DOES ACIDIC DRINKS VS. CONTROLS DIFFERENTS INTERFERE WITH THE FORCE OF ORTHODONTIC CHAIN ELASTICS?

BEBIDAS ÁCIDAS VERSUS DIFERENTES CONTROLES INTERFEREM COM A FORÇA DE ELÁSTICOS ORTODÔNTICOS EM CADEIA?

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ABSTRACT: This study aimed to investigate alterations in physical properties of orthodontic elastomeric chains when in contact with different controls and acidic beverages. Elastomeric chains were divided into 6 groups (n=18) of elastic chain segments, distributed as follows: Group CW (Deionized water) Group CS (Artificial saliva), Group CC (Coca-Cola®) Group SP (Sprite®) Group GA (Guaraná Antártica®) and Group FA(Fanta®). Elastics were stretched in 50% of the initial length and were held for initial, 1, 7, 14, 21 and 28 day time intervals. Force magnitudes were measured at 23.5 mm of activation using a digital meter. Force decay were assessed using analysis of variance(ANOVA) and Tukey's test($p<.05$). Control Group CS saliva demonstrated the highest elastic decay values, with statistical difference between time of 24h with time intervals of 14, 21 and 28 days ($p<.05$). In comparison between groups, there was statistical difference between Group CS and Groups CW and FA in all experimental time-intervals, with group CC in time-intervals 7, 14, 21 and 28 days and with Group GA in time-intervals 7, 14 and 21 days ($p<.05$). In decreasing order: Coca-cola®, Fanta®, Guarana Antartica® and Sprite® demonstrated capacity to influence elastomeric chain decay, however with less influence than the saliva medium.

KEYWORDS: Elastomeric chains. Soft Drinks. Force decay.

INTRODUCTION

In the oral cavity, orthodontic elastics are submitted to constant forces of decay since the first day of use (WANG et al., 2007). The effects of mechanical decay are identified as being one of the main causes of loss of clinical effectiveness in tooth movement, however, few studies (ARAÚJO; URSI, 2006; PAIGE et al., 2008) have evaluated the action of more aggressive environments, such as the chemical and thermal type (BEATTIE; MONAGHAN, 2004), on this decay.

There are various factors inherent to the material, which influence the mechanical properties of the orthodontic elastics, such as loss of elasticity, quantity of force dissipated and material composition (BEATTIE; MONAGHAN, 2004; DOS SANTOS et al., 2012). In addition to these, local factors are also involved, such as the influence of saliva, variations in pH, pigments, influence of food and beverages in the diet, and the effects of mandibular movements (ALEXANDRE et al., 2008).

However, as regards food and beverages, the effect of different acidic drinks on the properties of orthodontic elastics has been questioned, as there are many studies (SOBRAL et al., 2000; PRIETSCH et al., 2002) about their effects on tooth enamel and among these, it has been concluded that sodas and carbonated beverages in general cause tooth erosion. On the other hand, little is known specifically about the effects of soft drinks on elastomeric chains.

Thus the aim of the present study was to detect the elastic decay of orthodontic elastic chains when subjected to the effect of soft drinks, in a period of 28 days, to confirm or reject the commonly accepted hypothesis that soft drinks act on decay orthodontic elastomeric chains to a greater extent when compared with other substances.

MATERIAL AND METHODS

A laboratory study was conducted to test orthodontic elastomeric chains when they are exposed to soft drinks. The elastomeric chains were divided into 6 groups (n=18) of chain elastic segments of a mean size made up of 5 links (Medium chain Link, Gray color, Morelli, Sorocaba, SP, Brazil) from the same manufacturer and lot, distributed as follows: Group CW (Control, Deionized water, Milli-Q, Millipore, Bedford, MA, USA) Group CS (Control, Artificial saliva – pH (7.2), Pharmacy School of Federal University of Rio de Janeiro, Rio de Janeiro, Brazil), Group CC (Coca-Cola®) Group SP (Sprite®) Group GA (Guaraná Antártica®) and Group FA (Fanta®) (Table 1).

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Table 1. Acidic beverages tested in the study.

Groups	Beverages	Composition	Average pH	Manufacturer
CC	Cola Soft Drink	Carbonated water, sugar, cola nut extract, caffeine, caramel IV coloring, acidulant INS 338 and natural aroma.	1.8	Coca-cola®, Companhia Fluminense de Refrigerantes, Porto Real, RJ, Brazil.
SP	Lemon Soft Drink	Carbonated water, sugar, lemon juice, natural aroma, citric acid acidulant, sodium benzoate and potassium sorbate preservatives.	1.9	Sprite®, Companhia Fluminense de Refrigerantes, Porto Real, RJ, Brazil.
GA	Guarana Soft Drink	Carbonated water, sugar, guarana seed, natural guarana aroma, acidulant: citric acid, preservatives: and potassium sorbate and sodium benzoate, coloring agent: type IV caramel	1.9	Guaraná Antártica®, Companhia de Bebidas das Américas-AmBev, São Paulo, SP, Brazil.
FA	Orange Soft Drink	Carbonated water, sugar, orange juice, artificial synthetic aroma, citric acid acidulant, sodium benzoate preservative, stabilizers: Sucrose Acetate Isobutirate and Dioctyl sodium sulfosuccinate, coloring agent (crepuscule FCF).	2.3	Fanta Laranja®, Companhia Fluminense de Refrigerantes, Porto Real, RJ, Brazil.

The elastomeric chains were removed from the spool and cut into segments. The segments were always cut in the central portion of the sixth link, so that each segment of the sample consisted of five links. A personalized and adjustable template was used, presenting a series of pins separated by a distance of 23.5 mm, which corresponds to 50% activation of the elastomeric chain. The templates enabled the elastomeric chains in both the control and test groups to be submersed during the experiment. The chains were submersed in the soft drinks twice a day for 3 min, with an interval of 6 h between one exposure and the other.

After submersion in the respective solutions, the specimens underwent washing with deionized water in order to eliminate residues of acidic beverages and simulate the situation that occurs with saliva in the oral cavity. After this, the test groups were again submersed in artificial saliva and kept in an oven at 37ºC (Splabor, São Paulo, SP, Brazil).

Force measurements (N) were obtained with a digital dynamometer (Instrutherm, São Paulo, SP, Brazil) coupled to a base fabricated for the experiment. For readout of the elastomeric chain measurements, it was kept at the same length of 23.5 mm as length of the template pins. After each measurement, the force meter was redefined for zero readout before taking the next measurement. This test was performed for up to 28 days, with the measurements being performed in six different periods during the experiment: initial (0), 1st, 7th, 14th, 21st, and 28th day of the experiment, as these elastomeric chains are changed by the orthodontist every 4 weeks, on an average, during the patient's return visit. All the chains were measured in the vertical orientation, thereby guaranteeing consistent measurements.

After measuring the force decay in the different periods, the data were submitted to statistical analysis, using the program SPSS 13.0 (SPSS Inc., Chicago, IL, USA). Descriptive statistical analysis including mean and standard deviation were calculated for the groups evaluated. The values for the quantity of force released were submitted to the analysis of variance (ANOVA) to determine whether there were statistical differences among the groups, and afterwards the Tukey' test was performed ($p < .05$).

RESULTS

All the groups demonstrated an increasing decay of force during the experimental period, with statistical difference between the initial time and the other experimental time intervals ($p < .05$). Control Group CS saliva demonstrated the highest elastic decay values, with statistical difference between time of 24 h with time intervals of 14, 21 and 28 days ($p < .05$) (Tables 2 and 3).

Table 2. Elastic Decay (Mean/Standard Deviation) comparing the time intervals evaluated for the groups CW, CS and CC.

	CW	Stat.	CS	Stat.	CC	Stat.
Initial	5.61(0.75)	24h-p=.002* 07d-p=.000* 14d-p=.000* 21d-p=.000* 28d-p=.000*	5.85(0.92)	24h-p=.000* 07d-p=.000* 14d-p=.000* 21d-p=.000* 28d-p=.000*	5.58(0.93)	24h-p=.000* 07d-p=.000* 14d-p=.000* 21d-p=.000* 28d-p=.000*
24 h	4.72(0.57)	07d-p=.982 14d-p=.298 21d-p=.249 28d-p=.151	3.75(0.40)	07d-p=.110 14d-p=.004* 21d-p=.003* 28d-p=.002*	4.18(0.70)	07d-p=.864 14d-p=.929 21d-p=.969 28d-p=.929
7th d	4.56(0.59)	14d-p=.729 21d-p=.667 28d-p=.505	3.32(0.41)	14d-p=.839 21d-p=.806 28d-p=.770	4.47(0.56)	14d-p=1.00 21d-p=.393 28d-p=.295
14th d	4.25(0.66)	21d-p=1.00 28d-p=.999	3.12(0.28)	21d-p=1.00 28d-p=1.00	4.43(0.75)	21d-p=.502 28d-p=.393
21st d	4.23(0.39)	28d-p=1.00	3.11(0.29)	28d-p=1.00	3.98(0.91)	28d-p=1.00
28th d	4.17(0.91)		3.10(0.39)		3.94(0.61)	

Mean (N). S.D.= standard deviation; **P*=** correspond s to statistical differences (p< .05), for each; Group evaluated; Groups: (CW) Control destilled water; (CS) Control artificial saliva; (CC) Coca Cola.

Table 3. Elastic Decay (Mean/Standard Deviation) comparing the time intervals evaluated for the groups SP, GA and FA.

	SP	Stat.	GA	Stat.	FA	Stat.
Initial	5.71(0.71)	24h-p=.000* 07d-p=.000* 14d-p=.000* 21d-p=.000* 28d-p=.000*	5.46(0.78)	24h-p=.002* 07d-p=.000* 14d-p=.000* 21d-p=.000* 28d-p=.000*	5.95(1.04)	24h-p=.000* 07d-p=.000* 14d-p=.000* 21d-p=.000* 28d-p=.000*
24 h	4.31(0.68)	07d-p=1.00 14d-p=.112 21d-p=.052 28d-p=.042*	4.36(0.65)	07d-p=.999 14d-p=.972 21d-p=.693 28d-p=.044*	4.43(1.02)	07d-p=1.00 14d-p=.882 21d-p=.721 28d-p=.268
7th d	4.27(0.87)	14d-p=.150 21d-p=.073 28d-p=.059	4.25(0.68)	14d-p=.999 21d-p=.899 28d-p=.120	4.36(0.77)	14d-p=.970 21d-p=.882 28d-p=.444
14th d	3.65(0.60)	21d-p=1.00 28d-p=.999	4.15(1.26)	21d-p=.983 28d-p=.254	4.12(0.77)	21d-p=1.00 28d-p=.897
21st d	3.57(0.94)	28d-p=1.00	3.96(0.78)	28d-p=.661	4.03(0.70)	28d-p=.976
28th d	3.55(0.69)		3.55(0.60)		3.82(0.70)	

Mean (N). S.D.= standard deviation; **P*=** correspond s to statistical differences (p< .05), for each; Group evaluated; Groups: (SP) Sprite; (GA) Guaraná; (FA) Fanta.

In comparison between groups, there was statistical difference between Group CS and Groups CW and FA in all experimental time-intervals, with group CC in time-intervals 7, 14, 21 and 28 days and with Group GA in time-intervals 7, 14 and 21 days (p< .05). The groups that demonstrated the lowest loss of elasticity, in decreasing order, were as follows: CW, CC, FA, GA and SP. When considering the acidic beverages, there was statistical difference only between Groups CC and SP in the time interval of 7 days (p< .05), (Tables 4 and 5).

Table 4. Elastic Decay (Mean/Standard Deviation) comparing the groups evaluated for the time interval initial, 24 h and 7 days.

	Initial			24 hours			7 days		
Groups	**Mean (SD)**	**Stat.**		**Mean (SD)**	**Stat.**		**Mean (SD)**	**Stat.**	
CW	5.61(0.75)	CS	p=.958	4.72(0.57)	CS	p=.001*	4.56(0.59)	CS	p=.000*
		CC	p=1.00		CC	p=.208		CC	p=.999
		SP	p=.999		SP	p=.493		SP	p=.787
		GA	p=.996		GA	p=.648		GA	p=.730
		FA	p=.841		FA	p=.816		FA	p=.918
CS	5.85(0.92)	CC	p=.940	3.75(0.40)	CC	p=.433	3.32(0.41)	CC	p=.000*
		SP	p=.996		SP	p=.171		SP	p=.001*
		GA	p=.760		GA	p=.101		GA	p=.001*
		FA	p=.999		FA	p=.049*		FA	p=.000*
CC	5.58(0.93)	SP	p=.998	4.18(0.70)	SP	p=.995	4.47(0.56)	SP	p=.947
		GA	p=.998		GA	p=.973		GA	p=.918
		FA	p=.802		FA	p=.900		FA	p=.991
SP	5.71(0.71)	GA	p=.958	4.31(0.68)	GA	p=1.00	4.27(0.87)	GA	p=1.00
		FA	p=.958		FA	p=.995		FA	p=1.00
GA	5.46(0.78)	FA	p=.542	4.36(0.65)	FA	p=1.00	4.25(0.68)	FA	p=.999
FA	5.95(1.04)			4.43(1.02)			4.36(0.77)		

Mean (N). S.D.= standard deviation; **P*=** corresponds to statistical differences (p< .05), for each time evaluated; Groups: (CW) Control destiled water; (CS) Control artificial saliva; (CC) Coca Cola; (SP) Sprite; (GA) Guaraná; (FA) Fanta.

Table 5. Elastic Decay (Mean/Standard Deviation) comparing the groups evaluated for the time interval of 14, 21 e 28 days.

	14 days			21 days			28 days		
Groups	**Mean (SD)**	**Stat.**		**Mean (SD)**	**Stat.**		**Mean (SD)**	**Stat.**	
CW	4.25(0.66)	CS	p=.000*	4.23(0.39)	CS	p=.000*	4.17(0.91)	CS	p=.000*
		CC	p=.983		CC	p=.910		CC	p=.902
		SP	p=.199		SP	p=.076		SP	p=.069
		GA	p=.999		GA	p=.874		GA	p=.069
		FA	p=.996		FA	p=.960		FA	p=.608
CS	3.12(0.28)	CC	p=.000*	3.11(0.29)	CC	p=.005*	3.1(0.39)	CC	p=.004*
		SP	p=.320		SP	p=.378		SP	p=.330
		GA	p=.002*		GA	p=.007*		GA	p=.330
		FA	p=.003*		FA	p=.003*		FA	p=.020*
CC	4.43(0.75)	SP	p=.039*	3.98(0.91)	SP	p=.523	3.94(0.61)	SP	p=.510
		GA	p=.892		GA	p=1.00		GA	p=.510
		FA	p=.837		FA	p=1.00		FA	p=.994
SP	3.65(0.60)	GA	p=.393	3.57(0.94)	GA	p=.583	3.55(0.69)	GA	p=1.00
		FA	p=.472		FA	p=.405		FA	p=.840
GA	4.15(1.26)	FA	p=1.00	3.96(0.78)	FA	p=1.00	3.55(0.60)	FA	p=.840
FA	4.12(0.77)			4.03(0.70)			3.82(0.70)		

Mean (N). S.D.= standard deviation; **P*=** corresponds to statistical differences (p< .05), for each time evaluated; Groups: (CW) Control destiled water; (CS) Control artificial saliva; (CC) Coca Cola; (SP) Sprite; (GA) Guaraná; (FA) Fanta.

DISCUSSION

Although studies *in vitro* (TRAN et al., 2009; SAUGET et al., 2011; BUCHMANN et al., 2012) do not present a completely faithful result, due to the difficulty of reproducing the oral medium, involving factors such as the microbial flora, enzyme levels, exposure to dietary and functional factors and the different forces that act in the oral cavity, they are still the best method for comparisons based on different products in a constant environment, and act as an indispensible stage that precedes clinical protocols (SANADA et al., 1986; BEATTIE; MONAGHAN, 2004; ARAÚJO; URSI, 2006).

The *in vitro* experiment conducted was based on the comparison of force decay among the following groups: control (deionized water and artificial saliva) and the groups of acidic beverages, in different time intervals of evaluation. For selection of drinks used in this study was taken as based, soft drink that have a higher frequency of consumption and use in other studies (CARVALHO et al., 2013; MEDEIROS et al., 2014), in particular the cola soft drink. The orthodontic elastic chains were evaluated in a period of 28 days, as has been indicated in various studies (ASH; NIKOLAI, 1978; FERRITER et al., 1990; HWANG; CHA, 2003), as this coincides with the mean period for change of synthetic elastics practiced by orthodontists.

In this study, significant force decay could be observed in the first 24h with a trend towards stabilization in decay in the other periods of the experiment. Similar behavior has been observed in studies (WONG, 1976; KERSEY et al., 2003) that demonstrated that, as the time passed the force decay became slower. After 28 days of constant stretching, one can observe a high level of force decay in this study, similar to results found by other authors (ARAUJO; WEBER, 2006) in similar experiment with elastomeric chains immersed in artificial saliva at 37°C, which showed a 75.95% reduction in force.

The elastic force decay is linked to weakening of the intermolecular forces and subsequent chemical degradation after exposure to aqueous medium (HUGET et al., 1990). On the other hand, the use of this medium as control of the force decay does not appear to represent a condition close to that found in the oral cavity, in contrast to the results shown by artificial saliva, which corroborates with studies of other authors (VON FRAUNHOFER et al., 1992) who have reported that artificial saliva is the only medium that significantly affects all the elastomers, with a high or low modulus of elasticity.

The deionized water used as control had less influence on the decay of elastomeric chains, which corroborates with the findings of other authors (LARRABEE et al., 2012), while the groups saliva control and acidic beverages were shown to be capable of influencing the elasticity of the chains. This influence is related to the presence of chlorides, phosphates and preservatives in artificial saliva, and to the action of acid substances and preservatives in acidic beverages on elastic decay. These results corroborate the study of other authors (NATTRASS et al., 1998), who observed the influence of the salivary medium, soft drinks and condiments on elastic degradation, showing that the salivary medium had more influence than the acidic beverages (FERRITER et al., 1990).

The fact that force decay in saliva is greater than it is in the test groups may be explained when one takes into consideration the study conducted by other authors (FERRITER et al., 1990), who evaluated the effects of pH on the levels of force decay undergone by synthetic elastics that were kept continually stretched and immersed in acid pH (4.95) or neutral pH (7.26) solutions for 28 days. The results allowed them to conclude that the basic solution induced greater reduction in the levels of force than the acidic solution.

There is the hypothesis, that the decrease that occurs in the force generated by the elastics is inversely proportional to the pH of the oral medium, so that a very low pH or above neutral is considered more deleterious to the synthetic elastomeric chains. Although the effects of factors such as pH and temperature have been studied, there are still controversies (DE GENOVA et al., 1985). In addition to pH, suggest that the amount of preservatives, pigments, chlorides and phosphates in acidic beverages have a significant influence on the force decay, as observed in this study that the orange soft drink (pH=2.3) had more influence on the force decay compared to guarana soft drink (pH=1.9) and lemon (pH=1.9).

There is a complex system of physic-chemical interactions in the oral cavity, which causes greater decay of orthodontic elastics when compared with *in vitro* studies. Orthodontic chain elastics, in studies *in vivo* presented greater force decay than those tested in vitro, in artificial saliva or an aqueous medium (HWANG; CHA, 2003). The *in vitro* experiment is incapable of simulating the real and complex conditions that occur in the oral medium, but may help in gaining understanding of the process of decay that affects these materials (ELIADES et al., 1999 and 2005).

Among the methodological limitations of this study could cite the fact of being an *in vitro* study, and the static stretch subjected to elastics utilized in this study which differs in part from intraoral dynamic. However, *in vitro* studies allow a better standardization intra-group and guide future clinical studies, which can principally monitor the buccal pH of the orthodontic patients.

CONCLUSIONS

The null hypothesis was rejected; the tested soft drinks demonstrated less capacity to influence the force decay of the orthodontic elastomeric chains than was shown by the salivary medium. In decreasing order, the soft drinks Coca-cola®, Fanta®, Guarana Antartica® and Sprite® influenced the loss of elasticity.

RESUMO: Este estudo objetivou investigar as alterações das propriedades físicas de cadeias elastoméricas ortodônticas quando em contato com diferentes controles e bebidas ácidas. Cadeias elastoméricas foram divididas em 6 grupos (n=18) de segmentos de elásticos em cadeia, assim distribuídos: Grupo CW (água deionizada), Grupo CS (saliva artificial), Grupo CC (Coca-Cola®), Grupo SP (Sprite®), Grupo GA (Guaraná Antártica®) e Grupo FA (Fanta®). Os elásticos foram esticados em 50 % do comprimento inicial e mantidos pelos intervalos de tempo inicial, 1, 7, 14, 21 e 28 dias. Magnitudes de força foram medidos em 23.5 mm de ativação usando um medidor digital. Degradação da Força foi avaliada através da análise de variância (ANOVA) e teste de Tukey (p<.05). Grupo Controle CS saliva demonstrou os maiores valores de degradação elástica, com diferença estatística entre o tempo de 24 h com intervalos de tempo de 14, 21 e 28 dias (p<.05). Na comparação entre os grupos, houve diferença estatística entre o Grupo CS e os Grupos CW e FA em todos os intervalos de tempos experimentais, com grupo CC nos intervalos de tempo de 7, 14, 21 e 28 dias e com o Grupo GA nos intervalos de tempo de 7, 14 e 21 dias (p<.05). Em ordem decrescente: Coca-cola®, Fanta®, Guaraná Antartica® e Sprite® demonstraram capacidade de influenciar a degradação da cadeia elastomérica, porém com menos influência do que o meio de saliva.

PALAVRAS-CHAVE: Cadeias elastoméricas. Refrigerantes. Degradação de Força.

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