ORIGINAL ARTICLE

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Prediction of the Total Peripheral Resistance of Healthy Men During Resistance Training

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ABSTRACT

Background: Pulse pressure (PP) and mean blood pressure (MBP) are relatively convenient indicators of vascular function. This preliminary study investigated the effect of a single session of varying intensities of resistance training (RT) targeting the quadriceps femoris of healthy young men in the sitting position on the relationship between blood pressure and total peripheral resistance (TPR).

Methods: Twenty-eight sedentary, healthy young men (mean age, 19.9 years; mean body mass, 63.4 kg; mean height, 171.2 cm; and mean body mass index, 21.5 kg/m^2) were included. In a single session, the participants performed a total of 20 alternating knee extensions while sitting, with each excursion comprising a 5-s contraction and a 5-s rest period at 20%, 50%, and 80% load for a maximum of one repetition. During RT, we examined the correlations among MBP, PP, and TPR.

Results: We observed a correlation between MBP and TPR at each exercise intensity (20%, $r = 0.418$, $p = 0.027$; 50%, $r = 0.643$, $p = 0.0001$; and 80%, $r = 0.810$; $p = 0.0001$).

Conclusion: Changes in TPR during RT may be caused by changes in MBP.

Keywords: total peripheral resistance, resistance training, knee extension, mean blood pressure.

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INTRODUCTION

Vascular function generally declines with increasing age [1]. In particular, deterioration of artery function is related to the onset of myocardial and cerebral infarctions [2,3]. Moreover, arterial compliance decreases with age [4].In recent years, declining activities of daily living with aging have become a social concern. The American College of Sports Medicine encourages a load intensity of 70% of the maximum strength to improve strength and muscle hypertrophy [5]. However, the contraction of muscles during resistance training (RT) may have varying effects on intramuscular pressure and central and peripheral circulation. For instance, high-intensity RT >60% one-repetition maximum (1RM) reduced the flow-mediated dilation reaction [6].

Blood pressure (BP), especially systolic BP (SBP), fluctuates with age. Increased SBP correlates with pulse pressure (PP) and mean BP (MBP). MBP is defined by cardiac output and peripheral vascular resistance, while PP is defined by cardiac factors, aortic stiffness, and peripheral reflection waves [7]. Thus, PP and MBP may be relatively convenient indicators of vascular function. This preliminary study investigated the effects of a single session of varying intensities of RT targeting the quadriceps femoris of healthy young men sitting on the relationship between BP and total peripheral resistance (TPR). The findings of this study are relevant to the field of exercise physiology. However, further studies are needed involving patients with cardiac conditions in a rehabilitation setting.

MATERIALS AND METHODS

This resistance training (RT) study partial parts were non-smoking, healthy young men who exercised their quadriceps femoris muscle while sitting. Ethical approval was obtained from the Bunkyo Gakuin University Ethics Committee (2017-0042). In addition, the participants provided written informed consent.

The participants were 28 sedentary healthy men (mean age: 19.9 years, mean body mass: 63.4 kg, mean height: 171.2 cm, and body mass index: 21.5 kg/m^2). None of the participants had cardiorespiratory disease or orthopedic conditions in their lower limbs. Additionally, all participants were non-smokers.

Each participant was seated on the 'Leg Extension' device (HUR Co., Ltd. Finland) with a belt to stabilize the pelvis and knee at 0–90° flexion. The device's two arms were placed on the distal ends of the tibia in preparation for resisted quadriceps exercise. The participants held the two handles attached to the device (Figure 1).

Figures 1. Position of instruments and participants for impedance cardiography

The maximum strengths of the right and left quadriceps femoris were defined as 1RM, derived from the maximum number of repetitions at 60–75% of the load [8]. The strengths of the right and left quadriceps femoris muscles were measured individually, with the stronger side used in the study analyses. Exercise intensity was determined according to the revised version of the 2012 guidelines for rehabilitation in patients with cardiovascular diseases [9]. The exercise intensity was determined based on low, medium, and high-intensity loads of 20%, 50%, and 80% 1RM, respectively.

Using a metronome, the RT commenced with the right knee in 90° flexion. The knee was then extended to 0° flexion over 5 s. Immediately after returning to the starting position, the action was repeated on the left knee. These exercises were performed alternately for 20 repetitions. Each exercise and intensity was randomly performed, with an interval between measurements of ≥72 h.

The autonomic nerve hemodynamics and function were measured using impedance cardiography. Specifically, we used a cardiac function measurement task force monitor (TFM-3040; CN Systems Co., Ltd.) to analyze changes in heart rate using an autoregressive method. The hemodynamic parameters, including SBP, diastolic BP (DBP), PP, MBP, and TPR, were measured by each participant sitting during the rest and RT periods. The TPR was calculated from the BP, which was measured using an upper-arm cuff. In contrast, BP was measured using a finger cuff for the other parameters.

Using G*Power, the calculated sample size was 28.64, which was not rounded off to 29 as this number was already relatively adequate. The mean of each hemodynamic parameter was obtained during the rest and RT periods. Shapiro–Wilk tests were performed to compare the mean hemodynamic values before and after RT and to determine the normality of the distributions of continuous variables. Bonferroni tests followed this. Statistical significance was set at $p < 0.05$. Spearman's rank correlation coefficients were used to examine the relationships among the TPR, MBP, and PP. A predictive expression was made using simple linear regression analysis with items that showed a correlation. All statistical analyses were performed using IBM SPSS Statistics for Windows, version 26.0 (IBM Corp., Armonk, NY, USA).

RESULTS

The hemodynamic parameters during RT showed significant changes, except for PP at 80% 1RM during the rest period (Table 1). After RT, the PP increased significantly at 50% 1RM (p = 0.021), and TPR decreased significantly TPR (p = 0.0001). Additionally, SBP (p = 0.0001) and PP (p = 0.0001) increased significantly. TPR decreased significantly (p = 0.0001) at 80% 1RM (Table 1). Moreover, we observed a correlation between MBP and TPR at each exercise intensity (20%, r = 0.418, p = 0.027; 50%, r = 0.643, p = 0.0001; 80%, r = 0.810, p = 0.0001) (Table 2). Figures 2–4 depict the correlation chart of the predictive expression generated by a simple linear regression analysis.

Table 1: Changes in the mean ± standard deviation values of the haemodynamic parameters during resistance training

N=28

		sBP [mmHg]		dBP [mmHg]		pP [mmHg]		mBP [mmHg]		TPR [dyne*s/cm^5]	
20%	Rest	118.6± 9.7		71.1± 7.9		47.4± 4.6		90.0± 9.2		1142.5 ± 199.0	
	Exercise	131.3±11.0	0.0001	78.5± 9.3	0.0001	52.7±16.4	0.0001	100.0± 10.0	0.0001	1013.4 ± 157.2	0.0001
	Post	120.5± 6.9		72.0± 8.2		48.5± 6.5		91.3 ± 10.0		1214.1 ± 221.5	
50%	Rest	120.5± 8.4		72.5 ± 6.1		48.1 ± 5.6		91.7 ± 7.0		1306.9 ± 183.6	
	Exercise	140.7±17.5	0.0001	86.0 ±13.4	0.001	54.7 ± 7.4	0.0001	108.1 ± 15.1	0.0001	983.9 ± 170.4	0.0001
	Post	124.9±14.3		70.5 ± 8.4		54.3 ± 9.8	0.021	91.6 ± 10.3		1123.6 ± 210.4	0.0001
80%	Rest	120.7± 6.9		72.5 ± 7.8		48.2 ± 6.5		91.6 ± 9.1		1271.4 ± 175.7	
	Exercise	137.3±22.5	0.008	90.3 ±15.8	0.0001	47.0 ±15.8		109.7 ±17.9	0.0001	943.6 ± 169.6	0.0001
	Post	129.7±13.3	0.0001	72.9 ±10.8		56.7 ± 9.4	0.0001	94.4 ±12.0		1059.3 ± 214.7	0.0001

*p <0.05

Table 2: Mean ± standard deviation values of the correlation between total peripheral resistance and mean blood pressure during resistance training

N=28

	r	P
20%	0.418	0.027*
50%	0.643	0.0001*
80%	0.81	0.0001*

* p <0.05

Figure 2: Mean ± standard deviation values of the correlation between total peripheral resistance and mean blood pressure during resistance training at 20% load of one-repetition maximum

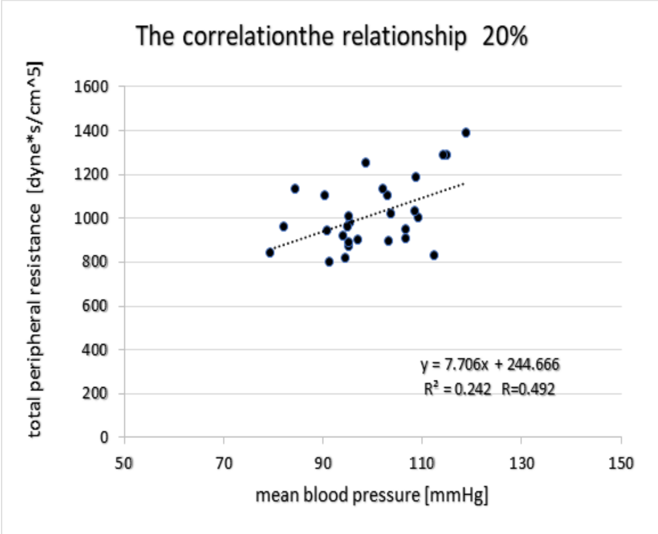


Figure 3: Mean ± standard deviation values of the correlation between total peripheral resistance and mean blood pressure during resistance training at 50% load of one-repetition maximum

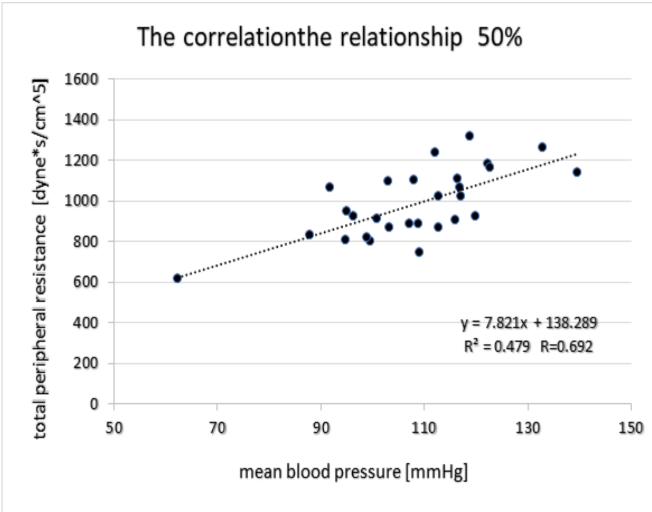
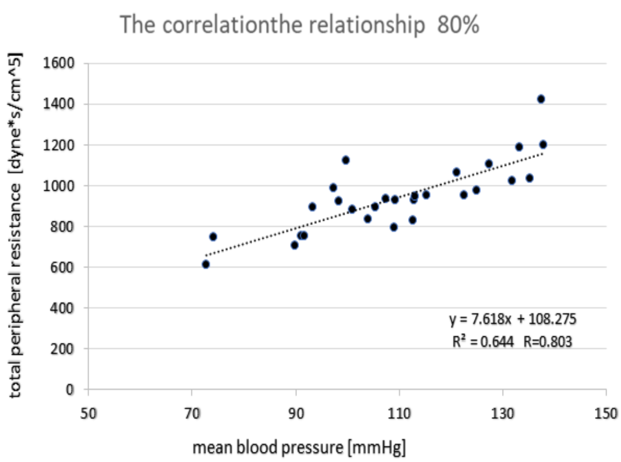


Figure 4: Mean ± standard deviation values of the correlation between total peripheral resistance and mean blood pressure during resistance training at 80% load of one-repetition maximum



DISCUSSION

The study findings showed a correlation between MBP and TPR during knee joint extension exercises. The interrelated relationship was significant with increased exercise intensity. After exercising at 50% 1RM, PP increased, while the TPR decreased. In contrast, at 80% 1RM, SBP and PP increased and TPR decreased. However, parameters related to vascular function, such as arterial elasticity, were not measured. Therefore, our interpretations were limited to the observations of the BP parameters and TPR.

Regarding local vascular adjustment, shear stress within blood vessels during exercise triggers vascular endothelial cell secretion of substances related to vascular dilation and constriction. Among these, endothelin-1, a vasoconstrictor, is secreted into non-active muscles during exercise at concentrations proportional to the exercise intensity [10]. In contrast, the secretion of nitric oxide, a vasodilator, decreases within 1 minute of exercise, although a small amount is still secreted due to increased shear stress [11]. The amount of secretion and duration of the effect of other vasodilators during exercise remains unknown [12]. Therefore, these may explain the BP parameters and TPR changes during RT. A previous study suggested that PP was associated with arterial wall compliance in the aorta, while MBP was associated with resistance vessels such as microarteries [7]. These findings may explain the correlation between MBP and TPR with increasing exercise intensity in the present study.

After exercise at 50% and 80% 1RM, PP and SBP increased, while TPR decreased. The decrease in TPR could occur due to the continuous increase in blood flow owing to the increases in SBP and PP, which cause blood vessel dilatation, thereby decreasing TPR. Additionally, the increase in SBP and PP was correlated with a decrease in compliance of the aortic vessel wall. Credeur et al. suggested that high-intensity RT (>60% 1RM) could exacerbate vasodilation [6].

This study included healthy men who underwent a single intervention. Therefore, the prediction of TPR from MBP requires verification in these patients. Vascular function should also be assessed. This study focused on indirect assessments based on central hemodynamics.

CONCLUSIONS

This study showed that a change in MBP may lead to a change in peripheral artery resistance during exercise. In addition, the change in PP could be due to decreased compliance of the aortic artery wall. Therefore, future clinical assessments of BP should include PP and MBP.

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