The Blood Pressure Responses to Dynamic Exercise in Older People

การตอบสนองของความดันโลหิตต่อการออกกำลังกายแบบมีการเคลื่อนไหวในผู้สูงอายุ

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ABSTRACT

Older people are at high risk of cardiovascular disease as a result of high blood pressure due to increased arterial stiffness. The hypertension can be lowered by long term exercise training but, the short term, blood pressure increases during exercise which makes it difficult to judge the relative risks of long term gains against short term risks without knowing more accurately how much blood pressure does rise during the type of exercise commonly used in training. The aim of this study was to examine the blood pressure responses to a moderate dynamic exercise in elderly people. Ten healthy older (age 65±5 yrs.) and ten young (age 24±3 yrs.) subjects undertook a progressive exercise test using a cycle ergometer. The exercise began at a load of 25 Watt, pedaling at 50 rpm and increased progressively by 25 W every 3 min until the subjects reached their heart rate of 50% heart rate reserve (HRR) which was continued to the end of that 3 minute stage. The older and young subjects terminated exercise at similar relative loads of 60 and 57% HRR respectively. There was a significantly greater rise in sBP in the older compared to young subjects at end of the exercise (52±15 vs. 33±8 mm Hg, p = 0.001). There were no significant changes in dBP during exercise and no differences between older and younger subjects. In conclusion, older healthy subjects have exaggerated blood pressure responses to dynamic exercise to the same moderate relative intensity of exercise compared to the young. This may increase the acute risk of stroke during exercise and it might, therefore, be advisable to monitor the blood pressure response of subjects to the exercise intensity that is prescribed for the management of hypertension.

บทคัดย่อ

ผู้สูงอายุเป็นวัยที่มีปัจจัยเสี่ยงสูงต่อการเกิดโรคทางระบบหัวใจและหลอดเลือด เนื่องจากผู้สูงอายุมีหลอดเลือดแข็ง จึงมักมีความดันโลหิตสูงเป็นปัจจัยเสี่ยงหลัก แม้ว่าการออกกำลังกายเป็นเวลานานสามารถลดความดันโลหิตสูงได้ แต่ขณะออกกำลังกายทำให้ความดันโลหิตเพิ่มขึ้นฉับพลันและอาจเพิ่มสูงมากจนผิดปกติในผู้สูงอายุได้ การศึกษานี้จึงมีวัตถุประสงค์เพื่อประเมินการเปลี่ยนแปลงของความดันโลหิตขณะออกกำลังกายที่ความหนักระดับปานกลางในผู้สูงอายุโดยศึกษาในอาสาสมัครสุขภาพปกติในผู้สูงอายุ 10 คน (อายุเฉลี่ย 65±5 ปี) และวัยหนุ่มสาว 10 คน (อายุเฉลี่ย 24±3 ปี) อาสาสมัครได้รับการทดสอบการออกกำลังกายแบบเพิ่มความหนักแบบก้าวหน้าด้วยจักรยานวัดงาน โดยเริ่มที่ความหนัก 50 วัตต์ ความเร็ว 50 รอบ/นาที แล้วเพิ่มความหนักขั้นละ 25 วัตต์ ออกกำลังกายขั้นละ 3 นาที เมื่ออัตราการเต้นของหัวใจเพิ่มขึ้น

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จนถึงระดับ 50 % ของอัตราการเต้นหัวใจสำรอง (HRR) อาสาสมัครออกกำลังกายต่อเนื่องด้วยความหนักนั้นจนครบ 3 นาที จึงสิ้นสุดการออกกำลังกาย ผลการศึกษาพบว่าความหนักของการออกกำลังกายที่จุดสิ้นสุดการออกกำลังกายในผู้สูงอายุและวัยหนุ่มสาวไม่ต่างกันคือ 60 และ 57 % HRR ตามลำดับ แต่ความดันโลหิตซีสโตลิคเพิ่มมากกว่าวัยหนุ่มสาว (52±15 เทียบกับ 33±8 มม.ปรอท p = 0.001) ความดันไดแอสโตลิกไม่เปลี่ยนแปลงและไม่แตกต่างเมื่อเทียบกับหนุ่มสาว สรุปว่าผู้สูงอายุสุขภาพดีมีความดันโลหิตซิสโตลิกเพิ่มขึ้นมากกว่าวัยหนุ่มสาวขณะออกกำลังกายแบบมีการเคลื่อนไหวที่ความหนักของการออกกำลังกายเพียงระดับปานกลางที่ใกล้เคียงกัน การเพิ่มของความดันโลหิตซิสโตลิกที่มากนี้อาจเพิ่มความเสี่ยงของการเกิดภาวะบาดเจ็บของหลอดเลือดสมองได้ ดังนั้นผู้สูงอายุจึงควรได้รับการวัดติดตามการเปลี่ยนแปลงของความดันโลหิตซิสโตลิกขณะออกกำลังกายที่ระดับความหนักที่ใช้ในการฝึกเพื่อลดความดันโลหิตสูง

Key Words: Blood pressure response, Dynamic exercise, Ageing

คำสำคัญ: การตอบสนองของความดันโลหิต การออกกำลังกายแบบมีการเคลื่อนไหว ผู้สูงอายุ

Introduction

In Thailand, as in all countries, age constitutes a major risk factors for cardiovascular disease (Kaufman et al., 2011) as a consequence of deteriorating cardiac function, altered autonomic cardiovascular control, atherosclerosis and stiffening of the arterial walls (Greenwald, 2007). A consequence of these aging changes, particularly increased arterial stiffening, is an elevated resting systolic blood pressure (sBP), and increased pulse pressure (PP) which both predict increased mortality in the elderly (Domanski et al., 2002).

Exercise training is widely promoted to improve the quality of life for elderly people and to control blood pressure (Cornelissen and Smart, 2013). During exercise there is an increase in blood pressure, which is necessary to adequately perfuse the working muscles, but there are two reasons why this might cause problems for older people. The first is that arterial stiffening may increase sBP, both at rest and during exercise. The second reason is that older people may have abnormal autonomic responses to exercise (Brocklehurst, 2010) and so have an exaggerated increase in blood pressure during exercise. This raises potential problems when prescribing exercise intensity for elderly subjects. There is little information about the changes in blood pressure during the type of exercise that might be prescribed as part of the long term management of hypertension in older people. Consequently the purpose of the present study was to determine the blood pressure responses to moderate dynamic exercise intensity which is often prescribed for healthy older subjects.

Methods

Subjects

Ten older (age 65±5 years; 1male/9female) and younger (age 24±3 years; 3 male/7 female) subjects were recruited from volunteers in Mueang Khon Kaen district, Khon Kaen Province. All participants were non-smokers and free from medication. Volunteers completed a detailed medical questionnaire and any with a clinical history of cardiovascular disease or diabetes mellitus, Subjects with resting BP greater than 120/80 mmHg, or an abnormal resting electrocardiogram were excluded. The study was approved by the Ethical Committee of Khon Kaen University and subjects gave their written consent to participate.

Study protocol

Participants were asked to avoid heavy exercise for 24h and fast overnight before attendance. Subjects rested in an easy chair for 30 min in a quiet temperature-controlled room before baseline cardiovascular measurements were made. Subjects then performed dynamic exercise on a cycle ergometer (828E; Monark Exercise AB, Varberg, Sweden). Resting HR was measured for 2 minutes before the start of exercise while sitting on the ergometer. The target exercise level was set to 50% of the estimated maximum heart rate reserve (HRR) assuming maximum heart rate to be 207-(0.7*age) (Gellish et al., 2007). Subjects began pedaling at 50 rpm for 1 min with no load and then 3 minutes against a load of 25W, increasing to a load of 50 W for the next 3 minutes and to 75 W, if necessary, for a further 3 minutes until the target heart rate of 50% HRR was achieved.

Blood pressure and heart rate

Blood pressure was measured with a digital bedside monitor (BSM-6701, Nihon Kohden, Tokyo, Japan) and an inflatable cuff placed around the subject's arm one inch above the elbow over the brachial artery. Electrocardiography was measured with electrodes attached in lead II configuration and connected to the BIOPAC system (BIOPAC System, Goleta, CA, USA) and HR determined from the R-R interval.

Data analysis

Data are presented as mean±SD. Differences within group and between groups were analyzed by paired t–test and independent t-test where appropriate. P<0.05 was considered significant. The statistical package used was SPSS for Windows (version 17; SPSS Inc., Chicago, Illinois, USA).

Table 1 Subject characteristics

Variables	Older	Younger
Age (Years)	65±5*	24±3
Weight (kg.)	59±10	62±13
Height (m.)	1.56±.08*	1.67±.11
BMI (kg/m^2)	24±2	22±2
Final workload (watt)	60±13*	85±24

BMI, body mass index. *p< 0.05, older vs. younger. All data are means ± SD.

Table 2 Blood pressure and heart rate responses to dynamic exercise

	Resting (old)	End exercise (old)	Change (old)	Resting (young)	End exercise (young)	Change (young)
sBP (mmHg)	111±8*	163±18*#	52 ±15*	105±5	137±9#	33 ±8
dBP (mmHg)	68±7	69±10	1 ±9	65±6	70±7#	6 ±6
MAP (mmHg)	82±7	100±11#	18 ±9	78±6	93±6#	15 ±6
HR (bpm)	70±6	122±5*#	52 ±3*	67±9	138±6#	72 ±9
% HRR		60			57	

sBP, systolic blood pressure; dBP, diastolic blood pressure; MAP, mean arterial pressure; HR, heart rate. HRR, heart rate reserve. All data are mean ± SD. # $p < 0.05$, resting vs. end exercise. *$p < 0.05$, older vs. younger.

Results

All subjects managed to cycle at a constant 50 rpm for an average of 5 minute before reaching the target heart rate for the older, and 7 minute for the younger, subjects. The HR at the end of exercise (Table 2) represented 57 and 60% of the estimated HRR or 76 and 73% of the estimated age-related maximum heart rate for the old and young subjects respectively. Reports of dyspnea (5/10) at the end of exercise were not statistically different between young and old.

Resting sBP was slightly, but significantly, higher in the older subjects (Table 2). At the end of exercise sBP in the older subjects was significantly greater ($p = 0.01$) than for the young subjects but there was no difference in dBP. The increase in sBP for the older subjects (52±15 mmHg) between rest and the end was significantly greater than that for the younger subjects (33±8 mmHg).

Discussion

Prolonged raised blood pressure is well known to have deleterious effects leading, amongst others, to left ventricular hypertrophy and an increased risk of stroke and the risks become progressively more threatening with advancing age. Physical activity and exercise are very effective treatments for hypertension at all ages but during physical activity blood pressure rises and there is thus a potential conflict between the long term benefits of exercise and the possible acute risks, such as of stroke. It is, consequently, important to determine the blood pressure responses to exercise in the elderly so as to be able to assess the risks and to determine the level of exercise that may minimize these risks. The main finding of this study is that when exercising at around 75% of maximum heart rate, or 50-60% HRR, older subjects have a substantially greater rise in systolic blood pressure than young subjects. This observation is in agreement with the study of progressive cycling exercise responses in supine (Stratton et al., 1994) and semirecumbent (Fisher et al., 2010) in old compare to young subjects at the similar moderate intensity (50 % HRR). However, this finding differs from that of Sharman and colleagues (2007) who found no substantial difference between young and old. This may have been due to the fact that the age range of the older subjects was lower than in the present study as was the level of exercise.

The blood pressure response to exercise is predictive of mortality. Gupta and colleagues (2007) in a very large study of subjects with an age range from 40 to 80 yrs suggested that rises systolic pressure of more than 44 mmHg is associated with substantially increased risk of cardiovascular disease. Of the 10 older subjects, five had increases in sBP at the end of exercise of more than 44 mmHg, indicating that, despite being apparently healthy, half this sample of older people were at increased risk of developing cardiovascular disease.

However it is the acute effects of exercise that are the main concern of the present study. Anderson and colleagues (2003) reported that 19% of patients had been physically active (>5MET) in the two hours before a stroke and Vlak and colleagues (2011) found that vigorous exercise was associated with 7.6% of cases of subdural hematoma. The present study was designed to compare young and old working at 50% of heart rate reserve (5-6 MET), which is a level of exercise that might be prescribed to improve fitness and reduce blood pressure.

The mean increase in systolic blood pressure at the end of exercise was 51 mmHg for the older subjects, compared with 24 mmHg for the younger subjects, suggesting that exercise at 50% HRR might increase the acute risk of stroke in some older people.

There are two main reasons why the blood pressure response to exercise might be greater in old compared to young subjects. The first is that with ageing there is increased arterial stiffness and reflection of the pressure wave (Gerhard et al., 1996; Greenwald, 2007) The second possibility is that the autonomic control of blood pressure may be disturbed in older subjects leading to higher responses to exercise (Brocklehurst, 2010). Further work will be required to distinguish between these possibilities.

Conclusion

Systolic blood pressure increases greater in healthy old than young subjects during dynamic exercise at moderate intensity. In prescribing exercise to reduce blood pressure for older subjects it must be born in mind that the exercise itself will raise blood pressure and in a significant number of older people the levels can reach values that are generally considered undesirable. It may be advisable to monitor blood pressure responses to prescribed exercise and adjust the training intensity accordingly.

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