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Short communication

Does the acute hemodynamic response to a maximum running exercise depend on the aerobic training status of the subjects?

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Abstract *Background:* High-intensity training has become increasingly popular in recent years but the exact effects of high intensity running on the hemodynamic system are not entirely understood and it is unknown whether the aerobic training status of the subjects might influence these hemodynamic reactions. Therefore, the study aims to evaluate whether the acute reactions of peripheral and central blood pressure (BP) and arterial stiffness (AS) to a maximal running exercise depend the training status of the subjects.
Methods: 41 healthy subjects were recruited. Of these were 21 aerobically trained (AE; 11 men) and 20 untrained (UN; 10 men). Aortic pulse wave velocity (PWV), peripheral and central BP was measured at rest and immediately after a maximal treadmill exercise using a ramp protocol including spirometric measurements.
Results: Resting hemodynamic values were not different between the groups. Systolic central and peripheral BP, and PWV increased in both groups in response to the running exercise. Δ of all measured parameters showed no difference between the groups.
Conclusions: The acute increases of AS and BP to a maximal running regimen seem to be independent of the subjects' training status and might therefore be an eligible training mode to maintain overall and vascular health.

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Background

Several studies illustrate the positive effects of moderate endurance training interventions on blood pressure (BP) and arterial stiffness (AS).[1,2] High-intensity training has become increasingly popular as it is superior compared to continuous moderate aerobic training for improving cardiorespiratory fitness.[3,4] Recent studies have also shown that high intensity exercise regimens are also suitable to prevent and manage hypertension.[5] During acute physical exercise, the cardiovascular system reacts to the specific conditions by increasing heart rate, BP, and by stiffening of the central the arteries due to vasoconstriction[6,7] to enable increased blood flow which is necessary to provide sufficient oxygen supply to the working muscles.

Aim

So far, little is known whether the aerobic training status influences these acute hemodynamic reactions. Therefore, the aim of this study was to evaluate whether the training status of the subjects influences the acute hemodynamic reactions resulting from a maximal treadmill running exercise.

Subjects and methods

41 healthy subjects participated in this study. Of these were 21 aerobically trained (AE; 11 men, 10 women) and 20 untrained (UN; 10 men, 10 women). Inclusion criteria were that subjects were healthy, non-smokers, between 20 and 30 years of age, and had a normal brachial BP (<140/<90 mmHg). To be included in the AE group, subjects had to report a training history in aerobic endurance sport for at least two years and a regular aerobic endurance training time of at least 6 h per week. To be included in the UN group, subjects had to report a training amount of ≤4 h per week. AE reported a regular aerobic endurance training time of 11.1 ± 4.4 (triathlon, middle-distance and long-distance running) and UN of 2.5 ± 0.9 h per week. All subjects gave written informed consent to participate in this study.

Anthropometric data of the subjects were measured using *seca® medical Body Composition Analyzer* (mBCA 515, seca GmbH & Co.KG., Hamburg, Germany). Subjects conducted a maximum running test on a treadmill (Woodway, Weil am Rhein, Germany) until subjective exhaustion using a ramp protocol with spirometric measurements (Metamax 3B, CORTEX Biophysik GmbH, Leipzig, Germany).[8]

All hemodynamic measurements were performed using Mobil-O-Graph (IEM, Stollberg, Germany) a validated device for the measurement of systolic and diastolic brachial BP (pSysBP, pDiaBP),[9] systolic and diastolic central BP (cSysBP, cDiaBP),[10] and aortic pulse wave velocity (PWV).[11] Hemodynamic measurements were performed pre (after 5 min of seated rest) and post running (30 s after finishing the test). The measurement takes 2.5 min with marginal deviation. The hemodynamic values presented for the post measurement were therefore recorded 3 min after the test. Results are expressed as mean ± SD. Anthropometric and performance data were analyzed using an unpaired t-test. A two-way mixed ANOVA (time × group) with Bonferroni post-hoc testing was used to evaluate the effects of the running exercise on hemodynamic parameters in AE and UN. Differences in Δ of the measured parameters between the groups were analyzed using an unpaired t-test. Differences were considered as significant with $p \leq 0.05$. Statistics were performed using the software package GraphPadPrism 6 (La Jolla, USA).

Results

Anthropometric and performance data of the participants are presented in Table 1. Running led to significant increases in both groups in pSysBP (AE: 118.9 ± 9.1 to 144.0 ± 19.5, $p < 0.001$; UN: 118.1 ± 10.7 to 147.1 ± 15.9, $p < 0.001$; Fig. 1a), cSysBP (AE: 105.7 ± 9.0 to 124.7 ± 14.9, $p < 0.001$; UN: 104.8 ± 8.2 to 124.4 ± 9.9, $p < 0.001$; Fig. 1c), and PWV (AE: 5.0 ± 0.4 to 5.8 ± 0.6, $p < 0.001$; UN: 4.9 ± 0.4 to 5.8 ± 0.4, $p < 0.001$; Fig. 1e). pDiaBP (AE: 74.0 ± 7.6 to 77.6 ± 10.2, $p = 0.044$; UN: 75.3 ± 9.1 to 77.5 ± 11.0, $p = 0.230$; Fig. 1b) and cDiaBP (AE: 75.9 ± 7.7 to 80.1 ± 10.3, $p = 0.006$; UN: 76.4 ± 8.3 to 79.4 ± 8.5, $p = 0.052$; Fig. 1d) increased significantly only in AE. Δ of

Table 1 Anthropometric, performance and peripheral blood pressure characteristics of aerobically trained and untrained subjects. Data are presented as means with ± standard deviation. *BMI* body mass index, *VO_2max* relative maximal oxygen consumption. *p ≤ 0.05 vs. aerobically trained subjects.

Parameter	Aerobically trained subjects (n = 21)	Untrained subjects (n = 20)	p value
Age [years]	23.3 ± 3.2	23.2 ± 2.3	0.881
Height [cm]	178.0 ± 8.0	173.5 ± 9.2	0.104
Weight [kg]	70.6 ± 8.8	73.1 ± 14.5	0.500
BMI [kg/m^2]	22.1 ± 1.5	23.7 ± 2.5*	0.012
Fat mass [%]	15.6 ± 7.0	21.9 ± 7.1*	0.007
Muscle mass [%]	40.1 ± 4.1	37.2 ± 5.1*	0.050
VO_{2max} [ml/kg/min]	52.2 ± 7.1	40.9 ± 6.2*	<0.001
Max. running velocity [m/s]	5.0 ± 0.6	4.2 ± 0.7*	<0.001
Time to exertion [s]	334.4 ± 56.4	249.0 ± 70.9*	<0.001
Pre systolic blood pressure [mmHg]	118.9 ± 9.1	118.1 ± 10.7	0.797
Post systolic blood pressure [mmHg]	144.0 ± 19.5	147.1 ± 15.9	0.576
Pre diastolic blood pressure [mmHg]	74.4 ± 7.6	75.3 ± 9.1	0.469
Post diastolic blood pressure [mmHg]	77.6 ± 10.2	77.5 ± 11.0	0.971
Pre heart rate [1/min]	67.1 ± 10.0	83.6 ± 16.3*	0.029
Post heart rate [1/min]	89.8 ± 19.3	103.8 ± 15.1	0.108