HEART RATE VARIABILITY IN TENNIS PLAYERS

VARIABILIDADE DA FREQUÊNCIA CARDÍACA EM TENISTAS

VARIABILIDAD DE LA FRECUENCIA CARDÍACA EN TENISTAS

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ABSTRACT

Introduction: Some studies suggest that playing tennis brings benefits for the anthropometric and metabolic profile of those who practice it, reducing the risk of mortality more significantly than other sports. In addition, changes in cardiovascular autonomic regulation have been highlighted as a common factor in the development of cardiometabolic disorders. Objective: To evaluate and compare hemodynamic parameters and cardiovascular autonomic modulation among former tennis players who still play the sport (ET), adults who play recreational tennis (TR), and adults classified as sedentary (S). Methods: Thirty-four men aged between 23 and 45 years participated in the study. They were divided into 3 groups: ET, TR and S. Anthropometric parameters and blood pressure were evaluated and the R-R interval was recorded to quantify the cardiac autonomic modulation at rest. Results: Similar values were observed between groups for blood pressure, waist circumference and body mass index. The amount of moderate and vigorous physical activities of the ET group was higher than that of the TR group. The ET presented resting bradycardia associated with increased pulse interval (PI) variance and high-frequency PI, and a reduction in low-frequency PI compared to the other groups studied. Reduced cardiac sympathovagal balance was observed in the ET group (1.7 ± 0.1) and TR group (2.5 ± 0.2) compared to the S group (3.2 ± 0.2); however, this change was exacerbated in the ET group compared to the TR group. Conclusion: The results suggest that playing tennis induces beneficial changes in cardiac autonomic modulation that appear to be intensified as the volume of physical activity increases, suggesting that this practice is beneficial in the management of cardiovascular risk. ***Level of Evidence II; Diagnostic Studies - Investigating a Diagnostic Test.***

Keywords: Exercise; Heart rate; Hemodynamics.

RESUMO

Introdução: Alguns estudos sugerem que a modalidade esportiva tênis traz benefícios aos perfis antropométrico e metabólico de seus praticantes, reduzindo o risco de mortalidade de forma mais significante que outras modalidades esportivas. Além disso, as alterações na regulação autonômica cardiovascular têm sido evidenciadas como fator comum no desenvolvimento de disfunções cardiometabólicas. Objetivo: Avaliar e comparar parâmetros hemodinâmicos e de modulação autonômica cardiovascular entre ex-atletas de tênis que ainda praticam essa modalidade (ET), adultos que praticam tênis recreativo (TR) e adultos classificados como sedentários (S). Métodos: Fizeram parte do estudo 34 homens com idade entre 23 e 45 anos, divididos em três grupos: ET, TR e S. Parâmetros antropométricos e pressão arterial foram avaliados e o intervalo R-R foi registrado para quantificar a modulação autonômica cardíaca em repouso. Resultados: Foram observados valores semelhantes de pressão arterial, circunferência da cintura e índice de massa corporal entre os grupos estudados. A quantidade de atividades físicas moderadas e vigorosas realizadas pelo grupo ET foi maior que do grupo TR. O grupo ET apresentou bradicardia de repouso associada a aumento da variância do intervalo de pulso (IP), da banda de alta frequência do IP e redução da banda de baixa frequência do IP em relação ao demais grupos estudados. Foi observada redução do balanço simpato-vagal cardíaco nos grupos ET (1,7 ± 0,1) e TR (2,5 ± 0,2) em comparação com o grupo S (3,2 ± 0,2); no entanto, essa alteração foi exacerbada no grupo ET quando comparado ao grupo TR. Conclusão: Os resultados permitem concluir que a prática do tênis induziu alterações benéficas na modulação autonômica cardíaca, as quais parecem ser intensificadas em função do volume de atividade física, sugerindo benefício desta prática no manejo de risco cardiovascular. ***Nível de Evidência II; Estudos diagnósticos – Investigação de um exame para diagnóstico.***

Descritores: Exercício; Frequência cardíaca; Hemodinâmica.

RESUMEN

Introducción: Algunos estudios sugieren que la modalidad deportiva de tenis trae beneficios a los perfiles antropométrico y metabólico de sus practicantes, reduciendo el riesgo de mortalidad de forma más significante que otras modalidades deportivas. Además, los cambios en la regulación autonómica cardiovascular se han evidenciado como un factor común en el desarrollo de disfunciones cardiometabólicas. Objetivo: Evaluar y comparar parámetros hemodinámicos y de la modulación autonómica cardiovascular entre ex atletas de tenis que aún practican esa modalidad (ET), adultos que practican tenis recreativo (TR) y adultos clasificados como sedentarios (S). Métodos: Hicieron parte del estudio 34 varones de entre 23 y 45 años, divididos en tres grupos: ET, TR y S. Se evaluaron los parámetros antropométricos y la presión arterial, y el intervalo R-R fue registrado para cuantificar la modulación autonómica cardiaca de reposo. Resultados: Se observaron valores similares de presión arterial, circunferencia de la cintura e índice de masa corporal entre los grupos estudiados. La cantidad de actividades físicas moderadas y vigorosas realizadas por el grupo ET fue mayor que del grupo TR. El grupo ET presentó bradicardia de reposo asociada a aumento de la varianza del intervalo de pulso (IP), de la banda de alta frecuencia del IP

y la reducción de la banda de baja frecuencia del IP en relación a los demás grupos estudiados. Se observó una reducción del balance simpático-vagal cardiaco en los grupos ET (1,7 ± 0,1) y TR (2,5 ± 0,2) en comparación al grupo S (3,2 ± 0,2); sin embargo, esta alteración fue exacerbada en el grupo ET en comparación al grupo TR. Conclusión: Los resultados permiten concluir que la práctica del tenis indujo cambios benéficos en la modulación autonómica cardiaca, los cuales parecen ser intensificados en función del volumen de actividad física, sugiriendo beneficio de esta práctica en el manejo de riesgo cardiovascular. ***Nivel de Evidencia II; Estudios de diagnósticos - Investigación de un examen para diagnóstico.***

Descriptores: *Ejercicio; Frecuencia cardíaca; Hemodinámica.*

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INTRODUCTION

There is current consensus that there is a direct relationship between the association of risk factors and the development of cardiovascular diseases (CVD).[1,2] In this sense, studies have pointed out that a common factor in the development of CVD are changes in ANS.[3] Spectral analysis (SA) of blood pressure (BP) and heart rate (HR) signals has reached considerable interest because it is a noninvasive method that estimates neural and nonneural activity for short and long term oscillations of these variables. The most widely used algorithms for the development of spectral power are the fast Fourier transform and autoregressive analysis. With this type of analysis, it is possible to obtain spectra and relevant powers from predetermined frequency bands characterized by modulation of the sympathetic branches (low frequency oscillations: LF) and parasympathetic branches (high frequency oscillations: HF) of the autonomic nervous system on the cardiovascular system.

It is worth noting that, in some situations, we can see changes in the modulation of this system on the organism, such as: greater sympathetic activity, reduced parasympathetic tone or both. These dysfunctions have been observed preceding some cardiovascular diseases such as hypertension, heart failure and events that include stroke and acute myocardial infarction, and accompanying others, such as dyslipidemias, diabetes mellitus and metabolic syndrome.[1,2,4-6]

It should also be considered that sedentarism is considered one of the most important risk factors for the development of CVD, having a higher prevalence than other risk factors such as smoking, hypertension, obesity and alcoholism in some regions of Brazil.[2,3,7] On the other hand, the regular practice of physical exercises helps prevent and control CVD, influencing almost all risk factors.[8] In this sense, due to many autonomic, cardiovascular and metabolic conditions, many researchers have suggested regular physical exercising as an extremely important alternative in the prevention and non-pharmacological treatment of cardiovascular dysfunctions.[9-12]

However, although the benefits of physical exercise are known, it is still uncertain whether the type of physical exercise could influence the benefit. Running, cycling and swimming are the most studied types of exercise with better known health benefits. However, tennis, one of the most popular sports in the world,[12] has been studied mainly for the intensity of exercise or increased heart rate and lactate[13,14] but it has not been so studied for its potential cardiovascular and autonomic benefits, which remain unknown.

In this regard, this study evaluated and compared anthropometric and hemodynamic parameters and cardiovascular autonomic modulation among former tennis athletes who still practice tennis, adults who practice recreational tennis and sedentary adults.

MATERIAL AND METHODS

Thirty-four male individuals participated in the study and were divided into three groups:

1. Sedentary (S), n=12, adults classified as sedentary or irregularly active A or B according to the criteria of the International Physical Activity Questionnaire (IPAQ) and who did not practice any competitive activities in any sports during childhood and adolescence;

2. Recreational tennis practitioner (RT), n=10, adults who started practicing recreational tennis at least one year prior and who did not practice any competitive activities in any sport during childhood and adolescence;

3. Former tennis athlete still practicing tennis (FT), n=12, adults who were professional tennis athletes as adolescents, and who continued to practice tennis as adults.

The following individuals qualified for the study: those who met the criteria described above, aged 23 to 45, non-smokers, those not making excessive use of alcohol, body mass index (BMI) of up to 30 kg/m^2 and not taking any medications that could interfere with heart rate variability.

The study volunteers were advised on the procedures and signed an Informed Consent Form. This study has been approved by the Research Ethics Committee for studies with human beings and is filed under no. 403894.

At first, the individuals answered the anamnesis containing questions about sports practice during life and the IPAQ questionnaire for classification as to the level of physical activity.

Tennis practitioners were instructed not to exercise for at least 24 hours before the day of data collection. All study participants were instructed to avoid caffeine for at least 24 hours before the day of collection.

On arrival at the laboratory, the individuals were kept at rest for 30 minutes. During this period, the transmitting belt of Polar s810i frequency meter was placed on the individual's chest for the purposes of recording pulse interval (PI) signals.â The log files were transferred to the Polar Precision Performance Software through Infrared Interface, or IrDA, which allows the bi-directional exchange of exercise data with a microcomputer for subsequent analysis of the recorded cardiac pulse interval variability.

PI variances were evaluated in time domain and frequency domain.[15] After data acquisition and storage in the computer, the RR intervals derived from the frequency meter were converted into Excel files for a visual inspection check, aiming to identify and/or correct incorrect markings. Then, the time series of each signal to be studied was generated — in this case, the cardiac RR interval. The data were analyzed and tabulated on MATLAB using the Fast Fourier Transform (FFT). After this analysis, the absolute power was derived from the relevant predetermined frequency bands: low frequency (LF, 0.04-0.15 Hz) and high frequency (HF, 0.15-0.4 Hz). Data were expressed in absolute values and standard units. The LF component was used as an index of sympathetic activity, while the HF component was an index of parasympathetic activity. The LF/HF ratio indicates the sympathovagal balance. Detection of RR intervals derived from the heart rate monitor followed the same criteria described above for setting up the time series of variability in the frequency domain. For this study, the total variance was used as an index in the time domain.[16]

Once the PI was recorded, the BP was measured three times (with a 2-minute interval between each measurement) at rest in the sitting position employing the indirect auscultatory method, using a stethoscope and a BD® sphygmomanometer, according to the recommendations of the Brazilian Society of Hypertension. Measurements of weight (Filizolaâ scales), height (wooden stadiometer) and waist circumference (Sannyâ anthropometric tape measure) were then taken.

The results are presented as mean ± standard error of the mean. Homogeneity of the variables was determined by the Levene test. The means were compared by analysis of variance (ANOVA) followed by the Student Newman Keuls post hoc test. The significance level adopted in this study was $p<0.05$. The sample power was calculated post hoc for the sympathovagal balance, obtaining a β of 0.98.

RESULTS

As shown in Table 1, age, body weight, height and body composition (BMI and waist) were similar among the groups studied.

In this study, individuals classified as "Sedentary" or "Irregularly Active Type B" were included in the sedentary group. Individuals from the groups RT and FT groups were all classified as "Very Active" or "Active" according to the IPAQ classification criteria.

Individuals in the FT group had participated in official competitions for 10±2 years and engaged more (minutes/day) in moderate and vigorous activities compared to the RT group. (Table 2)

No evaluated individuals presented systolic (SBP) or diastolic (DBP) blood pressure above the figures considered normal according to VI Guidelines of the Brazilian Society of Hypertension. The mean values of the groups represent groups of normotensive individuals. SBP and DBP were similar among the groups studied. (Table 3)

The group of former athletes had increased pulse interval compared to the other groups studied (FT=899±31*#, RT=825±37; S=797±27), revealing resting bradycardia in these individuals compared to sedentary individuals and recreational tennis practitioners. (Table 4)

No significant differences were observed in the standard deviation of the PI mean between the groups (FT=5322±670*, RT=4015±468; S=3511±378) (Table 4). PI variance was higher in the group of former athletes still practicing tennis, only compared to the sedentary group. (Table 4, Figure 1)

Regarding the analysis of HRV in the frequency domain, there was no difference between the groups in the absolute values of low frequency of PI (LF). However, there was an increase in the absolute values of the high frequency band (HF) in the group of former tennis athletes compared to the other groups studied. Moreover, the group of former tennis athletes presented decreased normalized values of the LF band and increased normalized values of the HF band compared to the group of recreational tennis practitioners and the sedentary group. (Table 4)

Sympathovagal balance (LF/HF) showed that recreational tennis practitioners (2.5±0.2) presented a lower ratio than the sedentary group (3.2±0.2). Besides, the group of former tennis athletes (1.7±0.1) had reduced LF/HF values compared to the sedentary group and recreational tennis practitioners. (Figure 2)

Table 1. Characterization of sedentary groups (S), recreational tennis practitioners (RT) and former athletes still practicing tennis (FT).

	S	RT	FT
Age (years)	29±1	33±2	30±1
Weight (kg)	77±4	79±2	77±3
Height (cm)	176±2	176±1	174±1
BMI (kg/m²)	24±3	25±1	25±1
Waist (cm)	87±1	86±2	85±2

Values representing mean ± standard deviation. Body mass index (BMI).

Table 2. Amount (minutes/day) of walking, moderate activities and vigorous activities. Sedentary groups (S), recreational tennis practitioners (RT) and former tennis athletes still practicing tennis (FT).

	S	RT	FT
Walking (minutes/day)	11±3.0	13±8.6	24±11.9
Moderate (minutes/day)	1±0.5	52±4.6*	206±28.3*#
Vigorous (minutes/day)	0±0.0	34±11.8*	68±14.6*#

Values representing mean ± standard error. * $p<0.05$ *vs.* S, # $p<0.05$ *vs.* RT.

Table 3. Blood pressure of groups of sedentary individuals (S), recreational tennis (RT) group and group of former athletes still practicing tennis (FT).

	S	RT	FT
SBP (mmHg)	115±2	122±2	119±1
DBP (mmHg)	77±3	77±3	76±3

Values representing mean ± standard error. Systolic blood pressure (SBP) and diastolic blood pressure (DBP).

Table 4. Evaluation of cardiac autonomic modulation of sedentary individuals (S), recreational tennis (RT) group and group of former athletes still practicing tennis (FT).

	S	RT	FT
SD (ms)	58±3	60±5	68±6
LF (ms²)	1041±157	1350±265	1838±301
HF (ms²)	471±112	538±72	1045±199*#
%LF (n.u.)	73±2	70±1	60±3*#
%HF (n.u.)	27±2	30±1	40±3*#

Values representing mean ± standard error. Standard deviation of the mean pulse intervals (SD). Absolute values of low frequency (LF) and high frequency (HF) bands of the pulse interval, percentage values of the low frequency (LF) and high frequency (HF) bands. * $p<0.05$ vs. S, # $p<0.05$ vs. RT.

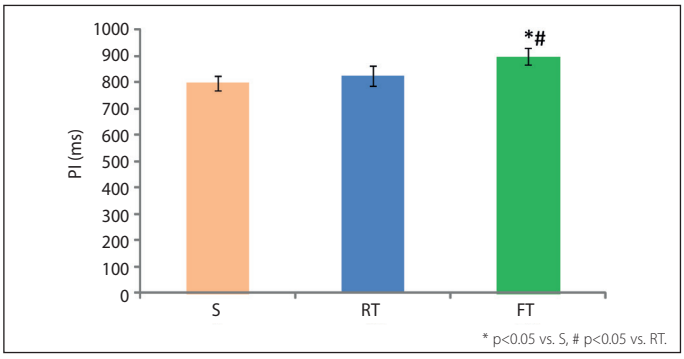

Figure 1. Pulse interval in the group of sedentary individuals (S), recreational tennis practitioners (RT) and former athletes still practicing tennis (FT).

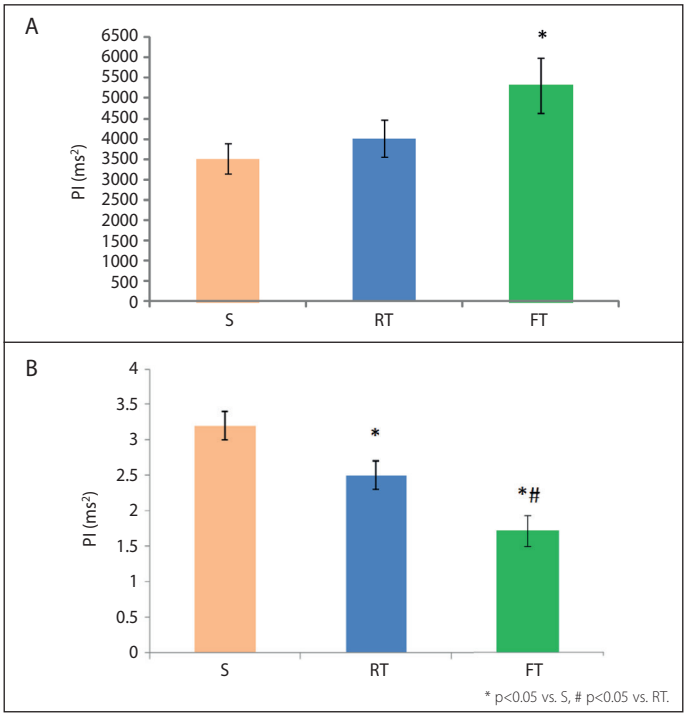

Figure 2. A. Pulse interval variance and B. Sympathovagal balance (LF/HF) in the groups of sedentary individuals (S), recreational tennis (RT) practitioners and former athletes still practicing tennis (FT).

DISCUSSION

The development of CVD, such as hypertension, heart failure, cardiomyopathy, arrhythmia, atherosclerosis, and other conditions, results from the association of risk factors, including lifestyle.[3,17] In this regard, abnormalities in the autonomic nervous system have been shown to be common factors in the development of CVD, associated with unfavorable changes in lifestyle.[9, 18]

By studying the modifiable factors for the development of CVD and its forms of control, it is found that the regular practice of physical exercises is recommended as a great ally for both the prevention and treatment of these diseases.[19-22] From the data collected in this study, it is possible to suggest that when tennis is practiced recreationally or by former tennis athletes, it is a physical activity that assists in the prevention of CVD by improving HRV.

In this study, systolic blood pressure and diastolic blood pressure presented normal values[7] and were not different among the studied groups. The effects of physical activity on BP at rest in normotensive and hypertensive individuals have been the object of several studies. There is consensus in the literature that exercising is responsible for reducing the blood pressure of its practitioners at rest. However, this effect is more pronounced in hypertensive individuals, since most of the studies carried out in normotensive patients did not show any change in BP or only some small reduction.[23,24]

We only found resting bradycardia (increase in PI) in the group of former athletes still practicing tennis, compared to the sedentary group and the group of recreational tennis practitioners. Interestingly, no resting bradycardia was observed in the group of recreational tennis practitioners compared to the sedentary group, suggesting that the volume of previous physical activity (10 years on average) or current physical activity (which was lower in moderate and vigorous activities in the RT group compared to the FT group) in the group of recreational tennis practitioners was not sufficient to induce such condition. It is important to note that the maintenance of normal cardiac function is achieved through cardiac neural regulation by the integration of sympathetic and parasympathetic nervous activity.[25] However, it is not clear which mechanism would be involved in the bradycardia of tennis practitioners. Bradycardia has been observed in both men and animal models, and has been attributed to increased vagal tone for the heart,[21] decreased sympathetic tone for the heart[26] and decreased intrinsic pacemaker HR.[12] One of the factors that may be associated with resting bradycardia in the group of former tennis athletes still practicing tennis compared to the other groups studied, is an improvement in cardiac modulation in the time domain in the group of former athletes still practicing tennis compared to the other groups, evidenced by increased PI variance. It is worth noting that increased heart rate variability is related to a neural response of increased activity of the parasympathetic nervous system.[20]

The increase in HRV values also corroborates other studies that evaluated the effects of physical training on athletes,[27] and are still similar to the values found in the study by Melo et al., who evaluated the effects of physical exercise on physically active non-athletes.[28] In this study, resting bradycardia and PI variance improvement were only found in the group of former tennis athletes, showing no significant change in recreational tennis practitioners.

Also, bradycardia in the group of former tennis athletes still practicing tennis may be associated with increased vagal modulation (HF band) observed in both absolute values and normalized values and reduced sympathetic modulation (LF band) observed in the normalized values compared to the other groups.

It is also worth noting that a reduction in the cardiac sympathovagal balance was observed in the exercised groups (TR and FT) compared to the sedentary group, demonstrating that people who practice regular physical activity have less sympathetic modulation compared to those who do not exercise regularly. This condition was more pronounced in the group of former tennis athletes compared to the group of recreational tennis practitioners. In this respect, it is possible that the previous practice of tennis (10 years on average), as well as the greater current amount of moderate and vigorous physical activities in the group of former athletes still practicing tennis is associated with this beneficial "volume- dependent" condition in autonomic cardiac modulation.

Considering that HRV reduction has been associated with higher mortality,[20] results of improvement and HRV in tennis practitioners in this study reinforce the findings of a study comparing former players of different sports (basketball, golf, soccer and baseball) with former tennis players, showing that the group of former tennis players presented lower morbidity and mortality compared to the other groups studied.[22]

CONCLUSION

In summary, considering the results obtained in this study, it was found that tennis practice induced beneficial changes in autonomic cardiac modulation, which seem to be intensified as a function of physical activity volume. Therefore, improvement in the cardiac sympathetic/vagal balance, representing a lower modulation of the cardiac sympathetic nervous system in the groups of tennis practitioners, may represent a reduction in an important risk factor for the development of cardiovascular diseases in this population.

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