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THE EFFECTS OF ACUTE BEER INGESTION ON RECOVERY OF NONLINEAR HEART RATE VARIABILITY AFTER EXERCISE: A RANDOMIZED, CROSSOVER AND CONTROLLED TRIAL

Yasmim M. de Moraes Pontes[1], Cicero Jonas R. Benjamim[2], Gabriela Augusto Liberalino[1]
Andrey A. Porto[3], David M. Garner[3,4], Vitor E. Valenti[3]

ABSTRACT

Objective: We estimated the acute effects of acute beer consumption on non-linear HR Variability (HRV) behavior after submaximal aerobic exercise. Equipment and methods: This is a transversal, crossover, randomized and controlled trial. Fifteen healthy female and 17 healthy male adults were included in the final sample. Subjects performed two protocols on two randomized days: Water (300 mL) and Beer (300ml). The subjects underwent 15 minutes seated at rest, followed by aerobic exercise on a treadmill (five minutes at 50-55% of maximum HR and 25 minutes 60-65% of maximum HR) and then remained seated for 60 minutes during recovery from the exercise. Water or beer was consumed between four and ten minutes after exercise cessation. Results: The symbolic analysis (0V% and 2LV%), the fractal analysis by Detrended Fluctuation Analysis and the Sample Entropy demonstrated a late recovery in males in the beer protocol. In the women's group, the results were contradictory among the HR fragmentation analysis indexes. Beer consumption by males after a submaximal aerobic test was able to delay recovery of non-linear HRV behavior.

Key words: Beer. Autonomic Nervous System. Cardiovascular System. Exercise. Heart Rate Variability.

RESUMO

Os efeitos da ingestão aguda de cerveja na recuperação da variabilidade não linear da frequência cardíaca após o exercício: um teste randomizado, crossover e controlado

Objetivo: Estimamos os efeitos agudos do consumo agudo de cerveja no comportamento não linear da variabilidade da FC (VFC) após o exercício aeróbio submáximo. Equipamentos e métodos: Trata-se de um ensaio transversal, cruzado, randomizado e controlado. Quinze mulheres saudáveis e 17 adultos saudáveis do sexo masculino foram incluídos na amostra final. Os sujeitos realizaram dois protocolos em dois dias randomizados: Água (300 mL) e Cerveja (300 mL). Os sujeitos foram submetidos a 15 minutos sentados em repouso, seguidos de exercício aeróbio em esteira (cinco minutos a 50-55% da FC máxima e 25 minutos 60-65% da FC máxima) e, a seguir, permaneceram sentados por 60 minutos durante a recuperação do exercício. Água ou cerveja foi consumida entre quatro e dez minutos após a cessação do exercício. Resultados: A análise simbólica (0V% e 2LV%), a análise fractal por Detrended Fluctuation Analysis e a Sample Entropy demonstraram uma recuperação tardia nos machos no protocolo de cerveja. No grupo de mulheres, os resultados foram contraditórios entre os índices de análise de fragmentação de RH. O consumo de cerveja por homens após um teste aeróbio submáximo foi capaz de retardar a recuperação do comportamento não linear da VFC.

Palavras-chave: Cerveja. Sistema nervoso autónomo. Sistema cardiovascular. Exercício. Variabilidade do batimento cardíaco.

1 - Physiological and Collective Sciences Nucleus, School of Juazeiro do Norte, Juazeiro do Norte-CE, Brazil.
2 - Department of Internal Medicine, Ribeirao Preto Medical School, University of Sao Paulo-FMRP/USP, Ribeirao Preto-SP, Brazil.
3 - Center for the Study of the Autonomic Nervous System-CESNA, UNESP, Marilia-SP, Brazil.
4 - Cardiorespiratory Research Group, Department of Biological and Medical Sciences, Faculty of Health and Life Sciences, Oxford Brookes University, Headington Campus, Oxford, OX3 0BP, United Kingdom.

E-mail dos autores:
yasmimota@gmail.com
jonasbenjamim@usp.br
liberalinogabriela@gmail.com
aa.porto@unesp.br
davidmgarner1@gmail.com
vitor.valenti@unesp.br

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INTRODUCTION

According to the World Health Organization, alcohol consumption is constantly increasing in high-income countrie (Licaj, 2014). Beer is a drink widely consumed in Western countries and the amongst the most consumed alcoholic beverages globally, this being reinforced by cultural norms (Dázio, Zago and Fava, 2016).

Deaths attributable to alcohol are highest in the European regions (Licaj, 2014). Healthy adults drink beer to quench their thirst, as part of social relationships or after exercise, as beer is considered the most popular alcoholic beverage among athletes and sports persons (Molina-Hidalgo and collaborators, 2019).

Questionable effects of the relationship between alcohol and changes in cardiovascular behavior suggest that beer consumption influences the autonomic control of heart rate (McManus and collaborators, 2016; Julian and collaborators, 2020).

Previous studies have shown that acute doses of alcohol are able to decrease autonomic control of heart rate in resting situations (Spaak and collaborators, 2010).

However, to date, there is no evidence that after stressful situations (e.g. exercise) parasympathetic reactivation of autonomic HR control is impaired with beer intake (Ralesvki, Petrakis and Altemus, 2018).

Heart rate variability (HRV) is a simple and non-invasive method that estimates cardiac autonomic control and has been enforced in numerous experimental and clinical situations.

Through the adjacent intervals between consecutive heartbeats (RRi) it is conceivable to investigate the activity of autonomic efferences on the heart, especially parasympathetic activity (Billman and collborators, 2015).

A greater predominance of parasympathetic activity is demonstrated in resting situations, characterized by an increase in HRV. Equally, in stressful situations (for example; exercise), an increase in the frequency and force of contraction of the heart muscle is required and, so, the sympathetic activity becomes more activated (Bustamante-Sánchez and collaborators, 2020; Gomes and collaborators, 2018).

The importance of assessing HRV signals is related to the study of the autonomic nervous system (ANS). This is a prognostic indicator of some cardiac and systemic diseases, as it permits the assessment of the balance between the autonomic influences on the cardiac (Camm, 1996; Santana and collaborators, 2019; Silva, Fazan and Marin-Neto, 2020).

The stimulation of physical exercise with the ensuing analysis of recovery is considered one of the most widely applied techniques to analyze the cardiac autonomic adaptation (Peçanha and collaborators, 2016).

Acute interventions have been enforced with the intention of determining their potential effects on the autonomic control of HR in the adaptation of recovery following exercise (Gonzaga and collaborators, 2017; Benjamim and collaborators, 2020).

Also, the study of HRV non-linear methods of analysis has become vital for their calculations that translate autonomic behavior, can characterize the dynamics of physiological systems in details (Caliskan and Bilgin, 2020).

As yet, there are limited studies in the scientific literature that assessed the consumption of alcoholic beverages on the modulation of cardiac activity after physical effort. Particularly beer, is one of the beverages widely consumed after physical activities as a means of socializing after sport (Dázio, Zago and Fava, 2016).

So, the amount of autonomic activity after stressful situations under the consumption of beer is needed to understand the physiological effects caused by this activity.

Taking into consideration the aforementioned questions, we enquire the following: Is beer capable of affecting the non-linear HRV recovery after physical effort? We believe that beer consumption after physical exertion is able to attenuate the optimization of autonomic reflexes to the heart and, therefore, affect the recovery of non-linear HRV indices.

To answer this question, our study was purposed to measure the degree of effect of acute beer consumption on non-linear HRV behavior after submaximal aerobic exercise.

MATERIALS AND METHODS

This is a transversal, crossover, randomized and controlled trial (Protocol number RBR-2j5294, http://www.ensaiosclinicos.gov.br/rg/RBR-2j5294, Approved by Research Ethics Committee in Research of Centro Universitário de Juazeiro do Norte, Approval Number 2.559.109).

The report of our study is in accordance with the recommendations of the CONSORT (Consolidated Standards of Reporting Trials) statement.

Sample Size

The sample calculation was accomplished by a pilot study performed in 10 (5 males and 5 females) subjects. We applied the online software from the website www.lee.dante.br, which provided the magnitude of the difference. We calculated the Root-mean-square of the successive normal sinus RR interval difference index (RMSSD) as a reference. We measured a standard deviation of 12.8 ms and the magnitude of the difference was 14.11 ms. The sample size provided was at least 11 individuals per group, with an alpha risk of 5% and beta risk of 80%.

Participants

We evaluated 50 healthy young adults (25 men and 25 women), physically active according to the International Physical Activity Questionnaire (IPAQ) (Rzewnicki, Vanden Auweele and De Bourdeaudhuij, 2003), who drank alcohol sociably (one or two measures with up to 5g of alcohol per week). In sequence, we investigated the presence of the following conditions: cardiorespiratory, neurological, musculoskeletal, renal, metabolic, endocrine and other medical conditions reported that would make it very difficult to successfully complete the protocols.

Interventions

Initial Assessment

The study was performed between 8:00hr and 12:00hr to standardize circadian effects, in a noiseless room, with humidity between 40% and 70% and temperature between 22 °C and 28 °C.

Subjects' characteristics were determined by the data collection as age (years), mass (kg), height (cm), BMI (kg/m^2).

The day prior to the experiment, participants were told to evade consuming alcoholic beverages, drinks/foods containing caffeine (for instance soda, coffee, chocolate, etc.) and not to exercise in the 24 hours before each procedure. We recommended they wore comfortable clothing for testing and consume only a light meal high in carbohydrate (e.g. bread and jeally, fruit juice or cookie) up to two hours before the procedure. We also requested that the same meal be eaten on both days.

Experimental Protocols

The experimental protocols were split into two stages, with a minimum interval of 48 to 72 hours between them, to permit the participants adequate recovery time. The Polar RS800cx HR monitor (Polar Electro, Finland) assessed the HR values.

At the start of the procedures, the subjects were told to rest (seated) and to breathe naturally for a period of 15 minutes. At that point, the subjects performed aerobic exercise on a treadmill with a 1% inclination in the first 5 minutes for warm-up (50-55% of the maximum HR (HR_{max}): 208 - 0.7 x age) and then 0.5 km/hr increments. Each minute was completed until submaximal HR (60-65% of HR_{max}) was attained for 25 minutes. Immediately following exercise, the subjects remained standing for three minutes on the treadmill and then sitting for full recovery for another 57 minutes, totaling 60 minutes of recovery (Santana and collaborators, 2019).

The subjects drank either beer (300 mL) or water (300 mL) in a glass between the fourth and tenth (4th to 10th) minutes following exercise. Throughout recovery from exercise, the subjects sat silently with spontaneous breathing.

HRV was recorded in the subsequent moments: Rest - 10th to 15th minutes of rest, during exercise (Ex) (15th to 20th minutes of exercise) - and during recovery from exercise - 18-25 (18th to 25th minutes after exercise), 25-32 (25th to 32th minutes after exercise), 32-39 (31th to 39th minutes after exercise), 39-46 (39th to 46th minutes after exercise), 46-53 (46th to 53th minutes after exercise) exercise) and 53-60 (53th to 60th minutes after exercise).

All through rest and recovery from exercise, participants were told to remain silent, sitting in an upright position without anxiety.

Beer Composition

The beer was produced in Petrópolis, RJ, Brazil and contained the following ingredients and nutritional information: 300mL, 138 Kcal (576Kj), water, barley malt, undistorted cereals, hops, sodium isoascorbate (INS 316), sodium metabisulfite (INS 223), propylene glycol alginate (INS 405), alcohol: 4.5%, carbohydrates: 12.6g, proteins: 0.24g, fats: 0g, cholesterol: 0mg, sodium: 0mg, potassium: 0mg.

Randomization

An independent researcher was answerable for the draw that designated the random allocation sequence of the research subjects. The draw was undertaken by means of letters aiming to randomize the order of the protocols (water and beer). The subjects were uninformed about the sequence of the protocols.

Outcomes

Symbolic analysis of HRV

The symbolic analysis was performed by distributing the number of RRi intervals in six levels (0 to 5), of which there is a spatial procedure with the sequence of three symbols, transforming them into a sequence of symbols. The possible patterns are grouped into four clusters according to the number and type of variation between symbols:
1) 0V corresponds to no variation [three identical symbols, e.g. (3,3,3) etc.];
2) 1V corresponds to a variation [two consecutive symbols are the same and the remaining symbol is different, for example (4,1,1) or (3,4,4)];
3) 2LV represents two similar variations [the three symbols form a ramp up or down, for instance (5,3,2) or (2,4,5)];
4) 2ULV represents two opposite variations [three symbols form a peak or valley, for example (2,5,2) or (5,2,4)].

Rates of occurrence of these clusters (0V%, 1V%, 2LV% and 2ULV%) were examined[21]. The 0V% index is typical of cardiac sympathetic modulation. The 1V% indices correspond to the global HRV modulation, namely, the simultaneous presence of sympathetic and vagal modulation 2LV% and 2UV% are related to cardiac vagal modulation (Porta, 2007).

Detrended Fluctuation Analysis (DFA)

To analyze the cardiac fractal properties, the detrended fluctuation analysis (DFA) was required for a time series of RR intervals obtained from the experimental protocols. The procedure for calculating the DFA consisted of the following steps: The RR series obtained experimentally was integrated using the expression:

$$y(k) = \sum_{i=1}^{k} (RR(i) - RRave)$$

Where, Y (k) is the kth term of the integrated series (k = 1, 2 ... N); RR(i) is the umptieth value of RR intervals; and RRave is mean of the RR intervals of time-series, with length N.

The integrated time series was split into intervals with a length of n, (n = 1, 2, 3 ... N).

For these intervals, the local trend of the series was calculated by a straight line of minimum squares adjusted to the data. The y coordinate of this line is called the $y_n(k)$. This integrated series is then decreased by the trend [Y(k)], subtracting the local trend $Y_n(k)$ in each interval. For a given range of size n, the fluctuation size characteristic for the integrated and extended series was calculated by:

$$F(n) = \left[\frac{1}{N} \sum_{k=1}^{N} [y(k) - y_n(k)]^2 \right]^{\frac{1}{2}}$$

This procedure is repeated for all intervals of size n, therefore obtaining a relationship between the mean of the fluctuations [F(n)] and the size of the intervals (n). A linear connection in a log-log graph indicates a law of the exponent of the scale, based on the following mathematical formula:

$$F(n) \approx n^{\alpha}$$

Where, α is the exponent of the scale, computed by linear regression in a log-log graph. The spectrum of the short (α_1) and long term (α_2) fractal exponents of the DFA is computed:

$$\alpha(nk) = \frac{\log[F(nk+1)] - \log[F(nk-1)]}{\log[nk+1] - \log[nk-1]}$$

For, α = 0.05, there is no correlation and the signal consists of white noise. If α = 1.5, the signal is similar to the random walk (Brownian motion); then 0.5 <α <1.5, there are positive correlations. An α of almost 1.0 indicates a complex or non-linear system, and finally for, α >1.0 the system tends to be less complex and linear (Makikallio, 1999).

Sample Entropy (SampEn)

SampEn was introduced to quantify the complexity of the RR(i) series of the two protocols (water or beer). SampEn is the negative natural logarithm of the conditional probability that two similar sequences for 1 point will remain similar at the next point within a tolerance r, where auto-matches are excluded in the calculation of the probability.

An irregular sequence will lead to higher SampEn values, while the regular signal is associated with lower values.

The expression for Sample Entropy is SampEn (r, l) = -1n(A/B), where A and B are the total numbers of direct matches of length l + 1 and l. Theoretically, SampEn is not reliant on time-series length.

And, even though l and r critically affect its outcome, there are no guidelines for the optimum selection of its values. We often apply the two values l = 2 and r = 0.15 × SD (RR(i)), where SD is the standard deviation of the 7-minute time series RRi (Richman and Moorman, 2000).

HR Fragmentation

Fragmentation analysis is described comprehensively in Costa e (Costa and collaborators, 2017). The NN intervals time series, {si}, 1 ≤ i ≤ N (N, time series length) were mapped to a ternary symbolic sequence as follows: “−1” if 1NNi < 0, “0” if 1NNi = 0, and “1” if 1NNi >0. In sequence, the percentages of different segments of l consecutive symbols, wi = (si,si+1, . . . ,si+l−1), 1 ≤i ≤ N −l+1, termed “words,” were calculated. For this study, we considered the analysis of the indices: PIP: percentage of inflection points; and W0, W1, W2, W3 percentage of words with 0, 1, 2, and 3 inflections points, correspondingly.

Software Analysis

The HR was reached beat-to-beat during the procedures via a HR monitor (Polar RS800cx, Finland). The assessments were undertaken using the PyBios software (Biomedical Signal Analysis in Python Version 1.2.0 (2020) developed at the Ribeirão Preto School of Medicine, University of São Paulo, São Paulo, Brazil) (Silva, Fazan and Marin-Neto, 2020).

The stationarity of the series was ensured by the manual and visual filtering of ectopic beats and artifacts. The data filtering was performed respecting the correction of up to 2.5% of the time series). The default value adopted for the Baseline Window Length was 10 and for the tolerance it was considered the value of 0.1.

Statistical analysis

The Gaussian distribution of data was undertaken via the Shapiro-Wilk normality test (z value >1.0). To compare the recovery time intervals after the two protocols, the repeated measures ANOVA-one-way (treatment x gender) test was enforced for the parametric distributions, followed by the Bonferroni post-test. For non-parametric distributions, the Friedman test was enforced and, after that the Dunn’s post-test (Laborde, Mosley and Thayer, 2017).

The effect size was calculated by Cohen’s d in order to measure the magnitude of the differences for the significant results (Quintana, 2017). We considered > 1.0 a large effect size, between <1.0 to > 0.8 a medium effect size and, between <0.8 to 0.5 a small effect size.

RESULTS

Sample Profile

After measuring the characteristics of the participants, we excluded individuals with HR greater than >100 bpm and with BMI >25.0kg/m^2 (Figure 1).

The final sample description for the 32 subjects in relation to age (years), mass (kg), height (cm), BMI (cm/kg^2) is revealed in Table 1, exemplifying the similarity within the groups.

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CONSORT 2010 Flow Diagram

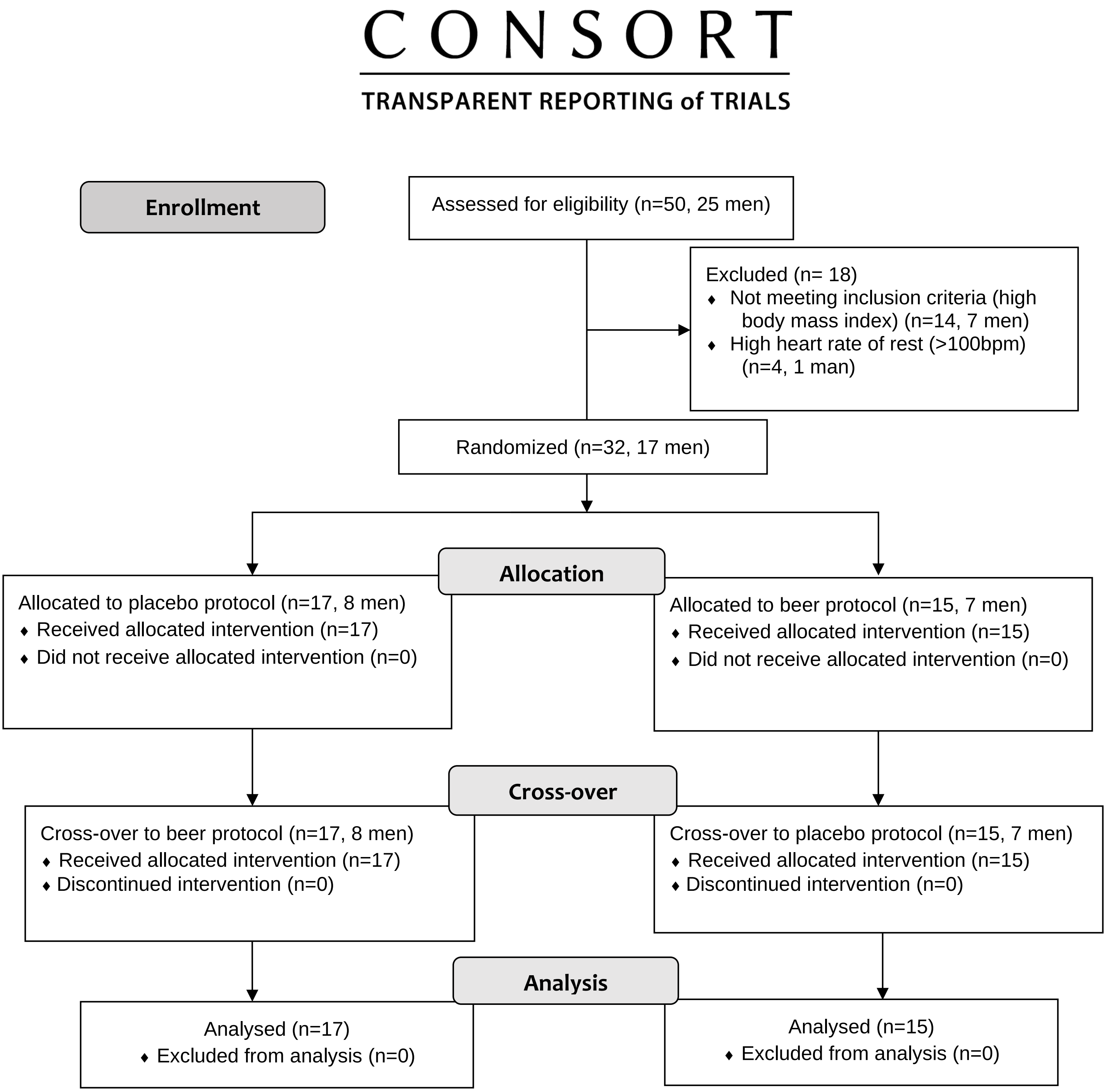

Figure 1 - Flowchart.

Table 1 - Characterization of the sample regarding age, mass, height and BMI. Mean + Standard deviation [minimum-maximum].

	Men	Women	p value	Cohen's d
Mass (kg)	65.22±7.65 [46.1 - 78.6]	60.99 ± 8 [48.9 - 79]	0.13	-
Height (m)	1.72 ± 0.06 [1.63 - 1.82]	1.62 ± 0.06 [1.56 - 1.79]	<0.001	1.67
Age (years)	20.94 ± 2.33 [18 - 26]	22.67 ± 3.56 [19 - 32]	0.13	-
BMI (kg/m^2)	21.92 ± 2.68 [17.35 - 24.8]	23.12 ± 1.95 [18.86 - 24.9]	0.16	-

Legend: BMI = body max index; kg = kilogram; m= meters.

Men (Beer & Water)

Throughout the water protocol, the 0V% of the symbolic analysis displayed an increased amid exercise vs. recovery for 25-60 minutes (25-32min: Cohen's d = 0.73; 32-39min: Cohen's d = 0.92; 39-46min: Cohen's d = 0.98; 53-60min: Cohen's d = 1.03). Through the beer protocol, 0V% increased amid exercise vs. rest (Cohen's d = 1.00) and decreased at recovery vs. during exercise for 39-53min (39-46min: Cohen's d = 0.78; 46-53min: Cohen's d = 1.01) (Figure 2).

The 2LV% index in the water protocol disclosed a decreased between rest vs. exercise (Cohen's d = 1.20) and increased between exercise vs. recovery for 18-60min (18-25min: Cohen's d = 0.90; 25-32min: Cohen's d = 1.03; 32-39min: Cohen's d = 1.22; 39-46min: Cohen's d = 1.32; 46-53min: Cohen's d = 1.25; 53-60min: Cohen's d = 1.59). In the beer protocol, it observed a decreased between rest vs. the exercise (Cohen's d = 1.17) and increased between exercise vs. recovery for 18-32min (18-25min: Cohen's d = 0.85; 25-32min: Cohen's d = 1.18) and 39-53min (39-46min: Cohen's d = 1.31; 46-53min: Cohen's d = 1.25) (Figure 2).

Throughout the water protocol, SampEn was unalike for increased during exercise vs. 39-46min recovery (Cohen's d = 0.58) (Figure 3).

The DFA for the water protocol, demonstrated increased between rest vs. exercise (Cohen's d = 1.15) and decreased between exercise vs. recovery for 18-60min (18-25min: Cohen's d = 1.18; 25-32min: Cohen's d = 1.19; 32-39min: Cohen's d = 1.31; 39-46min: Cohen's d = 1.26; 46-53min: Cohen's d = 1.23; 53-60min: Cohen's d = 1.42). During the beer protocol, it was decreased between exercise vs. recovery during only 18-25min (Cohen's d = 1.23) and 39-46min (Cohen's d = 1.04) (Figure 3).

The PIP was increased during the water protocol between exercise vs. recovery over 46-60min (46-53min: Cohen's d = 1.28; 53-60min: Cohen's d = 1.37). W1 was decreased in the water protocol during exercise vs. 46-60min recovery (46-53min: Cohen's d = 1.34; 53-60min: Cohen's d = 1.58).

During the beer protocol, we detected decreased during exercise vs. 53-60min of the recovery phase (Cohen's d = 0.85). W2 was different in the water protocol between exercise vs. 46-60min recovery (46-53min: Cohen's d = 0.71; 53-60min: Cohen's d = 0.90) (Figure 4).

Women (Beer & Water)

The symbolic analysis showed significant changes in the 0V% index. In the beer protocol, these decreased were seen between exercise phase vs. 18-32min recovery (18-25min: Cohen's d = 1.70; 25-32min: Cohen's d = 1.33) (Figure 2).

In the water protocol, PIP showed decreased alterations between exercise vs. 18-25min recovery (Cohen's d = 1.15), 46-53min (Cohen's d = 1.29) and 53-60min (Cohen's d = 1.31). During the beer protocol, we observed decreased between exercise vs. 39-46min recovery (Cohen's d = 1.49) and 53-60min (Cohen's d = 1.38) (Figure 4).

The W0 index was dissimilar in the water protocol between exercise vs 18-25min recovery (Cohen's d = 1.51). W1 was increased in the beer protocol between rest vs. exercise (Cohen's d = 1.68) and decreased between exercise vs. 18-25min recovery (Cohen's d = 1.19), 25-32min (Cohen's d = 1.03), 39-46min (Cohen's d = 2.06) and 53-60min (Cohen's d =

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1.84). For the water protocol, W2 was decreased amid exercise vs. the last recovery interval (53-60min: Cohen's d = 1.22). In the beer protocol, we observed decreased between exercise vs. the last recovery phase (53-60 min: Cohen's d = 1.29) (Figure 4).

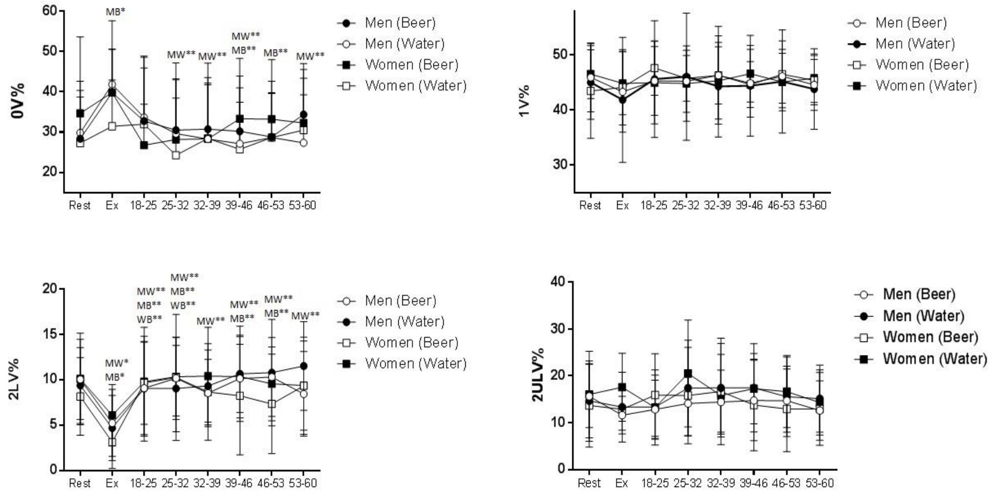

Figure 2 - Mean values and respective standard deviations of 0V%, 1V%, 2LV% and 2ULV% obtained at rest, exercise and during recovery from aerobic submaximal exercise protocol.
*MB: Values with significant differences in relation to rest (p<0.01) for beer protocol. *MW: Values with significant differences in relation to rest (p<0.01) for water protocol. *WB: Values with significant differences in relation to rest (p<0.01) for beer protocol. *WW: Values with significant differences in relation to rest (p<0.01) for water protocol. **MB: Values with significant differences in relation to exercise (p<0.01) for beer protocol. **MW: Values with significant differences in relation to exercise (p<0.01) for water protocol. **WB: Values with significant differences in relation to exercise (p<0.01) for beer protocol. **WW: Values with significant differences in relation to exercise (p<0.01) for water protocol.

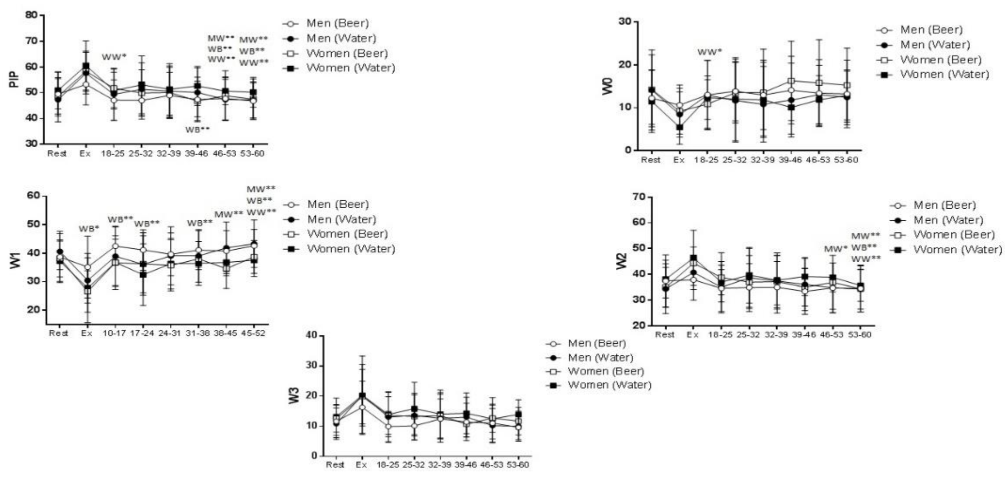

Figure 3 - Mean values and respective standard deviations of DFA and SampEn obtained at rest, exercise and during recovery from aerobic submaximal exercise protocol.

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*MB: Values with significant differences in relation to rest (p<0.01) for beer protocol. *MW: Values with significant differences in relation to rest (p<0.01) for water protocol. *WB: Values with significant differences in relation to rest (p<0.01) for beer protocol. *WW: Values with significant differences in relation to rest (p<0.01) for water protocol. **MB: Values with significant differences in relation to exercise (p<0.01) for beer protocol. **MW: Values with significant differences in relation to exercise (p<0.01) for water protocol. **WB: Values with significant differences in relation to exercise (p<0.01) for beer protocol. **WW: Values with significant differences in relation to exercise (p<0.01) for water protocol.

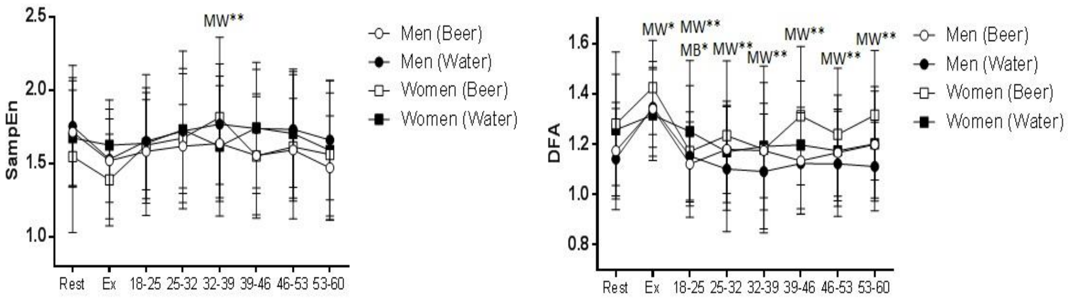

Figure 4 - Mean values and respective standard deviations of PIP, W0, W1, W2 and W3 obtained at rest, exercise and during recovery from aerobic submaximal exercise protocol.
*MB: Values with significant differences in relation to rest (<0.01) for beer protocol. *MW: Values with significant differences in relation to rest (p<0.01) for water protocol. *WB: Values with significant differences in relation to rest (p<0.01) for beer protocol. *WW: Values with significant differences in relation to rest (p<0.01) for water protocol. **MB: Values with significant differences in relation to exercise (p<0.01) for beer protocol. **MW: Values with significant differences in relation to exercise (p<0.01) for water protocol. **WB: Values with significant differences in relation to exercise (p<0.01) for beer protocol. **WW: Values with significant differences in relation to exercise (p<0.01) for water protocol

DISCUSSION

This is an original study that evaluated the effects of beer on non-linear HRV following submaximal aerobic exercise, where it was conceivable to observe that: 1) Symbolic analysis of the 0V% and 2LV% indexes demonstrated a late recovery in males for the beer protocol; 2) SampEn recovered faster in the water protocol; 3) Fractal recovery was delayed in the beer protocol in men; 4) In the women's group, any effect of beer was not confirmed.

Acute alcohol consumption is connected with the appearance of cardiac arrhythmias and sinus tachycardia. These effects can be supported here, by our results, in which the consumption of alcohol elevates cardiac excitation by falling vagal activity (Brunner and collaborators, 2017; Tirapelli and collaborators, 2008).

In part, these effects can be caused especially by the increase of norepinephrine in the synaptic terminals of the sympathetic fibers on the heart muscle, subsequently increasing the frequency and the force of contraction of the heart (Van de Borne and collaborators, 1997).

In addition, alcohol can potentiate an imbalance in autonomic behavior when consumed with stimulating drinks (e.g. energy drinks).

In the study by Wilklund and collaborators (2009) the participants who ingested alcoholic beverages in addition to energy drinks, had an impaired return on HR and HRV compared to the group that drank only energy drinks.

Previous studies have found that in alcoholics, there is a significant decrease in linear time domain and HRV frequency indices, indicating that chronic alcohol consumption causes impairment of the autonomic modulation of cardiac activity (Kumar and collaborators, 2014).

Additionally, there is indications that alcohol drinking-induced cardiac atrophy and dysfunction are related to the activation of inflammatory pathways (Shirpoor and collaborators, 2018; Mouton and collaborators 2020).

All through exercise, consumption of beer intake is able to negatively affect performance (Castro-Sepulveda and collaborators, 2016).

Albeit there is a limited amount of evidence in the scientific research literature on beer consumption explicitly, it is observed that it causes negative cardiovascular impacts. Our results specify that in males, the recovery of non-linear HRV dynamics was delayed with beer ingestion after aerobic exercise. It was possible to detect this, via Symbolic, Fractal and Sample Entropic analysis. Yet, it was unfeasible to see conclusive findings about the fragmentation of HR.

Symbolic analysis has been recognized as a tool capable of elucidating the neural pathophysiological mechanisms that occur in short periods of time, predicting acute cardiac impairments (Santana and collaborators, 2017).

This is founded on the transformation of RR intervals into symbols, divided into 4 categories: non-variation patterns, represented by 0V%, which characterizes the sympathetic behavior. The 1V% index is linked to the global HRV activity. Patterns of equal or different variations, 2LV% and 2ULV%, correspondingly, characterize parasympathetic activity.

The 0V% parameter recovery was delayed in the beer protocol in males, being possible to visualize the return only in the minutes of 39-46 minutes after the physical effort. No significant results were revealed for 1V% and 2ULV%. Then again, the performance of the 2LV% index suggested a better recovery in the water protocol in the same group.

For the group of females, following beer consumption, the 2LV% index displayed an enhancement in recovery, with the return of parasympathetic control between 18-25 minutes. But, as this effect was not expressed in other parameters, we are unable to support its effects on females.

However, Sample Entropy is a quantity of regularity or irregularity of the time series. Regularity specifies a high probability that the patterns will remain close, producing low values of entropy and irregularity indicates unpredictability, producing high values of entropy. In this study, it was possible to observe an unpredictable behavior determined by an elevation in SampEn values between 32-39 minutes of recovery after ingesting 350 ml of water in males.

DFA is characterized as a measure that quantifies the degree of self-similarity of signals or time-series (Maestri and collaborators, 2006). In its fractal analysis, it was recognized that the men who ingested the beer had a weak recovery following physical exercise compared to resting during the 18-25min interval. Yet, in an identical sample, DFA recovered faster when water was consumed.

The concept of HR fragmentation was introduced by Costa and collaborators (2017). The increase in the points typifies a loss of autonomic control of HR and is realized in populations with advancing age and the incidence of cardiovascular diseases.

In this study, the index that quantifies the percentage of inflections (PIP) and W0, presented differences between the intervals of 18-25 min. recovery compared to rest in the group of women who drank water. Even with this difference, it is not possible to perceive an attenuated response of the recovery, as in the final minutes of the recovery of the PIP index a response equal to the water and beer protocols was reported. The W1 index advises that the recovery in the beer protocol in women is heightened, yet, the other indexes do not conform to this and, so, further studies are required.

In males, despite the analysis of HR fragmentation showing contradictory results, the other indexes highlight that the ingestion of beer caused a decrease in the efficiency in adapting to the recovery phase after physical exercise. That is to say, mitigating the vagal (parasympathetic) resumption of the heart.

The application of non-linear indices as cardiovascular risk parameters can have a vital application, as in some cases, it can more accurately describe autonomic behavior (Costa and collaborators, 2017).

The effect sizes via the Cohen's d calculation in this study testify to the strength of our results. Yet, we must highlight that this is a new study that needs further investigations. We support further studies to assess beer and other types of alcoholic beverages for autonomic HR behavior. While our sample number has exceeded the minimum number of participants, our population is limited and, in future larger populations would be required.

CONCLUSION

Beer drinking by males following a submaximal aerobic test was able to delay the recovery of non-linear HRV behavior; whereas no significant effects were recognized in females.

CONFLICT OF INTEREST STATEMENT

On behalf of all authors, the corresponding author states that there is no conflict of interest.

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Correspondence to:
Vitor E. Valenti.
vitor.valenti@unesp.br
UNESP.
Av. Hygino Muzzi Filho, 737.
Mirante, Marilia-SP, Brazil.
CEP: 17.525-900.
Phone: +55 14 3402-1300.

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