Original Article

Pressure Response after Resistance Exercise for Different Body Segments in Hypertensive People

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Abstract

Background: **Resistance exercise has now been recommended as adjunct component of aerobic exercise on physical training program directed to the treatment and control of hypertension (HBP). However, it has not been widely incorporated yet into clinical practice, possibly by the scarcity of available evidence regarding the safe limits of the acute pressure response in this modality.**

Objective: **To investigate the acute effect of progressive resistance exercise of different body segments, the pressure response of patients with controled hypertension (HBP).**

Methods: **Twenty-five patients (14 women) with controled hypertension with medication (64.5 ± 10.8 years old) and sedentary, had three visits to a randomic progressive resistance exercise session, in the following muscle groups: femoral quadriceps, latissimus dorsi and brachial biceps. Blood pressure measurements were obtained at all visits at rest, immediately after each series of exercise and after 5 minutes of recovery.**

Results: **Immediately after acute resistance exercise, a significant increase in systolic blood pressures, without significant changes of diastolic pressure compared to pressure levels at rest for all muscle groups and for all intensities studied. Additionally, there was a greater tendency to elevation of systolic pressure when the femoral quadriceps muscle was exercised at high intensity.**

Conclusion: **Resistance exercise in different body segments promoted similar increases and safe levels of systolic blood pressure, although with a tendency toward greater response of it when large muscle groups at high loads are exercised. (Arq Bras Cardiol 2010; 95(3): 405-411)**

Key words: **Hypertension; exercise/physiology; exercise movement techniques/trends.**

Introduction

Systemic hypertension (HBP) is currently the first modifiable risk factor causing morbidity and mortality of cardiovascular disease worldwide[1]. Although its etiology is not yet fully elucidated, there is a growing body of evidence indicating it is multifactorial[2-4]. These suggest the influence of factors such as genetics, physical inactivity, overweight, excessive intake of sodium and alcohol and psycho social profile, in the genesis of HBP[2-4].

Once diagnosed, the first choice of treatment for HBP, in most cases, it is mainly, on life style changing (LSC), crucial to prevent deleterious complications of high blood pressure. LSC includes actions such as maintaining regular physical activity, healthy diet and interruption of smoking[4]. Currently, there is consensus that regular exercise is the main intervention (no medication) determining the success in prevention of HBP in adults with normal blood pressure levels and this reduction in hypertensive patients. It is well established that aerobic exercises are the most effective component in reducing blood pressure (BP) in hypertensive patients[5,6]. Its benefits are related to the metabolic muscle performance, reduced endothelial dysfunction, improvement of neuro-hormonal abnormalities and decreased insulin resistance, which results in the reduction of systemic vascular resistance, promoting a favorable effect on concomitant cardiovascular risk factors[5,7].

Moreover, resistance training has been less explored in this population[8-10]. A meta-analysis on the effect of resistance training on BP at rest suggests that it was carried out at moderate intensity, may be able to reduce the levels of BP[11].

Although the latest guidelines for control of HBP have recommended that resistance exercise should be add to the aerobic exercise component in the physical training program targeted for hypertensive patients, it has not been widely incorporated yet into the clinical practice[5,12-14]. Additionally, it is not known whether resistance exercise of different body segments promotes distinct pressure responses.

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Considering these findings, this study aimed at investigating the acute effect of progressive resistance exercise, of different body segments, on the BP of patients with systemic hypertension.

Material and methods

Sample

We evaluated 29 patients diagnosed with hypertension controlled by drugs and with medium risk stratification, according to cardiovascular risk, blood pressure levels, presence of risk factors, target organ damages and cardiovascular disease. Patients were screened by the waiting line of cardiac rehabilitation outpatient setting and a geriatric clinic outpatient setting.

All patients enrolled in the study were monitored as outpatients per clinician, or cardiovascular doctor, at least one year preceding the study, with clinical history, physical examination with repeated measurements of blood pressure in different visits with clinical examinations and routine laboratory tests, which confirmed the diagnosis of essential systemic hypertension. Inclusion criteria were: clinical diagnosis of HBP, referral and medical release for physical training program, and stable disease and controlled by medication (no change in medication in the last four weeks). Exclusion criteria were: presence of diabetes, congestive heart failure, ischemic heart disease, regular use of nitrates, use of hormonal supplementation, current smoking, locomotion problems limiting exercise and have been previously involved in physical training programs.

During the study period, external sessions of exercise or strenuous extra physical activities were controlled, as well as nutritional habits (coffee, tea, chocolate, alcohol) that could interfere with study results.

The study was approved by ethics committee on institutional research (Case No. 126325/2007), and all the participants provided informed consent.

Procedures

Anthropometric measures

The evaluation consisted of anthropometric measurements of weight and height. Patients were instructed to remove their shoes, standing in light clothing (trousers and shirt). The body weight measurement was performed using an anthropometric mechanical scale Welmy™ brand with a capacity of 140 kilograms (kg) and with divisions of 100 grams. To verify the height, the measurement was made after deep inspiration, maintaining the upright position. The feet were kept parallel with body weight distributed equally between them.

From the measurements of weight and height obtained, the body mass index (BMI) = weight/height^2 (kg/m^2) was calculated for classifying the nutritional status[14].

Blood pressure measurements

Measurements of blood pressure (systolic and diastolic) were obtained by aneroid sphygmomanometer Welch Allyn™ Maxi-Stabil with dimensions of the rubber bag to adults arm and with capacities up to 300 mmHg, calibrated and validated in accordance with the guidelines of Brazilian Society of Cardiology. For blood pressure measurements, it was followed the standard procedures by the guidelines recommended by HBP guidelines[15], always performed by the same examiner and at the same time of the day. These measures were obtained at rest, immediately after exercise and after 5 minutes of rest in the final session of resistance exercise during each visit. The blood pressure measurements obtained immediately after exercise were taken within 30 seconds after the end of the muscle work for all muscle groups studied. Blood pressure at rest was considered as the average value of baseline measurements at the three visits that involved the study.

Resistance exercise protocol

All participants underwent four visits to the outpatient cardiac rehabilitation setting. On the first visit, a test of one maximum repetition was performed by increasing technique, to determine the maximum voluntary contraction (MVC), which was the highest load (weight) that the individual could move during the entire movement without compensations[8]. Then, in other visits, a random resistance exercise session was held in the following muscle groups: femoral quadriceps, latissimus dorsi and brachial biceps muscles (Figure 1). At each visit, only one muscle group was exercised in order to avoid any influence of the cumulative effect of exercise on different muscle groups in BP response. Thus, each muscle group was exercised at random, with 48-hour intervals, allowing the effect of washout.

The resistance exercise session consisted of dynamic contractions (isoinertial) with progressive intensities derived from relative values of 50, 60 and 70.0% of MVC. Ten repetitions of each relative intensity were performed, following a suitable period of one second of muscular work and two seconds of rest in each contraction, with an interval of one minute between each set of exercise[16]. Both in determining the MVC as in resistance training, free weights were used halter and shin guards. Special attention was given to the influences of the positioning, of the joint angle and speed of contraction not to directly affect the production of strength in all muscle groups studied. Likewise, patients were asked not to hold their breath during muscle contractions, avoiding adverse outcomes associated with the valsalva maneuver[14].

Statistical analysis

The collected data were analyzed in a specific program for statistical analysis (SPSS - Statistical Package for Social Sciences™, version 13.0). The variables were expressed as mean and standard deviation. The differences between the basal blood pressure values immediately after exercise and at recovery were analyzed by ANOVA and Tukey's contrast test. The differences between the outcomes of blood pressure values immediately after exercise for each relative intensity resistance exercise on each muscle group were analyzed by ANOVA and the comparison among the three different segments (brachial biceps, femoral quadriceps and latissimus

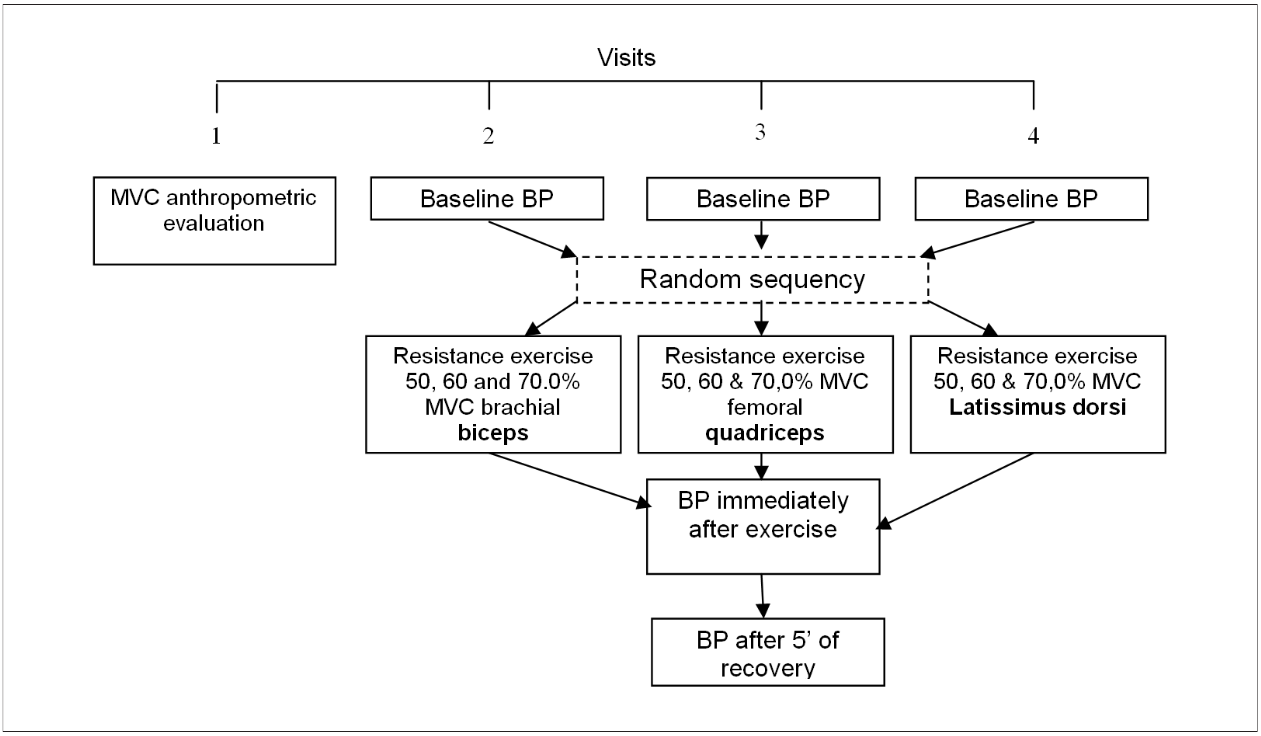

Figure 1 - Study flow chart.

dorsi) at each intensity. The probability of type I error was set at 5.0% for all tests ($p \leq 0.05$).

Results

Of the 29 patients recruited for this study, four were withdrawn during the initial evaluation because of associated comorbidities: obesity (BMI[3] 34.9 kg/m^2, n = 1), coronary artery disease (n = 1), diabetes mellitus (n = 1) and osteoarthrosis limiting the exercise (n = 1). Thus, twenty-five patients diagnosed with HBP diagnosis were enrolled in the study.

The demographic and anthropometric characteristics of the sample are shown in Table 1. The mean age of patients was 64.5 years old, with higher prevalence of elderly (68.0%), or aged over 60 years old. The sample can be considered homogeneous for sex, although with a slight female predominance (56.0%).

Regarding nutritional status, the sample was predominantly characterized as mild overweight (BMI = 28.2), with only one quarter of it characterized as eutrophic.

All patients had their blood pressure controlled by diuretics and beta blockers (Table 1).

All patients were able to carry out the assessment of the MVC, as well as training in charges related to all muscle groups studied, without any discomfort or adverse effect related to resistance exercise. Additionally, there was excellent adhesion to the visits required to complete the study protocol.

In Table 2, we show the average systolic and diastolic pressure in the baseline periods, taken immediately after the relative intensities of 50, 60 and 70.0% MVC, and after five minutes of recovery, in the different muscle sites exercised (elbow flexors, knee extensors and shoulders abductors). No difference was observed in the values of systolic pressure at rest and 5 minute recovery in all muscle groups studied. However, these values (systolic blood pressure at rest and recovery) differed from those obtained immediately after exercise, regardless of the relative intensities (50, 60 and 70.0% MVC) in different muscle groups exercised (Table 2 and Figure 2). Furthermore, no difference was observed in mean diastolic pressure at any time or in any muscle group assessed (Table 2).

When comparing the levels of systolic pressure elicited in the same relative intensity between different muscle groups, it can be observed a tendency of the knee extensor muscle to trigger higher levels of systolic pressure in the relative intensity of 70.0% of MVC, compared to groups of elbow flexors and

Table 1 - Characteristics of the studied population

	n = 25
Male/Female	11 / 14
Age (years)	64.56 ± 10.87
Height (m)	1.55 ± 0.07
Weight (kg)	67.98 ± 11.27
BMI (kg/m^2)	28.20 ± 4.26
SBP at rest	127.93 ± 12.51
DBP at rest	78.81 ± 7.71

Data presented in averages and standard deviation; BMI - body mass index; SBP - systolic blood pressure; DBP - diastolic blood pressure.

Table 2 - **Blood pressure levels in different evaluated moments**

	Systolic (mmHg)	Diastolic (mmHg)
Elbow flexors		
Rest	126.52 ± 13.35*	78.04 ± 8.08
50% MVC	137.39 ± 17.89	77.17 ± 16.15
60% MVC	141.52 ± 16.33	80.22 ± 8.59
70% MVC	140.95 ± 16.09	77.14 ± 10.30
Recovery	127.83 ± 14.12 §	78.48 ± 9.34
Knee extensors		
Rest	126.80 ± 12.23†	78.40 ± 7.31
50% MVC	142.40 ± 17.03	78.00 ± 8.48
60% MVC	142.60 ± 16.80	79.23 ± 8.44
70% MVC	149.50 ± 18.26 #	79.80 ± 9.43
Recovery	127.76 ± 11.13 //	80.80 ± 7.95
Shoulder abdutors		
Rest	130.48 ± 12.03 ‡	80.00 ± 7.74
50% MVC	140.00 ± 14.49	79.76 ± 8.13
60% MVC	139.47 ± 14.58	77.37 ± 9.10
70% MVC	140.56 ± 15.51	79.17 ± 9.43
Recovery	128.52 ± 14.16 ¶	80.95 ± 7.68

Data presented in average and standard deviation; MVC - maximum voluntary contraction; difference ($p \leq 0.05$) of SBP at rest versus SBP in relative intensities (*) of elbow flexors, (†) of knee extensors, (‡) of shoulder abdutors. Difference ($p \leq 0.05$) of SBP of recovery versus SBP in relative intensities (§) of the elbow flexors, (//) of knee extensors, (¶) of shoulder abductors and (#) for trend to difference ($p = 0.09$) of SBP`at 70.0% MVC versus SBP at 50 and 60,0% MVC of knee extensors.

shoulder abductors (149.50 ± 18.26 *vs* 140.95 ± 16.09 *vs* 140.56 ± 15.51, p = 0.09, respectively).

Discussion

The results of this study show that progressive resistance exercise of different body segments seems to promote modest and safe increases of the acute pressor response of patients with controlled systemic hypertension. Additionally, resistance exercise of different body segments promoted similar increases in levels of systolic blood pressure, although there was a greater tendency to present higher response of it when the knee extensors are exercised with high loads.

It is generally agreed that resistance exercise has not been the first therapy choice for physical activity, but should be incorporated into a training program for hypertensive patients, since this promotes blood pressure responses within safe limits.

Compared to aerobic exercise, the literature addressing the effect of resistance exercise on blood pressure is still scarce and conflicting. A recent meta-analysis suggests that resistance exercise training at moderate intensity is not contraindicated for hypertensive patients and is able to reduce modestly but significantly the levels of blood pressure[8,16]. However, the available literature has focused predominantly on the chronic effects of sequential resistance exercise[17,10]. Therefore, it becomes relevant the study of blood pressure response triggered by acute resistance exercise, since it is known that high peaks of blood pressure can cause disruptions of aneurysms, cerebral and myocardial ischemia.

In recent guidelines for management of HBP, it was considered that the exercise of lifting weights with high

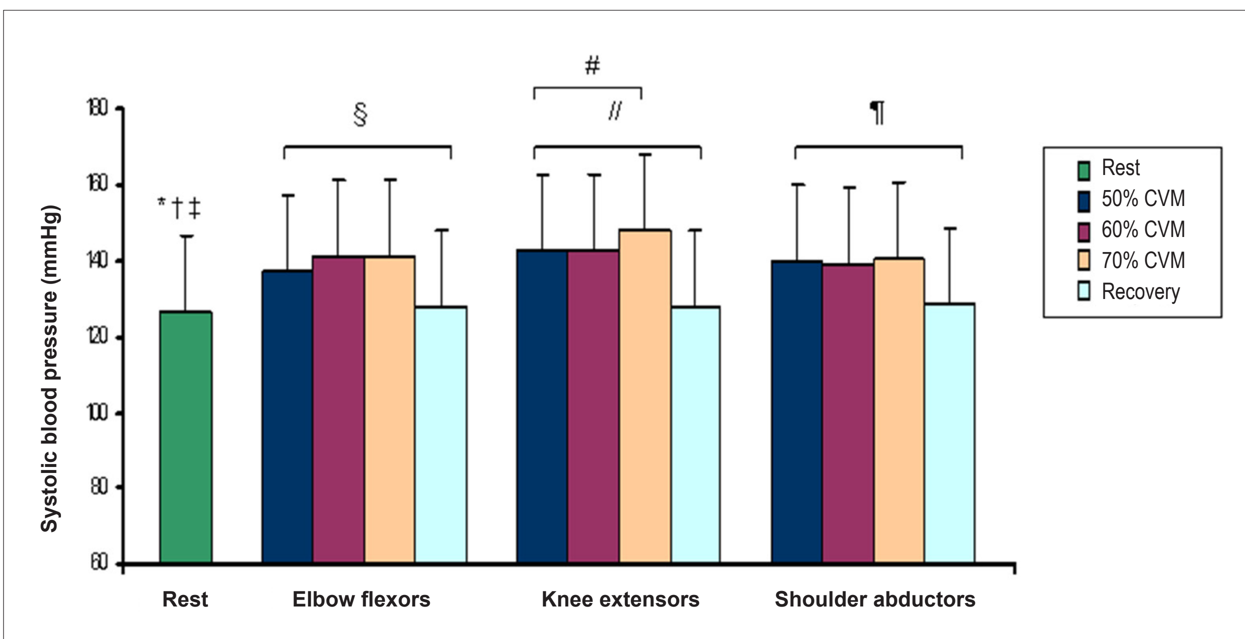

Figure 2 - Behavior of SBP at rest, after different intensities of resistance exercise and the recovery of the segments evaluated. Difference ($p \leq 0.05$) in SBP at rest versus SBP in the relative intensities (*) of the elbow flexors, (†) of the knee extensors, (‡) of the shoulder abductors. Difference ($p \leq 0.05$) of SBP recovery versus SBP in the relative intensities (§) of the elbow flexors, (//) of the knee extensors, (¶) of abductors of the shoulder. Tendency for the difference ($p = 0.09$) in SBP in 70.0% MVC versus SBP at 50 and 60.0% MVC of knee extensors (#).

intensities and isometric nature has pronounced effects on raising blood pressure levels and should therefore be avoided[18]. Thus, this study sought to evaluate the acute blood pressure response, immediately after the isotonic resistance exercise at different intensities and body segments of controlled hypertensive patients.

Resistance exercise carried out in an isotonic way has been recommended, especially for the elderly, with primary focus on prevention and rehabilitation of osteoporosis and age-related sarcopenia, and emerging indications for modification of metabolic risk factors[19-23]. Moreover, it is still open for discussion if resistance exercise can modulate arterial compliance.

Two different hypotheses have been raised: one suggests that the thickening of the arterial wall and hypertrophy present in hypertension, associated with resistance exercise, may be an adaptation of benefit against the risk of rupture; the other suggests that the reduction of arterial compliance may result in a poor arterial adaptation, increasing the cardiovascular risk[24].

A possible physiological explanation for the beneficial adaptation is the "fight or flight" response, ie associated with increased sympathetic activity and norepinephrine release, there is an acute response that facilitates blood clotting to prevent losses in injuries, which enhances the arterial wall against the risk of rupture, but, if sustained, can lead to increased blood pressure[25]. By contrast, poor adaptation of the cardiovascular system to resistance exercise may be due to reduced arterial compliance by imposing limits on chronic arterial wall, for a higher sympathetic tone[26,27].

Additionally, an increase of metabolic end products and cross-linking of collagen in the arterial wall is suggested, favoring thickening[27].

Studies have speculated that the degree of arterial adaptation may be greater in response to resistance exercise of long duration and moderate intensities than at high ones, and even more significant in middle age[24,28]. In this line of reasoning, Bertovic et al[29] observed that in competitive athletes, resistance exercise, performed at high intensities, were associated with lower arterial compliance than sedentary subjects[29].

It is known that during each repetition resistance exercise, it may occur increased blood pressure, however, as the resistance is not sustained, this returns to baseline, without offering substantial risk to the patient. During the execution of resistance exercise, increased pressure on the cardiovascular system will depend on the relative intensity of the resistance and the cycle of contraction/relaxation. With the intention that there is no cardiovascular overload, this study was based on the recommendation of AHA, determining one second contractions and rest periods between contractions of two seconds[13]. These parameters were provided with supervision and proper instructions to patients during the series resistance exercise due to the moderate relative intensity of effort.

The increase in blood pressure during the performance of resistance exercise is done primarily by increased peripheral vascular resistance, but the increase in cardiac output is also a factor involved. Therefore, elevation of blood pressure appears to be exacerbated in hypertensive non-medicated ones. However, the hypertensive patients under drug therapy of betablockers have reduced cardiac output by decreasing the inotropic and chronotropic response at sympathetic stimulation[21,30]. Thus, it is possible to suggest that this medication reduces the increase in blood pressure during resistance exercises.

Although a meta-analysis on the chronic effects of progressive resistance training has shown effectiveness of this intervention in reducing blood pressure levels[31], yet there are few studies assessing the acute effect of resistance exercise on BP of adults with controlled HBP. However, these studies evaluated the BP response after one or two hours of exercise session involving several muscle groups. In the study by Hill et al, it was observed significant reduction in diastolic blood pressure with no change in systolic and ended after one hour from the end the resistance exercise session of 11-18 minutes[22].

O'Connor et al[23] assessed the effects of 30 minutes of resistance exercise on BP in adult women after two hours of the session. Although no change was observed in DBP, a significant elevation of SBP in the first and 15th minutes after the exercise intensity of 80.0% of MVC[23].

Harris and Holly[24] observed modest increase in blood pressure of mild hypertensive patients during resistance exercise. On the other hand, Palatini et al[32] found notable increases, reaching values of 345/245 in one patient. However, it is worth noting that in both studies, hypertensive patients did not use antihypertensive[32].

In contrast, this study showed that progressive resistance exercise of different body segments, seems to produce safe increases in systolic blood pressure, without substantial changes in diastolic pressure, which may suggest that in patients with controlled HBP with medication, therapy for resistance exercises in the evaluated relative intensities measured can be performed.

Interestingly, resistance exercise of the knee extensor in the intensity of 70.0% MVC tended to show higher levels of systolic pressure. This trend could be explained by such group that have greater muscle mass, which recruits more blood flow, resulting in greater blood flow, determining higher diastolic end volume, increased cardiac output with subsequent increase in blood pressure. In this line of reasoning, resistance exercises for large muscle groups performed at intensities greater than 70.0% of MVC may be monitored by the possibility of triggering any pressure peaks in patients with potential risks.

This study had some limitations: first, it was not a placebo-controlled and the examiner was not blind to the intervention, and second, although all patients used diuretics and betablockers, and had the same risk stratification according to the usual risk classification, no description of the pharmacotherapeutics was recorded, so if they had intra-group differences in this respect, it is plausible that there was some influence of medication. And third, although resistance exercise appears to be safe in this population, the number of patients is small, and the study should be repeated on a larger number.

The main clinical implication of this study is that resistance exercise therapy in patients with hypertension controlled with medication should be monitored, especially when large muscle groups are exercised at high intensities. Thus, it is likely that these patients safely achieve more benefits from a physical training program.

In conclusion, our results indicate that in patients with controlled systemic hypertension, progressive resistance exercise of different body segments promotes modest increases in systolic blood pressure and appears to be safe, without effects on diastolic blood pressure.

Potential Conflict of Interest

No potential conflict of interest relevant to this article was reported.

Sources of Funding

There were no external funding sources for this study.

Study Association

This study is not associated with any post-graduation program.

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