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Effect of Prolonged Strenuous Exercise on Endothelial Function in Non-Elite Runners

Efeito de Exercício Extenuante e Prolongado Sobre a Função Endotelial em Corredores Não Elite

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Abstract

Background: Prolonged exercise has been shown to result in an acute depression in endothelial function. However, little is known about the effect of this type of exercise in non-elite runners.
Objective: To determine the impact of prolonged strenuous exercise on endothelial function in non-elite runners.
Methods: Nine males participating as recreational runners (age: 49.5±5.1y) at the Santiago of Cali Half-marathon (21.097m) were studied. Endothelium dependent femoral artery flow-mediated dilatation (FA-FMD) was evaluated one day before the race and at 1h, 24h, 48h, and 6 days after finishing the half-marathon.
Results: A decrease on FA-FMD was observed at 1h after the Half-marathon, followed by a non-significant recovery trend starting at 24h up to 6 days after the race. Increase in the posthyperemic diameter of the femoral artery was observed at 1h after race ending, with a trend to baseline values in subsequent measures.
Conclusion: Femoral artery diameter increased after prolonged running could explain the reduction of FA-FMD. More studies with larger sample size are needed to determine the effects of prolonged running on femoral artery endothelial function.

Keywords: Exercise, Marathon, Runners, Cardiovascular, Endothelial, Ultrasound

Resumo

Fundamentos: O exercício prolongado tem se mostrado resultar em uma depressão aguda da função endotelial. No entanto, pouco se sabe sobre o efeito desse tipo de exercício em corredores não elite.
Objetivos: Determinar o impacto do exercício prolongado e extenuante sobre a função endotelial em corredores não elite.
Métodos: Foram estudados nove homens participando como corredores de lazer (idade: 49,5±5,1 anos) na Meia-Maratona de Santiago de Cali (21,097m). A dilatação fluxo-mediada endotélio-dependente da artéria femoral (DFM-AF) foi avaliada um dia antes da corrida e em 1h, 24h, 48h e em 6 dias depois de completar a Meia-Maratona.
Resultados: Um decréscimo foi observado na DFM-AF 1h depois da Meia-Maratona, seguido por uma tendência à recuperação não significativa, começando em 24h e em 6 dias depois da corrida. Um aumento no diâmetro pós-hiperêmico da artéria femoral foi observado 1h depois do final da corrida, com uma tendência a atingir valores de base nas medidas subsequentes.
Conclusão: O diâmetro da artéria femoral aumentado depois de uma corrida prolongada poderia explicar a redução no DFM-AF. Estudos adicionais com amostras maiores são necessários para determinar os efeitos de corridas prolongadas sobre a função endotelial da artéria femoral.

Palavras-chave: Exercício, Maratona, Corredores, Cardiovascular, Endotelial, Ultrassom

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Introduction

Epidemiological studies have shown that people who participate in programs of regular physical activity achieve a considerably improvement on cardiovascular health.[1] This is consistent with the observation that a decreased aerobic exercise capacity is a good predictor of all-cause mortality.[2] However, high-intensity resistance training reduces arterial compliance and increases arterial stiffness.[3]

Endothelium-dependent vasodilatation function can be examined non-invasively in humans by measuring brachial artery mediated dilatation.[4,5] It has been demonstrated that regular exercise improved brachial artery flow mediated dilatation (FMD).[3] In fact, endothelial dysfunction plays a role in the pathogenesis of atherosclerosis and impaired endothelial function has been observed several years before traditional markers of cardiovascular disease appear.[6] Green et al.[7] reported that short-term aerobic and resistance training improves endothelium-dependent nitric oxide (NO)-mediated vascular function in both conduit and resistance vessels. In addition, there are several studies of endothelial function in moderately endurance-trained men,[8] but there are none in highly endurance-trained men athletes.

Furthermore, high-intensity endurance training at 70–80% of VO_{2max} has been linked to decreased antioxidant capacity and reduced endothelial function in moderately well-trained subjects.[7] Previously, others authors have demonstrated that marathon running results in a modest depression in cardiac function, primarily observed in indexes of left ventricular diastolic function.[8,9] Although exercise training of low to moderate intensity typically enhances FMD and endothelial function in humans,[10] intense exercise bouts are associated with inflammation and elevated oxidative stress,[7,9,11] both of which acutely impair NO-mediated vasodilator function.[8,12] It is also conceivable that prolonged intense bouts of exercise may be associated with NO substrate or cofactor exhaustion. However, it is unknown what happen with the endothelial function after prolonged strenuous exercise in recreational runners. This study evaluated the changes on endothelium dependent femoral artery flow-mediated dilatation (FA-FMD) in male recreational runners participating in a half marathon (distance 21.097m). We hypothesized that a prolonged and intensive bout of exercise would be associated with impaired endothelium-dependent nitric oxide (NO)-mediated vascular function.

Methods

Ten healthy, non-smoking males and recreational runners were invited to participate in the study. The exclusion criteria were: previous diagnosis of cardiovascular disease, presence of running injuries, family history of premature cardiovascular disease and diabetes. Written informed consent was obtained from participants and the investigation complied with the principles outlined in the Declaration of Helsinki, previously approved by the Universidad del Valle Human Ethical Committee *(UV114-09)*. Assessment of endothelium dependent femoral artery flow-mediated dilatation (FA-FMD), posthyperemic femoral artery diameter (FA-P) and baseline femoral artery diameter (FA-B) were performed by an experienced investigator using a high-resolution ultrasound device (Siemens SG-60, USA), equipped with a 7.5MHz linear array transducer, and an integrated electrocardiography package. The technique was performed following the protocol described by Corretti et al.[10]

Baseline data for FA-B, FA-P and FA-FMD were collected in an initial assessment at 24h (5 subjects) and 48h (4 subjects) before the start of the race. After race completion the measurements were performed at 1h, 24h, 48h and 6 days. On all testing days, the measurements were performed within a 2-h period to minimize the impact of circadian rhythm variation on vascular function (time of data acquisition 07:00 am, for research assistant: RA). Race conditions were warm and humidity with temperatures reaching 29°C at midday.

One-way ANOVA with repeated measures were used for the analysis of pre and post-race values of FA diameter, FA-FMD, weight, blood pressure and heart rate at baseline, 1h, 24h, 48h and 6th day. Prism 4.0b for MAC OSX (Graphpad, USA) was used for the statistical analysis and graph development. Data is presented as the mean±standard deviation (SD) and standard error of the mean (SEM) when it was appropriate. $p<0.05$ was accepted as significant.

Results

Nine males provided written informed consent to participate in the study. Subjects were 49.5±5.1 years, BMI 24.0±1.8kg/m^2, height 166±6cm. Seven subjects had history of physical activity of at least 6 years and 2 subjects have been training

for over one year. All nine runners finished the 21.097m of the half-marathon, eight presented for post-race evaluation, and seven completed all appointments in the study protocol, mean race time was (109±7, range 96-121 minutes). Anthropometric, cardiovascular, and sonographic parameters of the femoral artery, before and after the race, are shown in Table 1. FA-FMD was significantly reduced at 1h post-race, but not at 24h, 48h and 6 days, compared with baseline data (Figure 1). A non-statistically significant increase in FA-P was observed at 1h, with a trend for recovery to baseline values in subsequent measures.

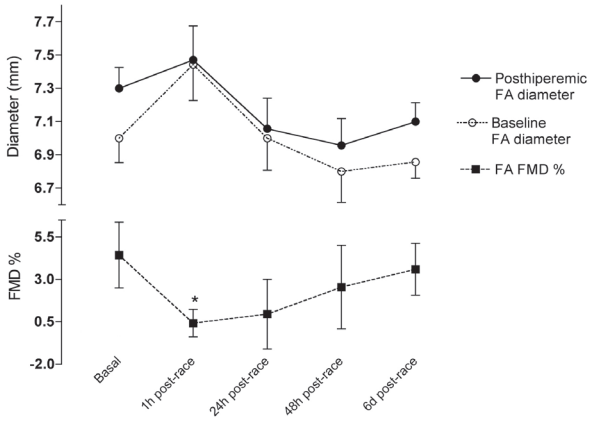

Figure 1
Flow-mediated dilatation (FMD) at different moments in non-elite runners
Data is presented as mean±SEM
FMD=flow mediated dilatation
ANOVA one way *(*p<0.05)*

Discussion

To the best of our knowledge, this is the first study attempting to assess vascular function after a prolonged intense bout of exercise in male recreational runners participating in 21.097m. Increased production of NO in endothelium by shear stress during exercise has been proposed as the main mechanism underlying vasodilatation during exercise.[13] However, other vasoactive substances such as prostacyclin, or endothelium-derived hyperpolarizing factor (EDHF)[14] have also a role in vascular function. FA-FMD was decreased at 1h after the race, findings that are consistent with previous studies.[10,15] FA posthyperemic diameter was increased at 24h, with a trend for recovery in subsequent measures; however these changes were not statistically significant probably due to the limited sample size used in this study. Other studies performed in marathon runners had proposed that shear rate and oxidative stress during intensive running could have detrimental effects on FA endothelial function.[16,17] An increase on the systemic levels of inflammatory cytokines (IL-6, IL-8, TNF-α) and reduction on the circulatory levels of hematopoietic progenitor cells has also been proposed as possible mechanisms of endothelial dysfunction after acute exercise.[18,19] Furthermore, other studies performed in athletes had shown differential impacts on flow mediated dilation, reporting that exercise cause a deleterious effect in vascular beds from active muscular groups (i.e. femoral artery) without changes on arteries from extremities no involved in the exercise (i.e. brachial artery).[20,21] However, the results obtained in this study suggest that prolonged running generates a maximum peak in femoral vasodilatation, which decreases the vasodilator response caused by occlusion.

The hypothesis that prolonged running do not decrease endothelial function is partially supported by the study of Rognmo et al.[22] In this investigation,

Table 1
Cardiovascular and anthropometric variables at baseline and 1h after the race

Variables	Baseline	Postrace (1h)	p value
Weight (kg)	56.6 ± 8.9	55.2 ± 8.3	0.018
Heart rate (beats/min)	55.5 ± 6.5	74.1 ± 26.7	0.109
Systolic blood pressure (mmHg)	134.8 ± 20.0	114.1 ± 10.9	0.012
Diastolic blood pressure (mmHg)	86.3 ± 13.3	66.8 ± 5.7	0.011
Artery diameter (mm)	7.0 ± 0.4	7.4 ± 0.5	0.051
Peak flow artery (cm/seg^3)	25.3 ± 7.4	23.6 ± 5.9	0.591
FMD (%)	4.2 ± 4.5	0.2 ± 2.1	0.042

Data is presented as mean±SD
FMD=flow mediated dilatation

the authors reported that high-intensity interval running exercise, in trained and sedentary males, generates a rise in NO bioavailability, increases the antioxidant status, but however decreases endothelium dependent brachial artery flow mediated dilation. Other studies performed on rat aortic vascular rings has shown that a single acute exercise session increases calcium influx into endothelial cells with release of NO,[23] improved endothelium-dependent vasodilatation for 48h,[24] and augments receptor mediated-vasodilatation responses.[25]

Limitations how the sample size in the present study is relatively small; however, we believe that the changes that we observed were relevant. A further limitation of field studies such as this one is that runners were not fasted before the race, and we did not specifically dictate prerace diet. However, studies of the impact of diet on FA-FMD have typically associated impairment with the ingestion of high-fat meals, and it is highly unlikely that any subject would have indulged in such a meal before a marathon.[26] We also collected self-reported data on fluid and food consumption, and no subject reported ingesting a high-fat meal prerace (or indeed any high concentration carbohydrate gels during the race). Furthermore, dehydration and associated changes in plasma volume cannot explain our femoral FA-FMD data since shear rate was in fact larger postrace in the femoral artery, not smaller as would be expected in the presence of reduced FA-FMD.[7] Any increase in viscosity that may have occurred would have further increased the shear stimulus to FA-FMD, yet the FA-FMD we observed was diminished. Future studies focused to determine the clinical impact of strenuous running on femoral endothelial function are needed.

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Potential Conflicts of Interest
I hereby declare that there are no pertinent conflicts of interest.

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