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ORIGINAL RESEARCH

Low intensity static stretching does not modulate heart rate variability in trained men

Gabriel Costa e Silva[I], Rodrigo Conceição[II], Fabrízio Di Masi[III], Thiago Domingos[III], Carlos Herdy[IV], Anderson Silveira[III]

I - Faculdade de Medicina do ABC, Ciências da Saúde, Santo André, SP Brazil.
II - Universidade Federal de São Paulo, Endocrinologia Clínica, São Paulo, SP, Brazil.
III - Universidade Federal Rural do Rio de Janeiro, Laboratório de Fisiologia e Desempenho Humano, Seropedica, RJ, Brazil.
IV - Club de Regatas Vasco da Gama, Setor de Fisiologia, Rio de Janeiro, RJ, Brazil.

OBJECTIVE: To investigate the acute effect of static stretching on heart rate variability in trained men.
METHODS: Eight subjects were randomly submitted to two situations, as follows: a static stretch protocol and 20 minutes at rest. The stretch protocol consisted of two sets of 30 seconds of static stretch of the chest muscles with a 40 second of interval between them. After 48 hours, the procedures were reversed so that all the subjects should were submitted to the two situations. The values of heart rate variability were measured before and after the experimental and control situation (stretch vs. rest). We registered the following cardiac variables: root mean square of standard deviation (rMSSD), the number of pairs of successive beats that differ by more than 50 ms (pNN50), low frequency (LF) and high frequency (HF). The Shapiro-Wilk and the paired Student's test were used for statistical analysis; a critical level of significance of $p < 0.05$ was adopted.
RESULTS: No significant differences ($p > 0.05$) were found (stretching vs. control) to the RMSSD, pNN50, LF and HF indices. However, although no statistical differences were observed, the figures show large changes on mean values, suggesting an unclear effect on the sympathetic-vagal modulation.
CONCLUSION: The present results suggest that a low intensity (motion range until discomfort point) and volume (1 minute) of static stretching does not significantly affect the acute sympathetic-vagal control in trained men. Because the protocol did not show differences regarding the studied variables, we suggest that there is not a sufficient level of physiological basis to perform this type of exercise in a traditional pre-exercise setting, if the purpose is obtain gains in physical performance.

KEYWORDS: Heart rate variability, Static stretching, Autonomic modulation.

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E-mail: gabriel_bill04@hotmail.com

INTRODUCTION

Daily physical activities involve the combination of strength, flexibility, power and muscular endurance.[1,2] Therefore, satisfactory levels of flexibility are essential not only for the functional capacity of the organism and the development and maintenance of health, but also for effective achievement of sport movements.[1,3] Stretching is an exercise for developing and maintaining levels of flexibility[4] and, historically it is accepted as preparation that improves the performance and reduces the risk of injury.[5,6]

However, some studies, in addition to questioning the prophylactic properties of stretching[7,8] also show that this can cause significant loss in power production,[4,9-12] and may impair oxygen delivery due to circulatory occlusion.[13,14] In spite of this evidence, such exercises are still performed in its traditional form, i.e., as a pre-exercise routine. Additionally, there is a scarcity of good descriptions of the behavior of the autonomic system in response to such stretching exercises.[15]

Heart rate variability (HRV) analysis has been widely used in sports science to evaluate the autonomic modulation

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of heart rate at rest and during exercise. The autonomic nervous system communicates with the cardiac muscle via afferent and efferent nerves, through sympathetic terminations dispersed throughout the myocardium, and through parasympathetic terminations spread throughout the sinus node, the atrial myocardium and the atrioventricular node.[16] Thus, some autonomic nervous system indices allow an evaluation of the neural control of the heart.[17,18]

Nonetheless, few experiments to the date[19-22] have been performed to analyze the effect of muscle stretching exercises on the autonomic response of heart in humans. In addition, most of the reported experiments[19,21] applied a medium or a high stretching load and/or volume.

Hence, there are questions without answers that indicate a lack of knowledge concerning this subject. Therefore, this study aimed to verify the acute effects of low volume and intensity static stretching on HRV in trained healthy men.

MATERIAL AND METHODS

Sample

Eight physically active men (n = 8) participated in the study (Table 1). The subjects had a long history (more than 5 years) of neuromuscular training experience and were already used to perform the exercises involved in this research for at least two years. For the inclusion of volunteers into this research process, the following conditions were observed: a) participants should be physically active; b) subjects performed no physical activity during the course of this study; c) participants had no functional limitation; d) participant had no adverse medical condition that could influence the outcome of the tests and responses. All participants read and signed a consent term that explained all test and data collection procedures. For the sake of safety, the PAR-Q[23] questionnaire was applied and all subjects responded "no" to all questions.

Table 1 - Descriptive characteristics of the sample

Variables	Mean ± SD	Min-Max	CV (%)
Age (years)	22.5 ± 4,.2	20-27	18.4
Mass (kg)	76.4 ± 2.8	70-78	3.6
Height (cm)	173.7 ± 9.2	166-184	5.3
BMI	25.3 ± 3.3	23.5-28.3	13.0
HSF Flex (º)	151.5 ± 9.9	154-146	6.5
HSE Flex (º)	46.5 ± 8.9	33-60	19.1
$HR_{resting}$ (bpm)	67.8 ± 10.3	49-82	15.1

SD = standard deviation; BMI = body mass index; HR = heart rate; HSF Flex = horizontal shoulder flexion flexibility accessed by Goniometry; HSE Flex = horizontal shoulder extension flexibility accessed by Goniometry CV = coefficient of variation.

This entire research was conducted within the ethical standards of the 1964 Helsinki Declaration and based on provisions of Resolution 466/2012 of the Brazilian National Health Council, with the approval of the Ethics Committee of the Universidade Federal Rural do Rio de Janeiro (case # 23083.011633 / 2011-37).

Procedures

The present study was conducted in a total of three non-consecutive visits, always at the same time. On the first visit, subjects signed the free informed consent, responded to the PAR-Q questionnaire and underwent an anthropometric evaluation followed by horizontal shoulder flexion goniometry flexibility measurement.[24] The flexibility measure was made by a universal goniometer (Carci, Industry and Trade of Surgical appliances and Orthopedic Ltda, Brazil).

On the second visit, the subjects were randomly divided in groups, with balanced input and alternated in two situations, as follow: a) two series of 30-second static stretch for the chest muscles with 40 second of interval (SS); b) 20 minutes at rest (CTRL). After 48 hours, at the third visit, the procedures were switched so all subjects would perform both situations SS and CTRL by the end of the study.

Before testing, all individuals had body temperature measured by a digital forehead thermometer (Microlife FR1DMI MIT, USA) and presented an average of 36.77 ± 1.09 °C. All study visits were conducted in a laboratory in which relative air humidity (55-60%) and environmental temperature (20-25 °C) were noted. Subjects were instructed not to consume any alcoholic or caffeinated substances while maintaining their eating habits throughout the research period.

Static stretching protocol

The subjects were submitted to the stretching protocol after 20 minutes at rest. Static stretching protocol consisted of two sets of 30-second static stretch for the muscles of the chest[3], with an interval of 40 seconds and motion range until discomfort point[3]. Chest stretching was passively performed and the adopted position consists in bending the shoulders horizontally at 90˚.[14] These exercises were performed bilaterally.

Measurements of heart rate variability

To record the cardiac variables collected in this study we used a Polar RS800CX (Polar Electro OY, Finland) already validated in previous studies.[18,25] The electrode was previously humidified by the study researchers and it was positioned approximately at the sternum, at the level of xiphoid process . Obtained data were transferred to an "infrared interface" Polar® microcomputer, processed by the Polar Precision Performance® "software" (Finland) and stored in a microcomputer for analysis. The data were subsequently exported to the Kubious HRV program (Finland), in which they were filtered according to the recommendations of the Task Force of Spectral Analysis from European Society of

Cardiology and the North American Society of Pacing and Electrophysiology.[26] The spectral analysis in the frequency domain was performed by the Fourier transform algorithm. The HRV parameters were analyzed according to the components of low frequency in normalized units (LF-nu), which provided information about the sympathetic nervous system; and high frequency in normalized units (HF-nu), which provided information about the parasympathetic nervous system; The standard deviation of differences between adjacent normal R-R intervals (RMSSD index) and pNN50 index, which provided information about the predominance of the sympathetic or parasympathetic nervous system were also analyzed. HRV was measured following a 10-minutes passive rest period upon arrival at the lab and for 10 minutes following the two situations (stretching or control).

Statistical analysis

The Shapiro-Wilk test was used to test the normality of the descriptive sample data involved in the study. Normal distributions were expected and a parametric statistic was adopted to compare the effect of the experimental protocol vs. the control condition. Paired Student t tests were performed. Statistical analyzes were performed using the statistical software package Graphpad Prism 5 for windows GraphPad Software (USA). For all analyzes a critical level of significance of $p < 0.05$ was adopted.

RESULTS

Regarding HRV analysis and considering the time domain, when the two situations (STRETCH vs. CTRL) were compared, no significant differences were demonstrated ($p > 0.05$) for the following indices: RMSSD [37.4 ± 22.2 (ms) vs. 50.3 ± 28.4 (ms)] (Figure 1A); pNN50 [9.4 ± 6.8 (%) vs. 10.6 ± 8 (%)] (Figure 1B).

When analyzing low frequency - Figure 2A - [LF: 22.4 ± 13.1 vs. 24.2 ± 11.9] and high frequency - Figure 2B - [HF: 10.6 ± 8 vs. 10.3 ± 8.9], both in normalized units (n.u), no difference between situations was found.

DISCUSSION

The purpose of this study was to investigate the acute effect of muscle stretching by a passive static method on autonomic response of physically trained men. Our results showed that the muscle stretching exercise (2 sets of 30 seconds to chest muscles) did not significantly modify HRV parameters [RMSSD (ms), pNN50 (%), LF (n.u) and HF (n.u)]. However, although no statistical differences were observed, the figures show large variations of values, suggesting an unclear effect on the sympathetic-vagal modulation.

Despite the fact that we found no differences for HRV after stretching, exercise generally stimulates changes in the autonomic system behavior. However, as regards the HRV indexes in time domain, no significant differences were demonstrated for RMSSD and pNN50, after application of stretching. These results are not altogether surprising because stretch is static and requires less energy when compared to exercises such as resistance training, running, cycling and others. But they do suggest that the stretching protocol seems to be unnecessary as a pre-exercise routine to improve physical performance.

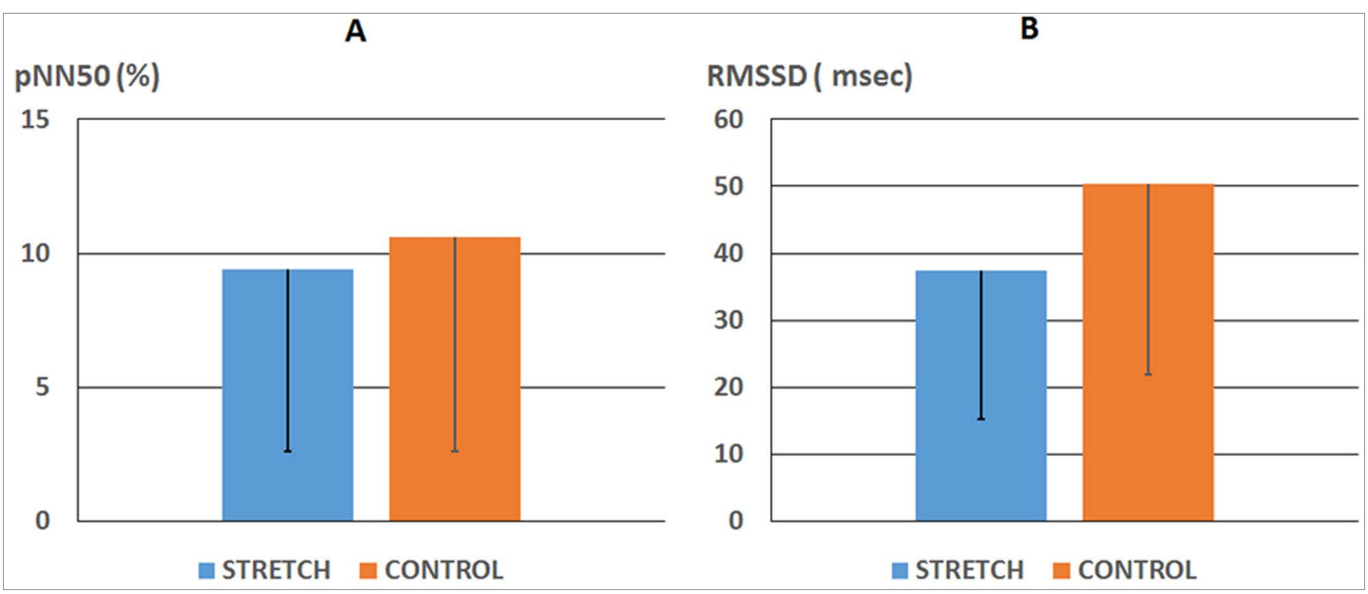

Figure 1 - Comparison of heart response rate variability (HRV), in time domain between control and stretching. A- percentage ratio between the amount of R-R intervals lasting longer than 50 milliseconds (ms) by the total number of intervals (pNN50%); B- square mean square root of differences between adjacent normal RR intervals in milliseconds (ms) (RMSSD). No significant differences were found ($p > 0.05$).

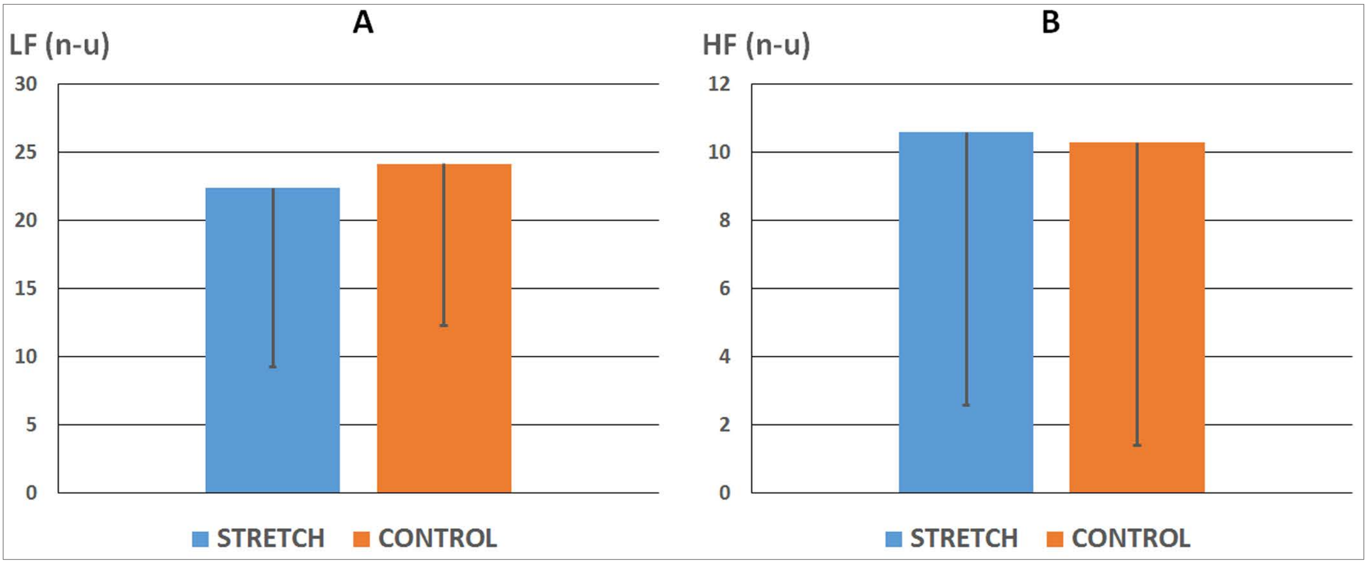

Figure 2 - Comparison of response of heart rate variability (HRV), in the frequency domain, between control and stretching. A- low-frequency component (LF), related to modulation with predominantly sympathetic modulation on the heart; B- high-frequency component (HF), related to performance of the vagus nerve on the heart. Normalized units (n.u). No significant differences were found ($p > 0.05$).

Taking a study by Farinatti et al.[21] as a model, the analysis of different domains (time and frequency) demonstrated that sympathetic activity rises during a static stretching exercise (each training session lasted approximately 10 minutes) and exhibits a slow reduction at the end of it. These results were not repeated in the present study (the stretching protocol lasted less than two minutes in addition to the aforementioned aspects). Perhaps this is because the subjects of the Farinatti study[21] were less flexible, whereas in this study the subjects had adequate levels of flexibility (trained men). This could explain the non significant autonomic activity responses after stretching as measured through RMSSD, pNN50 LF and HF in the present study.

When the frequency domain of HRV variables were analyzed, no significant difference were detected. Furthermore, a relative analysis of sympathetic and vagal modulation in the frequency domain can also be observed with higher reliability through other variables. Among these variables, the response of the HF index, which is directly correlated to vagal activity was not altered by stretching. Regarding the LF parameter, which is associated with the sympathetic component, there were no statistical differences after completion of the stretching. One possible explanation for this is that low intensity static stretching may not have been enough to statistically affect vagal or symphatetic activity.

According to a study by Mourot et al,[27] following physical activity, regardless of intensity, there is a slow return of sympathetic stimulation to resting values. In contrast, according to Dos Santos et al,[22] this phenomenon is not observed when applying the ballistic stretching technique (with a duration of 210 seconds), because stretching may produces autonomic changes similar to those of chronotropic incompetence.[28] However, no differences were observed after static stretching in our study.

Perhaps, the responses were not significant in any of the contents analyzed, because this study was performed with a small number of subjects (n = 8), and with the low intensity adopted in the experimental stretching protocol (2 x 30s). Published reports are insufficient when it comes to the effects on autonomic responses caused by stretching. However, it seems that stretching possibly activates type III fibers, thus interfering with neural control of the human heart.[29-31]

Finally, some limitations may have influenced the results of this research in some degree. In this light, even with proper care, the non-measurement of some control variables such as hormone levels, time of sleep and food may have influenced the analysis of these results. New studies involving chronic analysis, different stretching methods, different intensities, sample groups and variables should be considered for the extrapolation of the findings.[32]

CONCLUSION

In conclusion and considering the methodological limitation and the small sample size, the present study found no significant alterations on HRV after stretching by a passive static method, which suggests no positive effect in terms of performance.

It is possible that stretching reduces the neuromuscular excitatory input, as previously shown. Meanwhile, the stretching protocol did not modify significantly any of the variables that were analyzed and thus it seems to be unnecessary as a pre-exercise application to improve physical performance.

More evaluations must be done to elucidate how stretching should be used in collaborative way to autonomic cardiovascular control. We recommend new and more controlled studies with different protocols and samples are necessary to achieve more accurate results.

CONFLICT OF INTERESTS

The authors declare no conflict of interest.

AUTHOR PARTICIPATION

GCS and RRC: literature review, project elaboration, methodological design; data collection, analysis and filtering, writing and reviewing the manuscript. FDM, TD, CH: project elaboration and literature review, writing and reviewing the manuscript. AS responsible and help in literature review, statistical analysis and final reviewing of manuscript.

ALONGAMENTO ESTÁTICO DE BAIXA INTENSIDADE NÃO MODULA A VARIABILIDADE DA FREQUÊNCIA CARDÍACA EM HOMENS TREINADOS

OBJETIVO: Nosso objetivo foi verificar o efeito agudo do alongamento estático sobre a variabilidade da frequência cardíaca (VFC) em homens treinados.

MÉTODOS: Oito voluntários (n = 8) foram randomicamente submetidos a duas situações, a saber: alongamento estático (AE) ou 20 minutos em repouso (CTRL). O protocolo de alongamento consistiu em duas séries de 30 segundos para musculatura do peitoral (40 segundos de intervalo). Após 48 horas, os procedimentos foram realizados de maneira reversa, de forma que todos os participantes realizaram as duas situações (ALONGAMENTO e CRTL) ao final do estudo. Os valores de VFC foram medidos antes e imediatamente depois das situações experimental e controle (alongamento vs. repouso). Para registro das variáveis cardíacas coletadas (rMSSD, pNN50, LF e HF) no presente estudo, nós utilizamos um relógio Polar RS800CX (Polar Electro OY, Finland). As análises estatísticas realizadas foram feitas através da aplicação do teste de Shapiro-Wilk seguido pelo teste t de Student pareado, sendo adotado um nível crítico de significância de $p < 0.05$.

RESULTADOS: Nenhuma diferença significativa ($p > 0.05$) foi observada (alongamento vs. controle) quando as variáveis foram analisadas.

CONCLUSÃO: O presente estudo sugere que o alongamento estático com baixo volume de aplicação não altera significativamente o controle simpato-vagal em homens treinados. Na medida em que o protocolo utilizado não resultou em diferenças significativas nas variáveis estudadas, nós inferimos que não há fundamento fisiologicamente válido para a realização deste tipo de exercício em sua forma tradicional pré-exercício quando o objetivo for a obtenção de ganhos na performance física.

PALAVRAS-CHAVE: Variabilidade da frequência cardíaca, alongamento estático, modulação autonômica.

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