Corações	Ground roasted coffee
Instant Coffee Nescafé - Nestle	Water, coffee in powder or granule form
Natural Yogurt - Itambé	Whole milk, skimmed milk powder, milk proteins, dairy yeast
Activia Plum Yogurt	Whole Milk And/or Reconstituted Whole Milk, Sugar, Plum Preparation (Sugar, Plum, Water, Fructose, Starch, Flavoring, Natural Caramel Coloring, Preservative Potassium Sorbate, Thickener Xanthan Gum And Citric Acid Acidulant), Milk Protein, Cream Milk, Modified Starch And Dairy Yeast.
Activia Strawberry Yogurt	Whole milk and/or reconstituted whole milk, sugar, fruit preparation (strawberry, water, strawberry pulp, sugar, modified starch, calcium chloride, citric acid acidulant, natural carmine coloring, acidity regulator sodium citrate, flavorings, thickener xanthan gum and potassium sorbate preservative), skimmed milk powder, cream, modified starch, lactic yeast and pectin stabilizer
Chamyto probiotic	Skimmed milk and/or reconstituted skimmed milk, liquid sugar, concentrated whey, inverted liquid sugar, lactic ferments and flavorings.
Yakult Probiotic	Water, skim milk, glucose-fructose syrup, sucrose, citrus aroma and live bacteria Lactobacillus paracasei Shirota
Whole Milk - Paulista	Whole Milk Sodium Phosphate, Sodium Diphosphate Stabilizer, Sodium Monophosphate and Eratodent Citrate
Tic Tac Orange	Sugar, Maltodextrin, Rice Starch, Flavourings, Acidulants Citric Acid and Tartaric Acid, Gum Arabic Thickener, Magnesium Stearate Anti-Humming, Carnauba Wax Glazing
Tic Tac Mint	Sugar, Mastodextrin, Rice Starch, Fructose, Gum Arabic Thickener, Flavourings: Anti-humectant Magnesium Stearate, Carnauba Wax Glazing
Fruit Salt Eno Lemon	sodium bicarbonate, sodium carbonate, citric acid, sodium saccharin, lemon flavor and quinoline yellow.
Fruit Salt Tutti Frutti	sodium bicarbonate, sodium carbonate, citric acid, sodium saccharin, artificial fruit flavor, maltodextrin and red coloring
Engov After	Water, sucrose, maltodextrin, glucose monohydrate, trisodium citrate dihydrate, sodium chloride, caffeine, flavoring, acidity regulator: citric acid, acidulant: tartaric acid, preservatives: potassium sorbate and sodium benzoate and sweeteners: acesulfame potassium and sucralose

Fonte: autora

The evaluation of the samples was performed in triplicate and the pH evaluation was conducted immediately after opening the beverage. The initial pH value was measured using an electrode connected to a digital pH meter (K39-1014B – Kasvi, Paraná, Brazil). Before the beginning of each evaluation, the electrode was calibrated with standard buffers of pH 4.0 and 7.0. To avoid contamination, the meter was washed with distilled water. All drinks were tested at room temperature and each was opened following the manufacturer's instructions. After opening the packages, 50 mL of the freshly opened beverage were dispensed into an identified glass beaker, under constant stirring with an unheated magnetic stirrer (model) until an initial stable reading was obtained, and the package was placed on the side resting, sealed or closed again, as possible. Then, the initial pH value of the samples was recorded.

Subsequently, to perform the neutralization of the samples, artificial saliva (0.213 g/l $CaCl2·2H2O$; 0.738 g/l $KH2PO4$; 1.114 g/l KCl; 0.381 g/l NaCl; 12 g/l Tris43) was used with pH at 8,0 with HCL. After the initial stable pH reading, using a pipette, 5 mL of saliva was added every 1 minute until reaching a pH reading of 5.5 (considered a cut-off point). All measurements were performed in triplicate and an average result was obtained for each beverage. This procedure was repeated for all samples. At the end, the amount of saliva necessary to raise the pH from the initial value to the established value of 5.5 was recorded. The results obtained were analyzed and compared in tables and graphs.

To evaluate the neutralization capacity (NC) data, a graphic with pH x mL of salivary solution was added. The resulting curve allowed the comparison of different buffer capacities among the analyzed beverages.

After 15 minutes of opening the packages, another 50 mL of the beverage was dispensed into another identified glass beaker, under constant agitation with an unheated magnetic stirrer. The pH and neutralization measurements were performed the same as described above.

Results

Table 2 shows the initial pH, pH after 15 min and the amount of saliva needed to reach the cut-off value for all products. Of the total of all analyzed samples: 12,79% had a pH lower than 3; 45,34% pH between 3 and 4; 29,06% pH between 4 and 5.5; and 10% pH greater than 5.5.

In groups 1 and 2 all drinks had a pH below the critical value; in group 3, all drinks had a pH greater than the critical one, with the exception of Vodka Absolut that reached had a pH of 7,72; in group 4, the exception was coconut water (pH 4,56); and in group 5, only Tutti Frutti Fruit Salt, Tic Tac Menta, Extra Virgin Olive Oil and Paulista Whole Milk had a pH greater than 5.5.

As for the acid neutralizing capacity, figure 1 shows the pH performance after the addition of saliva in each of the beverages evaluated. It was found that 10 samples required saliva volumes greater than 100 ml (Lemon Juice, Grape Juice, Vodka w/ lemon, Red Bull Energy, TNT Energy, Catuaba, Rosé Sauce, Pepper Sauce, Ketchup, Mustard), with lemon juice being the one that required the largest amount to reach a pH of 5.5 (300 ml). Most of the samples required low volumes of artificial saliva to reach a pH of 5.5 (maximum 50 mL).

Table 2. pH values and amount of saliva used for each sample.

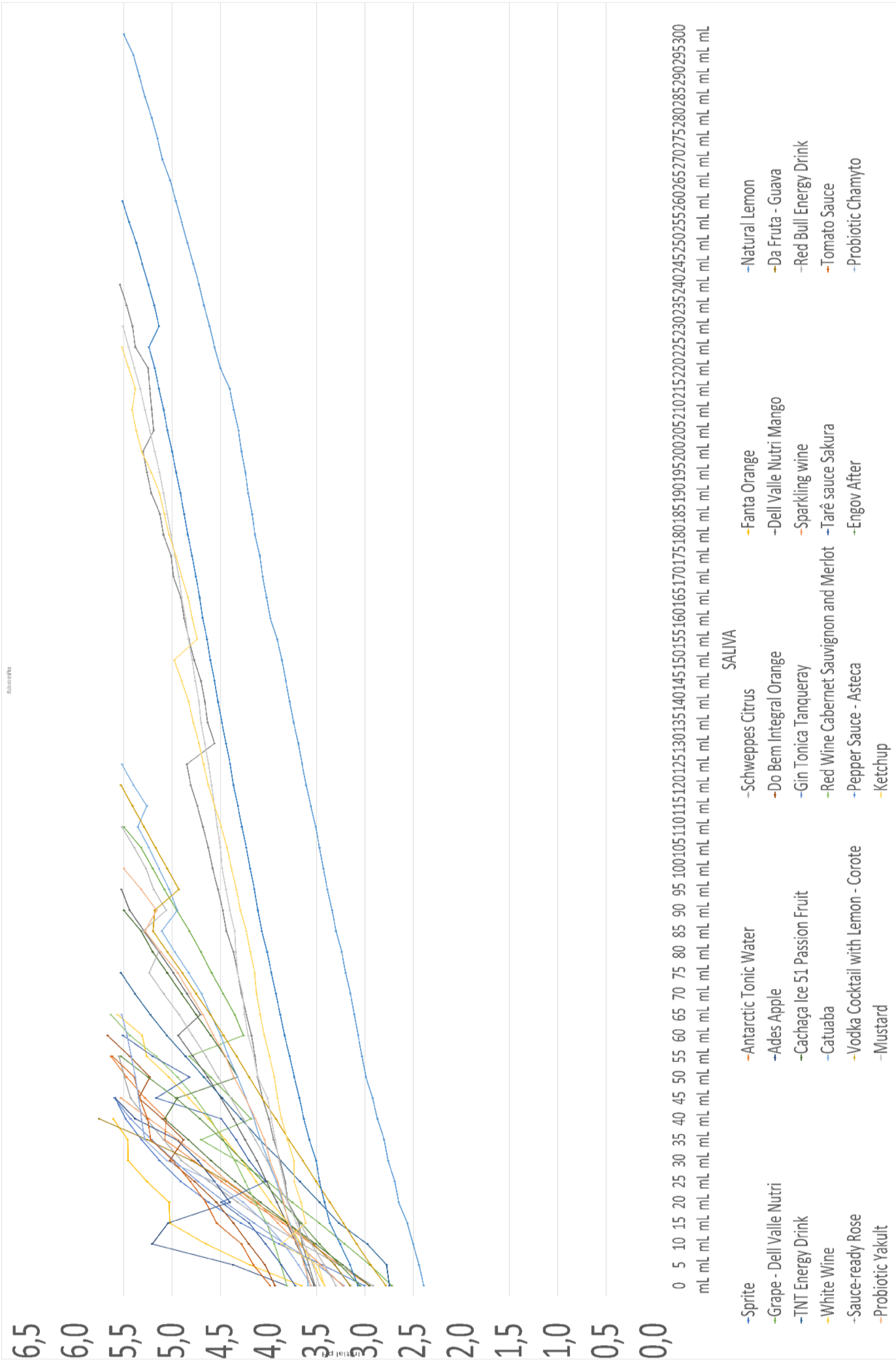
	Immediately		After 15 minutes	
	Average pH Standard deviation	Quantidade de Saliva (mL)	Average pH Standard deviation	Quantidade de Saliva (mL)
Group 1 - Carbonated Drinks /Soft Drinks				
1. Pepsi Cola	2,38 (0,0245)	25	2,40 (0,0668)	20
2. Regular Coca Cola	2,47 (0,1349)	25	2,45 (0,0655)	25
3. Coke Zero	2,87 (0,1003)	25	2,84 (0,1003)	30
4. Schweppes Citrus	2,92 (0,1223)	55	2,899 (0,1337)	45
5. Antarctic Tonic Water	2,96 (0,0411)	55	2,91 (0,1109)	55
6. Sprite	3,01 (0,0150)	45	3,00 (0,0550)	40
7. Guarana Antarctica	3,05 (0,1728)	35	3,07 (0,1857)	35
8. H2O2 Lemon	3,08 (0,2290)	20	3,08 (0,2195)	20
9. Coke Caffeine	3,22 (0,0450)	15	3,22 (0,0500)	15
10. Guarana Jesus	3,30 (0,0170)	35	3,27 (0,0249)	25
11. Fanta Grape	3,41 (0,2328)	35	3,40 (0,2585)	15
12. Fanta Orange	3,66 (0,1678)	40	3,59 (0,2029)	35
13. Flavored Carbonated Water	4,20 (0,0330)	20	4,21 (0,0094)	15
14. Crystal Sparkling Water	4,70 (0,0047)	25	4,70 (0,0082)	25
Group 2 - Juices				
15. Natural Lemon	2,39 (0,0535)	300	2,40(0,0589)	300
16. Grape - Dell Valle Nutri	2,72 (0,0125)	110	2,71 (0,0205)	115
17. Guava – Da Fruta	3,15 (0,0047)	40	3,28 (0,0141)	45
18. Cashew – Da Fruta	3,26 (0,0216)	25	3,13 (0,0047)	25
19. Peach - Dell Valle Nutri	3,37 (0,0047)	35	3,37 (0,0082)	35
20. Citrus Fruits - Dell Valle	3,40 (0,2988)	30	3,06 (0,0141)	30
21. Apple - Yakult	3,58 (0,1452)	35	3,54 (0,0556)	25
22. Mango - Dell Valle Nutri	3,53 (0,0665)	95	3,58 (0,1360)	85
23. Orange - Soy Ades	3,68 (0,0047)	20	3,67 (0,0125)	20
24. Grape - Ades Max	3,77 (0,1350)	20	3,80 (0,1600)	30
25. Pineapple - Ades	3,77 (0,0125)	25	3,78 (0,0000)	20
26. Soy Apple - Ades Max	3,81 (0,0309)	45	3,82 (0,0309)	35
27. Orange - Ades	3,91 (0,2250)	20	3,84 (0,1500)	20
28. Whole Orange – Do Bem	3,93 (0,1880)	60	3,89 (0,1391)	85
29. Soy Grape - Ades	3,96 (0,0141)	15	3,94 (0,0000)	30
30. Natural Orange	4,04 (0,0189)	40	3,98 (0,0698	40
31. Peach Soy - Ades	4,01 (0,1021)	20	4,02 (0,0262)	15
Group 3 - Alcoholic and Energy Drinks				
32. Energy Drink - TNT	2,75 (0,2719)	100	2,86 (0,3972)	130
33. Vodka Cocktail with Lemon - Corote	2,78 (0,0368)	120	2,79 (0,0245)	110
34. Cachaça Ice Passion Fruit - 51	2,95 (0,0850)	90	2,94 (0,1115)	75
35. London Dry Gin & Tonic - Tanqueray	3,22 (0,0386)	40	3,22 (0,0432)	45
36. Sparkling Wine - Terra Nova	3,23 (0,0386)	45	3,21 (0,0283)	50
37. Energy Drink - Red Bull	3,30 (0,1434)	110	3,31 (0,1349)	75
38. White Wine - Almaden	3,42 (0,0648)	65	3,41 (0,0618)	65

39. Smooth Bordo Wine - Quinta Morgado	3,44 (0,0510)	85	3,43 (0,0525)	100
40. Catuaba - Selvagem	3,59 (0,3074)	125	3,60 (0,3437)	110
41. Carbenet Merlot- Sauvignon Red Wine - Santa Carolina	3,61 (0,14850	20	3,62 (0,1414)	65
42. Red Wine Carbenet Sauvignon and Merlot - Kernel	3,81 (0,0141)	65	3,82 (0,0287)	70
43. Whiskey - Red Label	3,95 (0,1344)	5	3,96 (0,1327)	5
44. Pilsen Beer - Skol	4,16 (0,1190)	20	4,12 (0,0818)	20
45. Pilsen Beer - Brahma	4,20 (0,0245)	20	4,17 (0,0170)	20
46. Pilsen beer - Budweiser	4,25 (0,1744)	20	4,20 (0,1840)	20
47. Cognac - Domus	4,26 (0,0478)	5	4,29 (0,0249)	5
48. Beer 0.0% Alcohol - Heineken	4,41(0,0170)	15	4,41 (0,0163)	15
49. Witbier beer - Hoegaarden	4,41 (0,0943)	15	4,41 (0,0732)	20
50. Liquor Coffee -Stock	4,42 (0,1181)	5	4,55 (0,0579	5
51. Ipa beer - Eisenbahn	4,43 (0,0990)	15	4,37 (0,0094)	15
52. Pilsen Beer - Heineken	4,55 (0,0330)	10	4,55 (0,2245)	10
53. Pure Cachaça - 51	4,7 (0,2968)	5	4,86 (0,2229)	5
54. Pure Vodka - Absolut	7,72 (0,2255)	0	7,54 (0,1621)	0
Group 4 - Water				
55. Coconut Water - Obrigado	4,56 (0,0000)	5	4,56 (0,0000)	5
56. Mineral Water - Bonafont	6,24 (0,3159)	0	6,26 (0,2855)	0
57. Mineral Water - Crystal	7,52 (0,0712)	0	7,65 (0,0572)	0
58. Mineral Water - Ibirá	10,22 (0,0170)	0	10,14 (0,0967)	0
Group 5 - Tea				
59. Matte Tea - Leão	5,13 (0,0082)	5	5,15 (0,0047)	5
60. Matte Tea - Dr. Oetker	5,26 (0,0094)	5	5,28 (0,0340)	5
61. Chamomile Tea - Lion	5,96 (0,0205)	0	5,96 (0,0125)	0
62. Chamomile Tea - Dr. Oetker	6,30 (0,0946)	0	6,29 (0,0471)	0
63. Lemon tea - Lipton	3,48 (0,2027)	25	3,34 (0,0047)	25
64. Pineapple tea with Sicilian lemon - Desinchá	6,07 (0,1910)	0	6,07 (0,1840)	0
Group 6 - Sauces/Condiments				
65. Premium Shoyu Sauce - Sakura	4,52 (0,1556)	35	4,55 (0,1511)	30
66. Tarê Sauce - Sakura	3,72 (0,2493)	60	3,72 (0,2245)	65
67. Tomato Sauce - Heinz	3,98 (0,1312)	55	3,99 (0,1424)	50
68. Pepper Sauce - Asteca	3,07 (0,1212)	240	3,07 (0,1268)	255
69. Ready Rose Sauce - Hikari	3,52 (0,0368)	240	3,50 (0,0309)	280
70. Ketchup - Heinz	3,42 (0,0535)	225	3,40 (0,0377)	220
71. Mustard - Heinz	3,47 (0,0047)	230	3,46 (0,0082)	230
72. Extra Virgin Olive Oil - Borges	6,53 (0,0236)	0	6,54 (0,0047)	0
Group 7 - Others				
73. Tic Tac Orange - Ferrero	2,92 (0,0205)	10	2,91 (0,0205)	10
74. Engov After - Hypera	3,05 (0,0125)	55	3,06 (0,0141)	55
75. Probiotic - Chamyto	3,56 (0,1276)	65	3,54 (0,1268)	55
76. Probiotic - Yakult	3,57 (0,0216)	95	3,55 (0,0544)	95
77. Nescafé Instant Coffee - Nestlé	4,05 (0,0047)	40	4,28 (0,0047)	45
78. Plum Yogurt - Activia	4,13 (0,0602)	60	4,10 (0,0873)	50
79. Natural Yogurt - Itambé	4,15 (0,0478)	85	4,15 (0,0340)	85
80. Strawberry Yogurt - Activia	4,17 (0,0881)	40	4,15 (0,1061)	45
81. Strawberry Yogurt - Danone	4,18 (0,1699)	40	4,14 (0,1674)	65
82. Roasted coffee - Três Corações	5,01 (0,1652)	5	4,98 (0,1533)	5
83. Eno Lemon Fruit Salt - GSK	5,42 (0,3167)	25	5,94 (0,3057)	25
84. Tutti Frutti Fruit Salt - GSK	5,89 (0,0294)	0	6,11 (0,0245)	0

85. Tic Tac Mint - Ferrero	6,54 (0,0309)	0	6,53 (0,0309)	0
86. Milk - Paulista	6,64 (0,0650)	0	6,63 (0,0525)	0

Fonte: autora

Figure 1. Saliva neutralization curves in relation to the pH of all beverages that had a pH lower than 4 and more than 40mL of saliva.



Fonte: autora

Discussion

Changes in lifestyle of the population and the greater availability of industrialized drinks and foods, can lead to mineral loss of dental structures. There are some studies in the literature with this variety and quantity of products, but in other countries. So, as far as we know, this is the first study concerning brazilian products. Since diet is an important extrinsic factor for tooth wear, this study determined the pH and salivary neutralization capacity of different products, available on the brazilian market. They were selected to cover a wide variety of categories, including soft drinks, energy drinks, alcoholic beverages, waters, juices, teas, yogurts, sauces and medications. Each product had different characteristics and chemical compositions.

The corrosive potential of beverages is influenced by several physicochemical characteristics, such as: type of acid, concentration of hydrogen ions (pH), titratable acidity, concentration of calcium and phosphate, temperature, buffer capacity, frequency and contact time. (1,11–13) The pH is primarily responsible for the immediate dissolution and surface softening of the tooth structure.(23) It is accepted that the pH for enamel dissolution is 5.5, although wear is more evident in beverages with a pH below 4. Several authors discuss that titratable acidity does not play a critical a role in tooth wear as pH does, due to the limited time of exposure of teeth to liquids ingested during each ingestion and swallowing episode. (14,23–26) Therefore, it is also discussed that the pH at the time of exposure in the oral cavity is a very important chemical parameter to evaluate when determining the corrosive potential of beverages and foods. (23)

The results of this experimental study showed that most products available in Brazil have a pH lower than 4, corroborating with other studies. (24,27–29) Something to point out is the effect of acid type and CN, which can be seen by comparing Pepsi Cola (pH 2.38, CN=25 mL, phosphoric acid), with lemon juice (pH 2.30, CN=300 ml, citric acid). Both drinks have similar pH values, but Lemon Juice showed a greater need for saliva for acid neutralization than the soda drink.

Citric acid is a common component in many fruit juices and sodas. It is one of the most corrosive acids due to its chelating capacity. It is responsible for releasing H+ ions into the medium. Citrate ion will confiscate calcium from saliva and teeth, increasing the degree of subsaturation of hydrogen ions and favoring demineralization, making it inactive for remineralization. (30–32) Therefore, beverages with low pH and containing citric acid are considered to have the greatest corrosive capacity. (30,32) This information was possible to observe in this study, in which Lemon Juice, Mango Juice Dell Valle Nutri, Energy drinks (which have higher concentrations of citric acid) had lower pH values and needed a greater amount of saliva to reach a neutral pH. This is an alarming data because lemon is one of the most consumed fruits by Brazilians, requiring guidance from the dentist so that their patients can consume it safely and be the less aggressive to their teeth.

Some fruit juices have higher initial pH values than soft drinks, but required much more saliva. As already mentioned, the most acidic drink tested was lemon juice with a pH lower than 2.3, corroborating with other studies.(14,15,23,24,33–35) Soft drinks can contain several different types of acid that contribute to the low pH value.(36) Those based on cola contain phosphoric acid as the main buffer, presenting a low initial pH value (approximately pH 2.5), but a low titratable acidity and buffering and, as demonstrated in this study, much faster of being neutralized by saliva when compared to lemon juice (300 mL).(36)

Flavored distilled beverages are composed of sugars, citric and malic acid and have a pH around 3 and are more difficult to neutralize than pure beverages.(14,37,38) The passion fruit flavor 51 ICE cachaça had one of the lowest pH and needed the highest amount of saliva to neutralize. This situation is quite different from beers, when all of them have a pH greater than 4.0, and a small amount of saliva for neutralization was required, indicating a low potential to cause tooth wear. This information is in accordance with other studies. (28,38,39)

Another widely consumed drink by Brazilians is wine. All brands evaluated had an initial pH lower than 4, which is in line with other studies.(31,38) Catuaba and sparkling wine also had similar behavior, as they present a similar composition to wine.

It is important to emphasize that products that have calcium, phosphate and mineral content have a positive impact on corrosive potential. An example is yogurt, which had a pH lower than the critical one (<4.5), but its potential for tooth wear is much lower when compared to soda, for example. (14,32) This can be explained by the high levels of calcium and phosphate concentrations that probably minimize the demineralization process. Products with calcium in its composition cause saturation of apatite, preventing these ions from leaving the enamel.(40)

Saliva plays an important role in the reduction of tooth wear due to its ability to buffer, remineralize and form a protective film layer on dental hard tissues. (18,19,22,41,42) Of the total of beverages analyzed, 11,62% of them required more than 105 mL of saliva, demonstrating a high degree of resistance to the increase pH, indicating a high buffering capacity. From an hypothetical point of view, considering an average value of 2 ml/min of stimulated saliva (18), the results of graph 1 show that after just one sip it would take 55 minutes for the Red Bull energy drink to reach a pH of 5.5, while lemon juice takes approximately 1.5 hours.

Another factor that can impact corrosion is temperature. Several studies point out that drinks with lower temperatures would reduce the loss of tooth structure. However, the present study to maintain a standard evalution for all samples, room temperature was preferred. (30,43,44) Despite this, more studies are needed for more conclusive and evidence-based information.

It is important to emphasize that the frequency and duration of the acid in contact with the teeth are an important variable for the development and progression of tooth wear.(30,44) Drinking habits, such as holding or rinsing the liquid in the mouth before swallowing can favor tooth wear due to the prolonged duration of the acidic liquid in the mouth. Another relevant issue to be raised is brushing after an acid challenge. There are studies that show that waiting some minutes to brush your teeth would increase enamel resistance. (45–49) However , there is still no consensus in the literature, as other studies point out that the remineralizing effect of saliva does not occur even after waiting a while to brush the teeth. (4,8,50,51) Also, a recent systematic review showed that even the studies that waited up to 4 hours for remineralization, wear of dental structures was also observed. (5,47,51,52) Therefore, just putting off brushing after an acid challenge doesn't seem to be an useful and practical preventive measure for daily oral care .(1,50,52)

Knowledge of pH is essential for the development of preventive strategies for patients at risk for dental corrosion.(24,53) The information obtained in this study will allow dentists to make appropriate dietary suggestions and advice patients about the harmful effects of the acids they ingest. (1,3,23)

Prevention and control of progression of tooth wear is not an easy mission. This is because we are facing a multifactorial disease, in which we must investigate the patient's routine, behavioral and eating habits and also know the characteristics of the products consumed. It is necessary to recognize that there are several factors involved in the progression of the disease. (54) Some guidelines can be suggested: to rinse the mouth before brushing, use of toothpaste containing fluoride, use of soft bristle brushes and without mechanical force. Drinking through a straw also minimizes the contact of the drink with teeth and may cause less corrosion in susceptible individuals.(55) In addition, it is advisable to avoid the consumption of acid at night, preferring to replace it with dairy products.(1,3,8,54)

In conclusion, knowing the characteristics of the beverage and foodstuff that our patients are consuming is a plausible strategy to minimize the harmful effects of tooth wear. Advising on the reduction in the frequency of consumption of potentially corrosive foods and beverages will decrease the contact time of acid in the teeth surfaces and probably would prevent tooth wear and its progression.

Conclusions

Considering the limitations of this in vitro study, it can be concluded that:

• Although several samples had a pH below 4, neutralization was relatively easy, and this is related to the composition of each evaluated product. The initial pH value is an excellent indicator, but the salivary neutralization capacity of each product must be taken into account.

• All groups presented products with a pH lower than the critical one (pH 5.5).

• Drinks with the lowest pH values were: Lemon Juice (2.3), Pepsi Cola (2.38), Coca Cola (2.47), Grape Juice Del Valle (2.72), TNT Energy Drink (2.75), Schweppes Citrus (2.92), Cachaça 51 Ice Passion Fruit (2.95).

• The drinks that required the greatest amount of saliva for neutralization were: Natural Lemon Juice (300 mL), Rosé Sauce (240 mL), Pepper Sauce (240 mL), Mustard (230), Ketchup Heinz (225 mL), Catuaba Selvagem (125 mL), Vodka Cocktail with Lemon (120 mL), Red Bull Energy Drink (110 mL) and Del Valle Grape Juice (110 mL).

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5. Capítulo 3

Photobiomodulation therapy and 3% potassium nitrate gel on the treatment of cervical dentin hypersensitivity: a randomized clinical trial

Submetido para o *Clinical Oral Investigations*.

Photobiomodulation therapy and 3% potassium nitrate gel on the treatment of cervical dentin hypersensitivity: a randomized clinical trial

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Abstract

Objectives: The aim of this randomized controlled trial was to evaluate different protocols for dentin hypersensitivity treatment with low-power laser, desensitizing agent, and its association between low-power laser and desensitizing agent. Materials and Methods: Fifty-four patients were randomly allocated into three groups: G1: 3% nitrate potassium gel – UltraEZ - (n=17); G2: photobiomodulation therapy with a low-level infrared laser (PBM/LLIL) (n=17), 100mW, spot size of 0.028 cm2, dose of 1 J per point; and G3: nitrate potassium + PBM/LLIL (n=20). Treatments were applied to the buccal cervical region at intervals of 72 hrs and all protocols were performed in three sessions. The response of the patient to evaporative stimuli was rated on a visual analog scale (VAS). Re-evaluations occurred immediately with each application, 1 week, 1 month and 3 months after treatment. Two-way ANOVA repeated measures test, and Tukey's post hoc test were used for multiple comparisons (α=5%). Results: The results showed a reduction of pain levels at the end of treatment in all groups. There were no significant differences in VAS score changes between groups immediately after the treatment and after the third month when compared to the baseline ($P > 0.05$). Conclusion: The proposed three-session protocol is effective in reducing CDH after 3 months, regardless of the desensitization mechanism used.

Clinical Relevance: With the increase in the prevalence of Dentin Hypersensitivity, it is necessary to investigate invasive methods, which are easy to apply and have a long-term effect to reduce pain in patients.

Keywords: Cervical dentin hypersensitivity; Low-power laser; Potassium nitrate; Clinical trial.

Introduction

Cervical Dentin Hypersensitivity (CDH) is defined as a short, sharp pain that occurs in response to thermal, chemical, evaporative, tactile or osmotic stimuli (1). A recent systematic review found that the prevalence of CDH is variable in the adult population, ranging from 1.3% to 92.1%, with a world average of 33.5% (2). The etiology is multifactorial, involving an association of factors: tension (parafunctional habits and traumatic occlusion and disocclusion), friction (abrasion) and corrosion (degradation caused by acid from intrinsic and extrinsic sources) (2–5).

The most accepted theory to explain the CDH mechanism of pain is the hydrodynamic proposed by Brännström in 1964. According to this theory, when the dentinal tubules are exposed to the oral environment and there is stimulation on the tooth surface, the fluid inside the tubules moves inward and outward, depending on the type of stimuli. This displacement of intratubular fluid can activate mechanical receptors in the nerves, stimulate and deform the nerve fibers present between the odontoblasts, generating a painful sensation. Therefore, blocking the dentinal tubules or depolarizing the nerve fibers are considered necessary to control CDH. Examples include the application of potassium oxalate, strontium chloride, fluorinated varnishes, sodium fluoride, irradiation with high and low power lasers, application adhesive systems and restorative procedures (6–9).

Potassium-based agents will promote an increase in the concentration of potassium ion in nerve endings, decreasing the nerve's ability to conduct sensory stimulation, altering its action potential (10,11). On the other hand, laser irradiation will interact with the tissue, causing different tissue reactions, according to its active medium, wavelength, power density and optical properties of the target tissue. High power lasers, can create a melting surface and block the entrance of tubules. But low power lasers through photobiomodulation therapy (PBM), whose action stands out as a biomodulator of cellular responses, will promote the reduction of pain levels through the depolarization of nerve fibers and the formation of tertiary dentin (8,12,13).

The literature demonstrates a lack of clinical trials and divergent results (8) concerning the use of low level lasers. There is a need for more controlled studies emphasizing the effectiveness of PBM and nitrate potassium gel in controlling CDH. In view of the treatments mentioned, it is necessary to evaluate clinical protocols for the control of CDH over time, supporting its use and establishing measures to prevent and control pain.

In view of the above discussion, the objective of this research was to evaluate, through a randomized and controlled clinical study, the effectiveness and longevity of different treatment protocols for CDH with photobiomodulation low-power laser, desensitizing agent, and its association between low-power laser and desensitizing agent. The null hypothesis of this study was that there will be no difference between the desensitizing treatments, regardless of the experimental times analyzed.

Methods

The present research was a parallel-arms randomized, double-blind controlled trial conducted at the School of Dentistry of University of São Paulo from September 2019 to March 2020. It was approved by the University's local Ethics Committee (number 3.612.518), following the rules of the CONSORT statement (14). The Brazilian Clinical Trials Registry, (UTN) is U1111-1273-4113.

The study was conducted in accordance with the principles of the Declaration of Helsinki (World Medical Association Declaration of Helsinki, 2008). Participation in the study was voluntary and informed consent was obtained from all participants.

Eligibility criteria

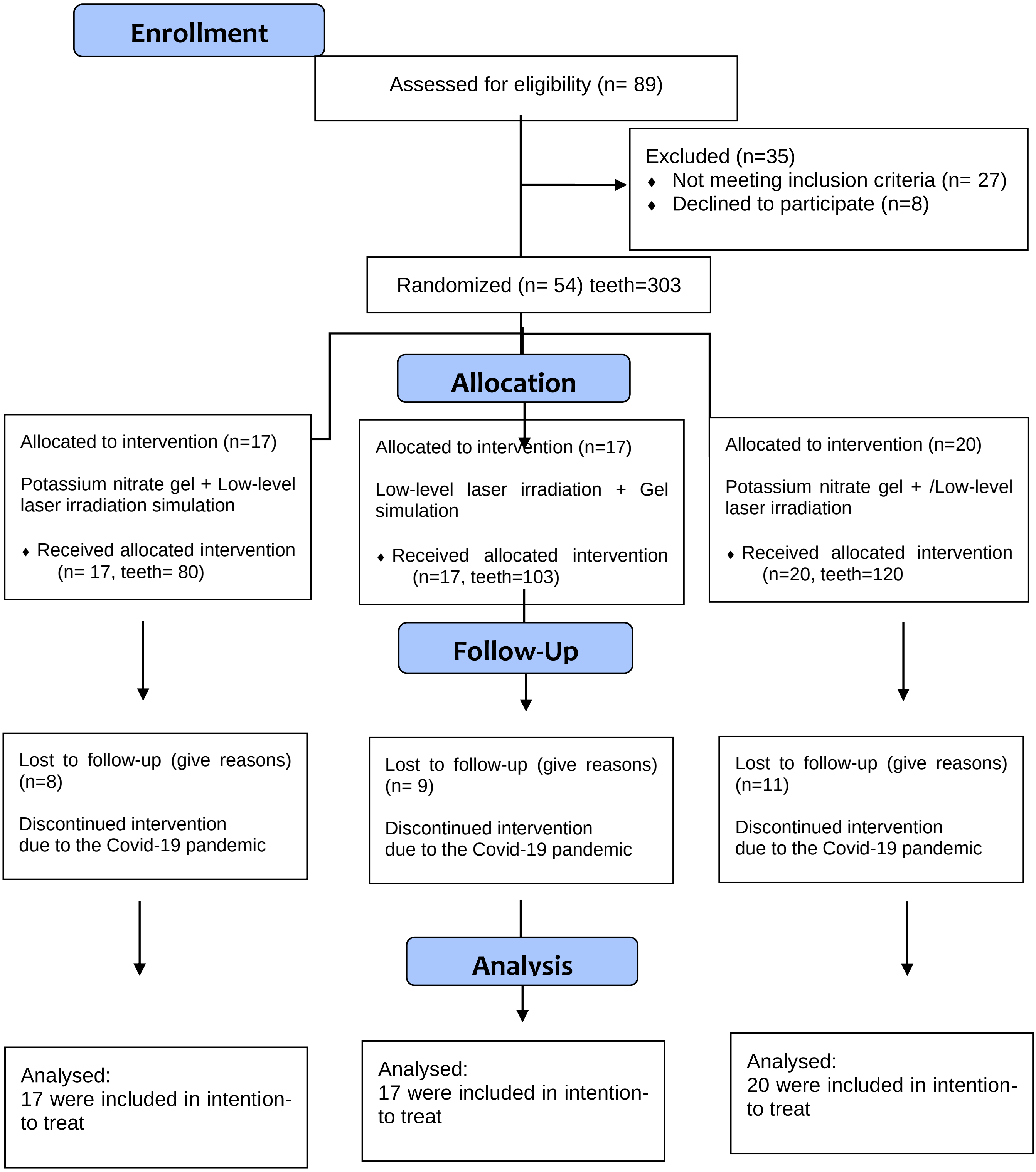
Participants of both genders were recruited and were considered eligible if they were aged between 18 and 45 years, in good general health with at least one tooth with CDH equal to or greater than 4 on the Visual Analog Scale (VAS). The initial evaluation was carried out by means of an evaporative test with air jets from a dental syringe. Participants who had active carious lesions or defective restorations; loss of dental tissue that requires restorative treatment; performed any professional desensitizing treatment in the last 6 months; used desensitizing pastes within 3 months; were using anti-inflammatory drugs or analgesics at the time of recruitment; pregnant or breastfeeding were excluded from this study.

Subject randomization

Sample calculation was based on the comparison of means, with a minimum expected difference of 2 units between groups in VAS and a standard deviation of 2. Considering as 5% and 80% power, 17 patients per group would be necessary. To compensate for possible losses to follow-up, we included 54 participants.

After clinical examination, 54 participants were randomly allocated into the three groups. The random sequence was generated by a researcher not involved in the study, using the Excel program from the Microsoft Office package. Stratified randomization was performed. This researcher allocated the groups based on cards placed in sequential number in opaque and sealed envelopes with one of the three treatment groups. The envelopes were opened only at the time of the procedure by operator 1. Patients and researcher evaluator (operator 2) did not know in which group they were assigned, neither patients' pain level. A flowchart of the study can be observed in Figure 1.

Fig 1. CONSORT flow diagram of the clinical trial



Dentin Hypersensitivity assessment

The stimulus adopted to trigger the CDH was the evaporative stimulus (triple syringe). The level of CDH was determined by the visual analogue scale of pain (VAS), a one-dimensional instrument to assess pain intensity numbered from 0 to 10, with 0 being “no pain” and 10 being “worst pain”. The participant was then asked to indicate on the scale the level of CDH felt after application of the stimulus.

The clinical evaluation consisted of the application of a triple syringe air jet, perpendicularly, at a distance of 1 cm from the cervical region of the tooth, lasting 2 seconds. Adjacent teeth were isolated with the aid of cotton rolls so as not to interfere with the measurement of that specific tooth. Immediately after the evaporative stimulus test, the patient indicated on the VAS the level of sensitivity experienced, and the record was included in the clinical chart. The examiner of the CDH level was previously calibrated.

All treatments were performed by the same researcher (operator 1). Stimuli and pain measurements were performed by another previously calibrated examiner (operator 2). To minimize errors and to avoid bias, operator 2 (who was not aware of the treatments) assessed the response of each tooth to air stimuli and then measured and recorded the levels of dentin hypersensitivity.

Interventions

After clinical examination and anamnesis, patients were treated according to their allocation. Two weeks before the beginning of the study, the participants went through a wash out period, where they used only the oral hygiene products indicated by the researchers, which should be used until the end of the study. The oral hygiene kit consisted of 1 soft toothbrush (Professional Lab Series, Colgate Palmolive Company) and a fluoridated toothpaste (Colgate Total 12, 1450 ppm F, Colgate Palmolive Company) and 1 dental floss (Colgate, Colgate Palmolive Company).

Before treatments all teeth received a dental prophylaxis with a rubber cup, 2% chlorhexidine and pumice stone. Then, the area was washed with air/water spray, dried with cotton. Sequentially, relative isolation with the aid of cotton rolls was done and treatments were performed according to the groups.

The treatments were carried out in three sessions, with an interval of 72hrs between applications. The effectiveness of the products was measured immediately after each treatment session using the VAS scale. Participants were called back at 1 week, 1 month and 3 months and the VAS level was measured using the same evaporative stimuli. Table 1 summarizes the application of desensitizing therapies used in the three groups. Laser parameters were tested before every irradiation using a power meter (Laser Check, MMOptics, São Carlos, SP, Brazil).

Table 1. Description of the division of the evaluated groups.

Groups	First Session	Second Session	Third Session
G1	Potassium nitrate gel + /Low-level laser irradiation simulation	Potassium nitrate gel + /Low-level laser irradiation simulation	Potassium nitrate gel + /Low-level laser irradiation simulation
G2	Gel simulation + /Low-level laser irradiation	Gel simulation + /Low-level laser irradiation	Gel simulation + /Low-level laser irradiation
G3	Potassium nitrate gel + /Low-level laser irradiation	Potassium nitrate gel + /Low-level laser irradiation	Potassium nitrate gel + /Low-level laser irradiation

Fonte: autora

For the study, the evaluator and the patient were blinded. Also, patients were unaware of the treatment they were receiving. In Group 1, equipment that simulated laser irradiation was used. The laser tip was positioned on the tooth surface, but no emission was performed. In group 2, a placebo gel (water) was also applied in the same way as the KNO3 desensitizing gel, according to the manufacturer's instructions. The desensitizing and placebo gels were placed in identical containers so that patients could not identify which product was being applied.

Group 1. 3% Potassium nitrate desensitizing gel

After prophylaxis, a #000 retraction cord (Ultrapack, Ultradent South Jordan, UT, USA) was inserted in the gingival sulcus and then the desensitizing gel (Ultradent, South Jordan, UT, USA) was applied to the non-carious cervical lesion using a micro-applicator (KG Sorensen, Cotia, Brazil) spreading throughout the cervical region from mesial to distal. The desensitizing gel was placed and removed after 5 minutes. Then, the retractor cord was detached, the excess was removed and again the gel was applied and for more 5 min. Then, the surface was washed with water until all visible gel was removed. This protocol follows the recommendations made by the manufacturer. As the patient did not know which treatment he was allocated, the researcher simulated the irradiation with a Laser equipment (DMC, São Carlos São Paulo, Brazil) with the same characteristics as the one used in the research, but without the emission of radiation.

Grupo 2. Photobiomodulation/Low-level laser irradiation

In this group, all participants received phobiomodulation therapy (Laser Therapy EC, DMC Equipment LTDA, São Carlos, Brazil), wavelength of 808nm (infrared laser) under relative isolation with fixed power of 100mW, spot size of 0.028 cm^2, dose of 1 J per point. The tip was placed perpendicular to the tooth, with irradiation at the cervical and apical point, totaling a dose of 2J. In molar teeth, irradiation was performed in the cervical mesial, mesial apical, distal cervical and distal apical, totaling 4 points and 4 J. The treatment was carried out in 3 sessions with an interval of 72 hours between them.

During all laser treatments, protective glasses was used by both the researcher and the patient, as well as all safety rules were followed. Sequentially, an application of a desensitizing agent was simulated using the same UltraEZ package, but containing water. A retractor cord was then inserted and a microbrush was used to spread the gel and left for 10 minutes, as in group 1.

Group 3. PBM therapy associated with gel desensitizer

The subjects in group 3 received the application of the desensitizing gel and laser irradiation immediately after, as the description of protocols in groups 1 and 2.

Statistical analysis

Means and standard deviations of each group were calculated at each experimental time. Adherence to the normal curve was tested using the Shapiro-Wilk test and homoscedasticity was verified using the Levene test. As normality and homoscedasticity were observed, two-way Analysis of Variance was used: group and time (repeated measures factor), to compare the groups and the change in time. Tukey's post hoc test was used for multiple comparisons.

Two analyzes were performed for the dataset: by protocol (considering all missing data) and by intention to treat. In the intention-to-treat analysis, the last observation carried forward method was used as the data imputation method. In this method, each participant's last observed value is used to replace the missing data. All analyzes were conducted considering an alpha of 5%.

Results

Fifty-four participants (303 teeth) were treated. There were participants with only one tooth with CDH and others with 15 teeth. The age-range was 18 to 45 years (mean age of the subjects was 26,9 years). The demographic characteristics of the participants are described in table 2.

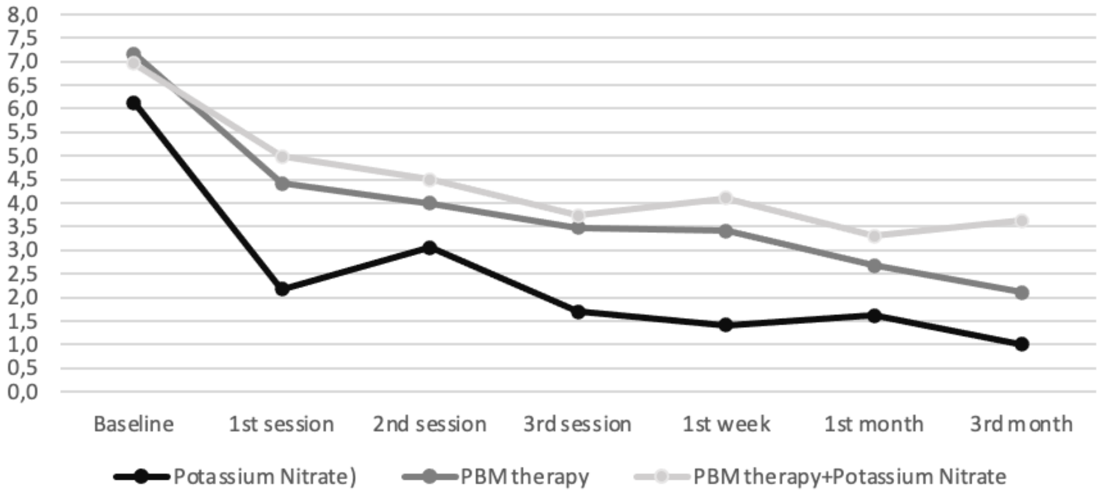
Table 2. Characteristics of the participants

Characteristic	Total (%, n)
Gender	
Male	25.92% (14)
Female	74.07% (40)
Age (years)	
18 - 25	44.44% (24)
26 - 35	46.29% (25)
36 – 45	9.26% (5)
How long have you been with Sensitivity?	
< 1 years	11.11% (6)
1 – 5 years	44.44% (24)
> 5 years	44.44% (24)
How much does sensitivity bother you?	
A few	1.84% (1)
medium	42.60% (23)
a lot	55.55% (30)
Visual Analogic Scale	
Moderate Sensitivity (4 to 7)	79.63% (43)
High Sensitivity (8 to 10)	20.37% (11)

Fonte: autora

In figure 2, it is possible to observe the differences in the mean values of CDH per treatment performed. After the 3 sessions, it was possible to notice that there was a decrease in pain levels. In table 3, the CDH remained relatively stable among the other post-treatment time intervals. There was no difference between groups at any time during the study ($p > 0.05$). There was a significant intra-group reduction, compared to baseline, in the three experimental groups ($p < 0.05$).

Fig 2. Differences in the mean values of CDH per treatment.



Fonte: autora

Table 3. Mean, standard deviation and comparison between groups regarding dentin hypersensitivity. Intention-to-treat analysis.

Groups	Baseline	1st session	2nd session	3rd session	1st week	1st month	3rd month
Group 1 (Potassium Nitrate)	6.23 (1.50)	4.49* (1,95)	4.36* (2.00)	3.74* (1.99)	3.15* (2.04)	2.87* (1.94)	2.87* (1.97)
Group 2 (PBM)	6.78 (1.54)	4.68* (2.19)	4.27* (1.98)	3.62* (1.91)	3.84* (1.98)	3.47* (2.18)	3.45* (2.27)
Group 3 (PBM + Potassium Nitrate)	6.47 (1.19)	4.83* (1.68)	4.24* (1.93)	3.72* (1.90)	3.76* (2.06)	3.46* (2.11)	3.41* (2.16)

2-way ANOVA; group effect: p = 0.79; time effect: p < 0.001; time x group interaction: p = 0.88. Alpha = 5%
* significant difference from baseline
Fonte: autora

Table 4 shows the mean values for pain reduction (baseline – 3 months). These results were analyzed by 1-way ANOVA, and no difference was observed between groups (p = 0.78).

Table 4. Mean, standard deviation and comparison between groups regarding pain relief. Intent-to-treat analysis.

Groups	Pain relief	p
Group 1 (Potassium Nitrate)	1.84 (3.35)	0.78
Group 2 (PBM)	2.60 (2.53)	
Group 3 (Potassium Nitrate + PBM)	2.59 (4.66)	

Fonte: autora

Discussion

To the best of our knowledge, this was the first clinical study to evaluate the control of dentinal hypersensitivity using a combination of Photobiomodulation therapy with a low power laser and a desensitizing gel with a concentration of 3% potassium nitrate.All protocols evaluated proved to be effective in reducing CDH, after the application of the three session's protocol in a 3-month follow-up. However, no significant differences were observed between the studied groups.

The implementation of public health policies made the population live longer and better. In addition, access to information and awareness of oral health care led to a decrease in caries prevalence rates. However, we are currently living in a more stressful, anxious world with new behavioral and eating habits. All these last observations result in a change in society's lifestyle, which leads us to face a new disease such as the non-carious cervical lesions and, consequently, cervical dentin hypersensitivity.(2–5,15) Epidemiological studies suggest an increase in the prevalence of CDH and a negative impact on individuals' daily activities such as eating, drinking, breathing and brushing teeth.(3,4,15–17) In the present study, there were reports of patients that described the level of pain was so intense that they needed to warm up the water to get their teeth brushed. For these reasons, this condition directly impacts the quality of life of patients (17,18) studies that investigate the efficacy and longevity of desensitizing protocols are extremely relevant.

In the market, it can be observed a lot of products with different modes of action, however, there is not an universally or standardized protocol accepted for the treatment of CDH. Photobiomodulation (PBM) with low power laser is a contemporary option to control CDH. It is non-invasive, painless and conservative therapy. However, a recent systematic review showed that more consistent studies should be conducted to adequately observe the advantageous therapeutic effect of PBM.

Laser therapy is dose-dependent, so it is generally used in sequential appointments with a time interval. Therefore, in the present study, the authors decided to carry out consecutive applications with potassium nitrate also, in order to carry out a new standardized clinical protocol and to compare the 3 strategies of treatment.

The results found indicate that pain levels were significantly reduced after 3 months, in all protocols applied. However, these data should be considered with caution, as it can be discussed the need of a larger sample size to allow a more robust comparison.

The evaluation of the CDH during treatments and follow-up was through air jets (evaporative stimulus). The choice of this specific stimulus is due to the fact that it acts by promoting the evaporation of fluid from the interior of the dentinal tubules. It is the easiest and the most used stimulus that can be applied by clinicians and has been used for a long time in the literature (9,11,19,20) For the evaluation of the level of pain, the visual analogue scale (VAS) was used precisely because it is easy to apply and well understand by patients, being an adequate and reproducible method (8,11,19,21,22).

Considering the results of the present study, it can be observed that it took at least three sessions to achieve low levels of CDH. Probably, just a single application may not be enough, both for laser irradiation (dose-dependent) and for potassium nitrate gel (time-dependent), which suggests that a multiple-session approach can result in the maintenance of the desensitizing effect for longer periods (8,9,11,19,23,24).

DH treatment can be managed by two neural strategies. The first one is related to the use a physical method that is through the low power laser. The second one is the use of chemical agents to desensitize sensory nerves, blocking the transmission of noxious stimuli from the dentinal tubules to the central nervous system. Both laser irradiation and potassium nitrate are considered as neural strategies because they do not obliterate the dentinal tubules but acts directly on the transmission of pain.

Potassium nitrate for the treatment of CDH has been used in the form of a gel, mouthwash or incorporated into toothpastes. (25) In this study, it was used it in gel form, being one of the most routinely used neural desensitizing agents in the dental clinic. Potassium nitrate acts in the transmission of nerve impulses, preventing the occurrence of repolarization. Depolarization occurs when the concentration of potassium ions increases in nerve endings, inactivating the action potential and preventing pain.(1) Potassium ion concentrations above 0.08% around axons are required to support nerve depolarization (26). In the present study, the product was able to reduce on average 47.36% the level of pain of patients after the 3 sessions and after 3 months a reduction of 74% was observed, demonstrating the efficacy of potassium in reducing the levels of CDH, in agreement with previous studies (11,19,24,25,27–30).

The second proposed protocol was the physical neural mechanism through Low Power Laser. Laser therapy is widely explored in the treatment of CDH and unlike high power lasers, do not lead to mechanical changes in the dentinal surface. Low power lasers act in cell membrane electrical potential, activating Na+/K+ ATPase pumps, bringing benefits such as analgesics, modulation of anti-inflammatory effects and biomodulating the tissue(9). The results found in this study were satisfactory in the reduction of CDH levels. After the 3 sessions of irradiation it was found a pain reduction of 55.75% and after 3 months it was 64.30%, corroborating to the present literature. (8,9,11,31–33).

Comparing all tested protocols for initial and 3-month CDH levels, no significant differences were found. In other words, all products were effective regardless of the mechanism of action used. Therefore, these results support the use of 3 sessions to promote a stable and effective reduction of CDH. In view of the significant decrease in the VAS level of pain after a few weeks, it is assumed that the performance of neural desensitizing agents may become more prominent if the observation period was longer(29). This study initially had the purpose of following the patients for at least 6 months and data collection was already underway, but in March 2020 a Lockdown was determined due to the COVID-19 pandemic, shutting down the University. Therefore, it was impossible to catalog a larger number of individuals and for a longer period of follow-up.

In view of the limitations and difficulties of clinical research protocol, the authors believe and hypothesized that the combination of PBM therapy with potassium nitrate would significantly reduce sensitivity over a longer period of time, even if significant difference was not seen with the other desensitization treatments over the 3-month period showed in this study. This is still an inconclusive statement as we would need a clinical trial with longer period of follow-up to confirm this data.

It is necessary to emphasize that the dentist must always, firstly, identify the etiological factors involved in the CDH so that it is possible to remove or modulate them. Using only a desensitizing agents in the management of CDH can lead to limited and short-term results (2,3,5,15,34–36). Removal and modulation of etiological factors for CDH such as occlusal factors (distribution of occlusal contact and presence of parafunctional habits), oral hygiene habits (involving brushing technique, applied force and types of toothpaste) and the presence of acids of different origins in the oral cavity (acid diet and gastroesophageal disorders) are needed. And, therefore, only later, establish the strategy for pain.

Conclusion

Under the limitations of this clinical study, it can be concluded that all proposed protocols were effective in reducing cervical dentin hypersensitivity after the three-session treatment protocol.

Acknowledgments

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6. CONSIDERAÇÕES FINAIS

Para os estudos de pH, a ideia inicial era realizar um experimento com um volume ainda maior de bebidas e alimentos. No estudo clinico, o projeto previa um acompanhamento dos pacientes de, no mínimo, 6 meses. Porém para conter a transmissão do COVID-19, foi imposto regras rígidas de isolamento e Faculdade de Odontologia da Universidade de São Paulo paralisou todas as atividades acadêmicas forçando-nos a adiar projetos e a interromper outros. Portanto, um impacto direto e indireto na sequência das minhas pesquisas.

Mesmo diante de todas as limitações, oo longo da tese foi possivel discutir e apresentar resultados relevantes que poderão nortear novas pesquisas e a prática clinica dos profissionais da saúde. Considerando as limitações dos estudos, podemos concluir que:

A maioria das bebidas avaliadas apresentou pH inicial abaixo de 4 e as bebidas energéticas, gel de carboidrato, suco de limão apresentaram maior resistência à neutralização com saliva artificial. O consumo dessas bebidas é recomendado por profissionais do esporte para que o atleta atinja seus objetivos, mas pode ter impacto na saúde bucal. Trabalho e orientações multidisciplinares são necessários para minimizar as alterações dentárias em atletas.

Apesar de várias amostras apresentarem pH abaixo de 4, a neutralização foi relativamente rápida, e isso está relacionado à composição de cada produto avaliado. O valor de pH inicial é um excelente indicador, mas deve-se também levar em consideração a capacidade de neutralização salivar de cada produto. Todos os grupos apresentaram produtos com pH inferior ao crítico (pH 5,5).

Todos os protocolos propostos foram eficazes na redução da hipersensibilidade dentinária cervical após o tratamento em três sessões clinicas.

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ANEXO A – Parecer do Comitê de Ética em Pesquisa

USP - FACULDADE DE ODONTOLOGIA DA UNIVERSIDADE DE SÃO PAULO - FOUSP

PARECER CONSUBSTANCIADO DO CEP

DADOS DO PROJETO DE PESQUISA

Título da Pesquisa: Protocolos de tratamento da hipersensibilidade dentinária com laser de baixa potência e nitrato de potássio em grupo de risco: estudo clínico longitudinal.

Pesquisador: Andrea Barros Tolentino

Área Temática:

Versão: 5

CAAE: 11965419.7.0000.0075

Instituição Proponente: Faculdade de Odontologia da Universidade de São Paulo

Patrocinador Principal: Financiamento Próprio

DADOS DO PARECER

Número do Parecer: 3.612.518

Apresentação do Projeto:

"Comparar clinicamente a efetividade de tratamentos de consultório para hipersensibilidade dentinária (HD) através de estudo clínico randomizado, duplo cego, intervencional. Os sujeitos que apresentarem ao menos um dente com valor acima de 4 VAS (se mais de um dente sensível estiver presente, será utilizada a média dos valores VAS obtidos de cada lesão, por paciente) serão aleatoriamente alocados nos grupos experimentais. Grupo 1: dessensibilizante Ultra EZ 3%; Grupo 2: Laser de AsGaAl; e Grupo 3: Irradiação similar ao grupo 2, mas na última sessão será realizado a aplicação do dessensibilizante Ultra EZ 3%".

Objetivo da Pesquisa:

"O objetivo deste trabalho será o de avaliar através de um estudo clínico randomizado e controlado a efetividade de diferentes protocolos de tratamento para HD com laser de baixa potência associado com pasta dessensibilizante de nitrato de potássio em um grupo de risco: pacientes".

Avaliação dos Riscos e Benefícios:

Riscos mensurados.

Benefícios mensurados.

Endereço: Av Prof Lineu Prestes 2227 - 1° andar , sala 02 da administração
Bairro: Cidade Universitária **CEP:** 05.508-900
UF: SP **Município:** SAO PAULO
Telefone: (11)3091-7960 **Fax:** (11)3091-7960 **E-mail:** cepfo@usp.br

USP - FACULDADE DE ODONTOLOGIA DA UNIVERSIDADE DE SÃO PAULO - FOUSP

Plataforma Brasil

Folha de Rosto	folha_de_rosto.docx	18:51:01	Tolentino	Aceito

Situação do Parecer:
Aprovado

Necessita Apreciação da CONEP:
Não

SAO PAULO, 01 de Outubro de 2019

Assinado por:
Alyne Simões Gonçalves
(Coordenador(a))

Endereço: Av Prof Lineu Prestes 2227 - 1° andar , sala 02 da administração
Bairro: Cidade Universitária **CEP:** 05.508-900
UF: SP **Município:** SAO PAULO
Telefone: (11)3091-7960 **Fax:** (11)3091-7960 **E-mail:** cepfo@usp.br

ANEXO B – Termo de Consentimento Livre e Esclarecido

Você está sendo convidado a participar da pesquisa “Protocolos de Tratamento da Hipersensibilidade Dentinária com Laser de baixa potência e nitrato de potássio em grupos de risco: estudo clinico longitudinal” com o objetivo de avaliar tratamentos dessensibilizantes para dentina exposta. A dentina exposta é causa de muita sensibilidade frente às bebidas geladas, alimentos doces ou ácidos ou mesmo durante a escovação.
Os participantes da pesquisa serão acompanhados inicialmente após 1 semana, 1 mês, 3 meses e 6 meses após o tratamento dessensibilizante, quando possíveis dúvidas sobre a pesquisa poderão ser resolvidas (ou a qualquer momento).

Instruções necessárias

- A participação da pesquisa é em caráter voluntário, e os participantes estarão se submetendo a um tratamento de forma gratuita.
- O tratamento será realizado em três sessões, e o acompanhamento será realizado em 1 semana, 1 mês, 3 meses e 6 meses após a última consulta. E cada participante participará de grupos diferentes de tratamento.
- O participante da pesquisa tem o direito a indenização em caso de danos decorrentes do estudo, mas o tratamento realizado não será invasivo e não oferecerá riscos permanentes.
- Em qualquer momento da pesquisa o participante da pesquisa poderá desistir e terá liberdade de recusar e retirar o consentimento sem qualquer penalização.
- O participante da pesquisa deverá usar um kit de higiene oral que será utilizado até o final da pesquisa. Será aplicado "wash out" de duas semanas antes do início da pesquisa (Wash out - É o tempo que o participante da pesquisa fica sem utilizar pastas de dentes não-indicadas para que o mesmo seja eliminado de seu organismo).
- Os pesquisadores também poderão remover os participantes do estudo do estudo, caso achem necessário e encaminharão o participante conforme sua necessidade.
- A identificação do participante da pesquisa será preservada pelos pesquisadores responsáveis, bem como o sigilo de seus dados.
- Os tratamentos utilizados neste estudo oferecem riscos ou danos transitórios/permanentes mínimos ao participante do estudo. Sejam eles efeitos colaterais, toxicidade, exposição acentuada a situações de desconforto, divulgação de informações, interferência na vida e na rotina dos sujeitos, e etc. Durante o tratamento a laser, as normas e procedimentos internacionais de segurança e proteção serão rigorosamente seguidos. Porém qualquer inconveniente que ocorra ou para maiores esclarecimentos, os mesmos poderão procurar a pesquisadora responsável que irá oferecer assistência integral, imediata e de forma gratuita pelo tempo que for necessário.
- O benefício da pesquisa ao participante será de forma direta, imediata ou posterior na redução ou eliminação da hipersensibilidade dentinária por um determinado tempo, possibilitando a devolução da qualidade de vida.
- Para a solução de quaisquer dúvidas ou esclarecimentos, bem como problemas, contatar as pesquisadoras responsáveis (Profa. Dra. Ana Cecília Aranha) no Laboratório Especial de Laser em Odontologia (LELO) no telefone 3091-7645, Avenida Lineu prestes, 2227, CEP-05508-00, São Paulo.

Se houver dúvidas sobre a ética da pesquisa entre em contato com o Comitê de Ética em Pesquisa da Faculdade de Odontologia: CEP-FOUSP - Comitê de Ética em Pesquisa da Faculdade de Odontologia da Universidade de São Paulo – Avenida Professor Lineu Prestes nº 2227 – 05508-000 – São Paulo – SP – Telefone (11) 3091.7960 – e-mail cepfo@usp.br. O horário de atendimento ao público e pesquisadores é: de segunda a sexta-feira das 9 as 12h e de 14 as 16h (exceto em feriados e recesso universitário). O Comitê é um colegiado interdisciplinar e independente, de relevância pública, de caráter consultivo, deliberativo e educativo, criado para defender os interesses dos participantes da pesquisa em sua integridade e dignidade para contribuir no desenvolvimento da pesquisa dentro de padrões éticos.
Este documento se apresenta em 2 vias e ambas deverão ser assinadas, sendo que 1 via ficará de posse do participante da pesquisa, e a outra com o pesquisador responsável.

Tendo lido o termo de consentimento acima, concordo em participar desta pesquisa.

São Paulo, de de 20 .

Nome:

____________________________ ____________________________

Andrea B. Tolentino
Pesquisador Responsável — Assinatura do participante da pesquisa

Rubricas: Pesquisador Responsável Participante da Pesquisa

ANEXO C – Questionário

FICHA CLINICA PARA AVALIAÇÃO CLINICA

Nome:____ ID:
Email:____
Telefone: (__) ______________Celular (__) _____________
Data de nasc.: ___/___/___ Idade:_________ Ocupação principal:___________________

ANAMNESE:

1. Quais as marcas da escova e pasta dentais? Escova: Macia ( ) Média ( ) Dura ( )
2. Faz uso de enxaguantes/bochechos? SIM( ) NÃO( )

Qual a marca ?____________________________

3. Queixas do paciente / Hipersensibilidade:

Há quanto tempo tem tido a dor? ____

Dói quando toca nele(s)? SIM( ) NÃO( )

4. A dor ocorre somente após um estímulo (bebidas/alimentos quentes ou frios, doces ou algo mais)?

SIM ( ) NÃO( )

Quente ( ) frio ( ) doce ( ) toque ( ) outro ( )

5. Quanto ela o incomoda? Pouco ( ) médio ( ) muito ( )
6. Tem tomado algo/passado algo para aliviar a dor ?

SIM( ) NÃO( ) o quê ?____________________

Caso afirmativo, alivia a dor?

SIM ( ) NÃO( ) Por quanto tempo ?______________________________

7. Já passou por tratamento dessensibilizante (tratamento que alivia a sensibilidade)?

SIM ( ) NÃO( )

Ajudou ? SIM ( ) NÃO( )

8. Nível econômico:

( ) até 4 salários mínimos (até R$ 2488,00)
( ) de 5 a 10 salários mínimos (de R$ 3110,00 a R$ 6220,00)
( ) mais de 10 salários mínimos (mais de R$ 6220,00)

Dieta Ácida:

9. Costuma consumir bebidas alcóolicas?	( ) 1x/2x semana ( ) 3x ou mais semana	( ) Não
O que costuma tomar: ( ) cerveja ( ) energético ( ) whisky ( ) destilado ( ) vinho		
10. Costuma ingerir água com limão em jejum?	( ) 1x/2x/semana ( ) 3x ou mais/semana	( ) NÃO
11. Costuma ingerir café preto?	( ) 1x/2x/semana ( ) 3x ou mais/semana	( ) NÃO

12. Costuma consumir sucos de frutas (laranja, maçã, morango, limão, lima, pêssego, romã, abacaxi, tangerina, tamarindo)?	( ) 1x/2x/semana ( ) 3x ou mais/semana	( ) NÃO
13. Costuma consumir refrigerantes?	( ) 1x/2x/semana ( ) 3x ou mais/semana	( ) NÃO
14. Você faz uso de suplementos nutricionais habitualmente (Ex: Whey Protein, Lipodrol Integralmédica, Creatina BP Suplementos, Whey 3W Max Titanium, e etc)?	( ) SIM	( ) NÃO
15. Utiliza Canudos quando ingere bebidas ácidas ? (sucos cítricos, refrigerantes, bebidas alcoolicas)	( ) sempre ( ) às vezes ( ) nunca	

16. Já teve algum problema de estômago??	( ) Bulimia ( ) Anorexia	( ) Gastrite	( ) Refluxo Gastrointestinal

17. Costuma ranger os dentes?	( ) Sempre	( ) Quase Sempre	( ) Quase Nunca	( ) Nunca
18. Costuma apertar os dentes?	( ) Sempre	( ) Quase Sempre	( ) Quase Nunca	( ) Nunca
19. Costuma morder lábio, bochecha e língua?	( ) Sempre	( ) Quase Sempre	( ) Quase Nunca	( ) Nunca
20. Costuma morder Objetos como caneta, clips, etc.?	( ) Sempre	( ) Quase Sempre	( ) Quase Nunca	( ) Nunca
21. Costuma roer unhas?	( ) Sempre	( ) Quase Sempre	( ) Quase Nunca	( ) Nunca
22. Faz Academia?? (Musculação, Crossfit, aeróbicos)	( ) 1x/2x/semana ( ) 3x ou mais/semana		( ) Não	
23. Pratica esporte?	( ) 1x/2x/semana ( ) 3x ou mais/semana		( ) Não	
24. Horas de exercicios semanais?	( ) 4 a 6 horas/semana ( ) mais de 6 horas/semana			
25. Utiliza algum proteror para a prática esportiva?	( ) SIM		( ) NÃO	

26. Realiza escovação com força excessiva?	( ) Sim	( ) Não
27. Assim que termina as refeições, você escova os dentes imediatamente ou aguarda?	( ) imediatamente	( ) aguarda 20-30 min

28. Escova os dentes quantas vezes por dia?	( ) 1 a 2 x dia ( ) 3x ou mais	( ) Não
29. Já recebeu orientação sobre como escovar os dentes?	( ) Sim	( ) Não

30. Qualidade do sono
( ) Boa ( ) Razoável ( ) Péssima

31. Impacto da Hipersensibildiade na sua Qualidade de Vida?
( ) pouco ( ) razoável ( ) muito

32. Grupo De Risco que se aplica
( ) Pós-ortodôntico
( ) Atletas
( ) Apertadores
( ) Refluxo Gastro-esofágico
( ) Drogas Ilicitas

EXAME CLINICO

1. Presença de placa bacteriana: ( ) Sim ( ) Não
2. Presença de retração gengival (RG): ( ) Sim ( ) Não
   Dentes: ____

3. **FATORES OCLUSAIS**

- Ausência Elemento Dentário: Sim ( ) Não ( ) Qual(ais): ______________
- Já usou aparelho fixo: Sim ( ) Não ( )
  - Há mais de 5 anos
  - Há menos de 5 anos
  - Há mais de 1 ano
- Oclusão Normal: Sim ( ) Não ( )
- Oclusopatia : Sim ( ) Não ( )
  - Mordida Aberta
  - Mordida Profunda
  - Mordida Cruzada Anterior
  - Mordida Cruzada Posterior
- Guia Canina Direita: Sim ( ) Não ( )
- Guia Canina Esquerda: Sim ( ) Não ( )

HIPERSENSIBILIDADE DENTINÁRIA (HD):

Avaliação Inicial

Dente	**VAS**

Tratamentos

1ª Sessão		**2ª Sessão**		**3ª Sessão**	
Dente	**VAS**	**Dente**	**VAS**	**Dente**	**VAS**

4. Acompanhamentos

1 ª Semana		**1 Mês**		**3 Meses**		**6 meses**	
Dente	**VAS**	**Dente**	**VAS**	**Dente**	**VAS**	**Dente**	**VAS**