South African Journal for Research in Sport, Physical Education and Recreation, 2009, 31(1):19-26.
Suid-Afrikaanse Tydskrif vir Navorsing in Sport, Liggaamlike Opvoedkunde en Ontspanning, 2009, 31(1):19-26.
ISSN: 0379-9069

LIMITING THE BLOOD PRESSURE RESPONSE IN YOUNG MALES DURING DYNAMIC RESISTANCE EXERCISE THROUGH INTERMITTENT REST

Theunis P. KRUGER* & Johannes M. VAN ROOYEN**
**Department of Human Movement Science, University of the Free State, Bloemfontein, Republic of South Africa*
***School of Physiology, Nutrition and Consumer Sciences, North-West University, Potchefstroom, Republic of South Africa*

ABSTRACT

Studies have shown that resistance exercises are beneficial in the lowering of blood pressure. This is of great significance to hypertensive patients. Unfortunately the acute effect that resistance exercises have on blood pressure can be harmful. The seated single leg press was used in this study due to the availability of equipment and the controllability of it. Fifteen young males, which served both as the control and test group, were selected as participants and were familiarized with the protocol a week prior to testing. Each participant did the exercise according to the traditional (control – no rest) and an intermittent (test – 3s rest) method. Both methods were done at 60%, 75% and 90% 1RM to determine whether the differences in blood pressure response would be the same at different intensities for both methods. Results showed that the acute mean blood pressure response to the intermittent method was 7 mmHg lower than that of the traditional method at all the tested intensities. The aim of this study was to determine whether three seconds of rest between each repetition of a given exercise will limit the acute blood pressure response, if compared with the traditional method of resistance training of the same exercise.

Key words: Blood pressure; Dynamic resistance exercise; Males.

INTRODUCTION

Exercise plays an important role in the prevention of diseases like obesity, high cholesterol, diabetes, osteoporosis and hypertension according to Hurley and Roth (2000: 255) and Mazzeo and Tanaka (2001: 815). Although primarily aerobic exercises have been prescribed for preventing and treating hypertension (Blumenthal *et al*., 2000:1950; Welton *et al*., 2002: 499; Brownley *et al*., 2003: 980), several studies have proven that resistance exercises can also lower resting blood pressure over the long term (Yeater *et al*., 1996:13; Martel *et al*., 1999: 1219; Castaneda *et al*., 2002: 2339; Kraemer *et al*., 2001: 264).

The acute effect of resistance exercise on blood pressure unfortunately is not as favorable as the chronic effect (Van Hoof *et al*., 1996: 415; Orbach and Lowenthal., 1998: 356; Wallace, 2003: 588). This means that individuals with hypertension can not reap the benefits of resistance training as its acute effect on blood pressure can be harmful to them. To limit this response, Stone *et al*. (1991: 215) and Wallace (2003:588) suggested that alterations like limiting maximal efforts and the amount of sets per session should be made. This would mean that the full benefit of resistance exercises will still elude people suffering from hypertension

as maximal effort and numerous sets are necessary for developing strength and muscle endurance respectively (Foran, 2001: 75). The question has to be asked: "Why is the acute blood pressure response to resistance exercises so much more significant than that to aerobic exercises?" Blood pressure is determined by cardiac output and peripheral vascular resistance to blood flow (McArdle *et al*., 1991: 326; Meyer *et al*., 2004: 13.20, 14.8). With the onset of exercise**,** cardiac output increases due to an increased heart rate and stroke volume and both peripheral arteries and veins constrict, with the exception of those in the active muscles (Guyton & Hall, 1996: 254-255).

Another factor that contributes to raising blood pressure according to Klabunde (2004) is contracting muscle fibres. When muscle fibres contract they impede blood flow. This phenomenon is probably the reason why the acute blood pressure response to resistance exercises is higher than that to aerobic exercises. Muscle fibers are always contracted to a certain degree during resistance exercises. Keeping this in mind the aim of this study was firstly to determine whether a three second rest period between each repetition of a given resistance exercise would limit the acute blood pressure response. Secondly, if this is true, would the response to different exercise intensities also be limited?

The aim of this study was to determine whether three seconds of rest between each repetition of a given exercise will limit the acute blood pressure response, if compared with the traditional method of resistance training of the same exercise.

METHODS

The method of exercise testing used in this study is based on that of Baum *et al*. (2002: 442) as used in their study. The study design is a parallel-intervention study where use were made of the Latin square design to subject every participant to both exercise interventions (traditional and intermittent methods).

Participants

Fifteen young males (aged ±21 years) were recruted as participants. Each subject served as his own control. They were all healthy, exercised on a regular basis and did not use any medication at the time of the analysis. The study was approved by the Ethical committee of the University of the Free State. The characteristics of the participants are shown in table 1.

TABLE 1. **CHARACTERISTICS OF THE PARTICIPANTS USED IN THIS STUDY**

Variable	N	Mean ± SD
Age (years)	15	21 ± 2
BMI (kg/m²)	15	26.9 ± 3
SBP (mmHg)	15	131 ± 17
DBP (mmHg)	15	75 ± 10
MBP (mmHg)	15	94 ± 11
HR (beats/min.)	15	80 ± 12

Where BMI = body mass index; SBP, DBP and MBP = systolic, diastolic and mean blood pressure; HR = heart rate.

Protocol

Before participating in any activities of the study the participants had to read and fill in an informed consent form so that they would know what to expect. Their 1RM was determined and they were familiarized with the testing protocol a week before the testing. Each participant had to do a seated single leg press according to the intermittent and the traditional method of the protocol as shown in figure 1.

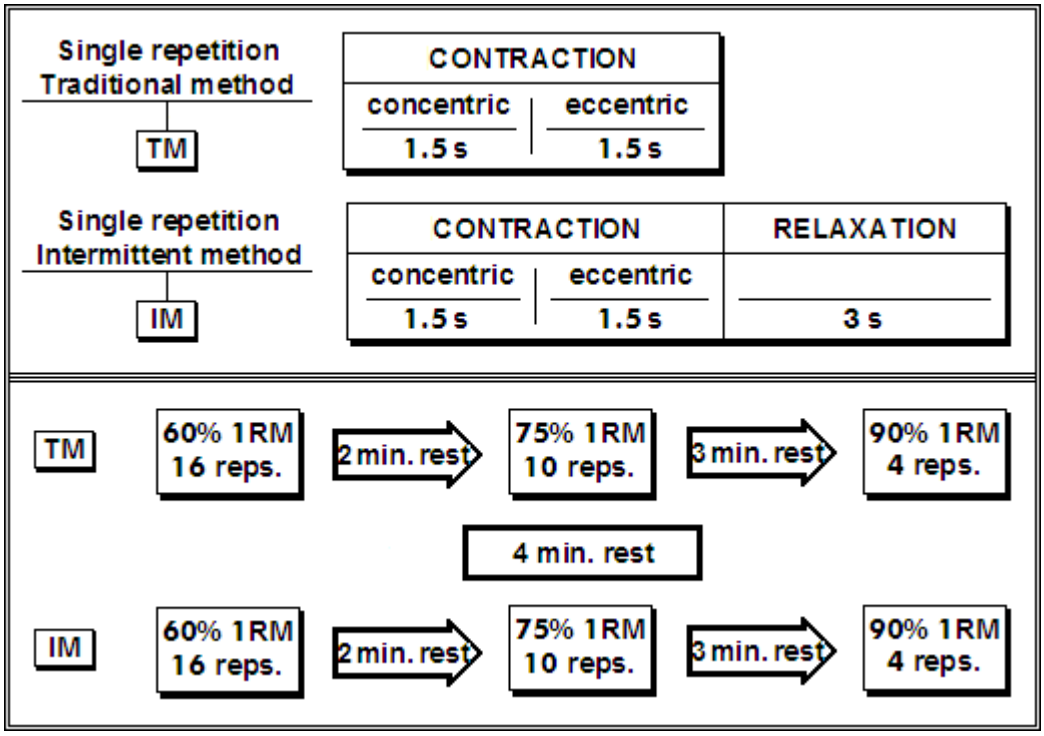

FIGURE 1: **EXERCISE PROTOCOL**

The upper part of the figure shows the concentric and eccentric duration of contraction with the relaxation of three seconds with the intermittent method (IM). The lower part of the figure shows the normal protocol for the different workloads.

Traditional method (TM) - No rest was allowed in between each repetition during this method. The participants were asked not to let the weight plates touch after the eccentric phase, as would be done in traditional resistance training.

Intermittent method (IM) - In between each repetition of this method a three second rest period was allowed. During this rest period the participants had to lower the weight plates completely and release as much tone in their quadriceps muscles as possible.

An audio signal was used to ensure that all the repetitions were of the same duration. The signals were 1.5 seconds apart. The first beep signaled the beginning of the concentric phase and the second the beginning of the eccentric phase. During the intermittent method one beep had to be skipped after each concentric-eccentric cycle to allow for the three second rest period. After the set at 60% 1RM, a two minutes rest period was allowed, three after 75% 1RM and four between the two methods.

The order of the two methods changed with each subject. This means that the intermittent traditional method was alternately done first and second to eliminate biasness towards any of the two methods. Both methods were done at 60, 75 and 90% of 1RM of each subject.

Measurements

A Finometer blood pressure device (FMS, Amsterdam, The Netherlands) was also connected to each participants' non-dominant hand to measure their systolic (SBP) and diastolic (DBP) blood pressure as well as heart rates. As the Finometer gives a continues blood pressure recording, it was easy to determine each participants' peak blood pressure response. To ensure that as little tone as possible is present in the participants' quadriceps muscles during the rest periods, an EMG was also connected to the participants. This reading was shown to them so they could regulate their muscle tone. The Valsalva maneuver (increasing intrathoracic pressure) was also avoided as far as possible by encouraged them to breath normally.

Statistical analysis

Descriptive statistics included mean and standard deviation. A paired sample T-test was used to analyze mean differences between exercise conditions for blood pressure and heart rate. Significance was set at $p< 0.05$.

RESULTS

Due to the fact that blood pressure is a variable parameter the mean peak readings had to be compared. The differences are illustrated in figures 2 and 3.

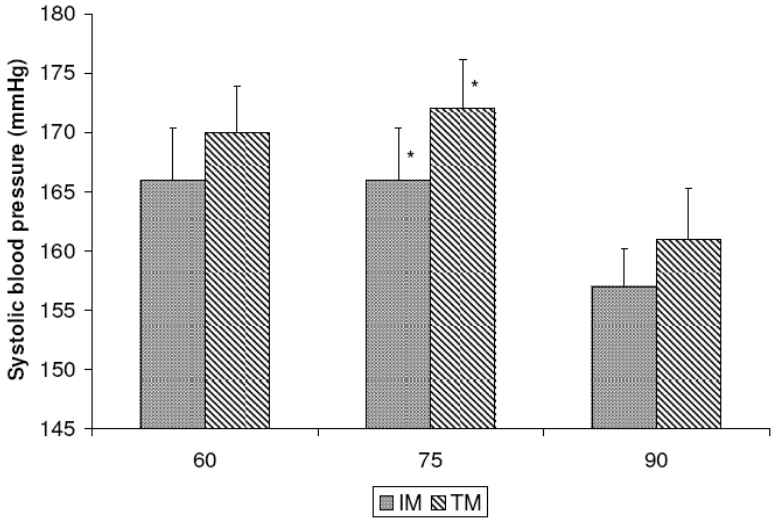

FIGURE 2: **SYSTOLIC BLOOD PRESSURE RESPONSES AT THE THREE TESTED INTENSITIES. IM = INTERMITTENT METHOD AND TM = TRADITIONAL METHOD OF EXERCISE**

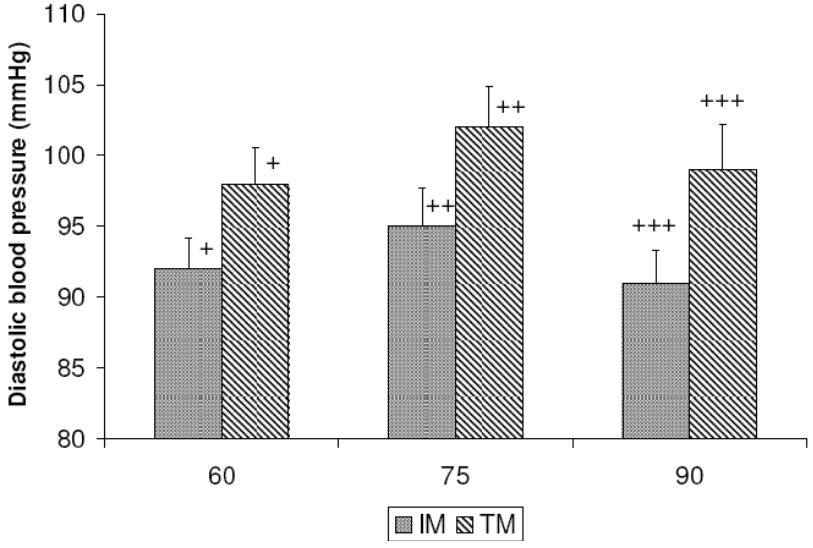

FIGURE 3: **DIASTOLIC BLOOD PRESSURE RESPONSES AT THE THREE TESTED INTENSITIES. IM = INTERMITTENT METHOD AND TM = TRADITIONAL METHOD OF EXERCISE**

Only the two systolic blood pressure readings' differences, those at 60 (p=0.335) and 90% 1RM (p=0.211), were not significant. At 75% 1RM however, the systolic reading showed a significant difference (p=0.002) between the two methods of exercise. Diastolic readings at all the intensities (60% - p=0.01; 75% - p=0.0004; 90% - p=0.004) showed significant differences between the two methods. The mean peak readings for all the measured parameters showed that the intermittent method indeed limited acute blood pressure responses. The acute mean blood pressure response to the intermittent method was 7 mmHg lower than that of the traditional method at all the tested intensities.

DISCUSSION

The results from this study show that the acute mean blood pressure response to the intermittent method of exercise was lower (mean of 7 mmHg) than that of the traditional method at all the tested intensities. This result also correlate with those of Baum *et al.* (2002:442). Their results, however, showed higher peak mean responses due to the fact that they used a seated double leg press exercise in their tests. According to McDougall *et al.* (1985:788) and Wayne (1999) a larger muscle mass will cause a greater blood pressure response. It also indicates that the highest intensities do not cause the greatest acute response. According to Wilborn *et al.* (2004) this is because the lower intensities cause a greater increase in heart rate.

The results of this study, however, show that heart rate and blood pressure responses at the same intensities do not correlate. No difference in mean heart rate was found at 90% 1RM, while the second greatest difference in mean systolic blood pressure occurred at the same intensity. This means that impedance of blood flow by contracted muscle fibres has to play an important role in the acute blood pressure response to exercise. The highest difference in SBP response (when the intermittent and the traditional methods compared) was 3.6% and the difference in DBP response was 9%. This large difference in DBP response also reflects larger peripheral vascular resistance changes in the participants with the traditional method of exercise. This higher after load placed on the heart with higher DBP responses as found in the participants with the traditional method of exercise activate the baroreceptor reflex mechanism for blood pressure control and this may mask the heart rate responses as found in the different methods of exercise.

In conclusion this study proved that the acute blood pressure response to resistance exercise can be limited without making drastic changes to a normal routine. Three seconds rest between each repetition of a resistance exercise can reduce the risk of cardiovascular events in healthy and diseased participants in daily routine exercise. This applies to all intensities. Although this study proves that rest between repetitions limits the acute blood pressure response to exercise, further research needs to be done on older subjects and hypertensive patients (who has stiffened arteries), under strict supervision, to see if it will have the same positive effect on them. The findings of this study, and that of Baum *et al.* (2002:441-445), however, laid the foundation for further studies on this subject.

REFERENCES

BAUM, K.; RÜTHER, T. & ESSFELD, D. (2002). Reduction of blood pressure response during strength training through intermittent muscle relaxations. *International Journal of Sports Medicine,* 24: 441-445.

BLUMENTHAL, J.A.; SHERWOOD, A.; GULLETTE, E.C.; BABYAK, M.; WAUGH, R.; GEORGIADES, A.; CRAIGHEAD, L.W.; TWEEDY, D.; FEINGLOS, M.; APPELBAUM, M.; HAYANO, J. & HINDERLITER, A. (2000). Exercise and weight loss reduce blood pressure in men and women with mild hypertension: Effects on cardiovascular, metabolic, and hemodynamic functioning. *Archives of Internal Medicine,* 160(13): 1947-1958.

BROWNLEY, K.A.; HINDERLITER, A.L.; WEST, S.G.; GIRDLER, S.S.; SHERWOOD, A. & LIGHT, K.C. (2003). Sympatho adrenergic mechanisms in reduced hemodynamic stress responses after exercise. *Medicine and Science in Sports and Exercise,* 35(6): 978-986.

CASTANEDA, C.; LAYNE, J.E.; MUNOZ-ORIANS, L.; GORDON, P.L.; WALSMITH, J.; FOLDVARI, M.; ROUBENOFF, R.; TUCKER, K.L. & NELSON, M.E. (2002). A randomized controlled trial of resistance exercise training to improve glycemic control in older adults with type II diabetes. *Diabetes Dare,* 25(12): 2335-2341.

FORAN, B. (2001). *High-performance Sports Conditioning*. Champaign IL: Human Kinetics.

GUYTON, A.C. & HALL, J.E. (1996). *Text book of medical physiology* (9th ed.). Philadelphia, PA: W.B. Saunders.

HURLEY, B.P. & ROTH, S.M. (2000). Strength training in the elderly: Effects on risk factors for age related diseases. *Sports Medicine of Auckland,* 30(4): 249-268.

KLABUNDE, R.E. (2004). Cardiovascular physiology concepts: Skeletal muscle blood flow. [http://www.cvphysiology.com/Blood%20Flow/BF015.htm]. Retrieved 22 September 2004.

KRAEMER, W.J.; KEUNING, M.; RATAMESS, N.A.; VOLEK, J.S.; McCORMICK, M.; BUSH, J.A.; NINDL, B.C.; GORDON, S.E.; MAZZETTI, S.A.; NEWTON, R.U.; GOMEZ, A.L.; WICKHAM, R.B.; RUBIN, M.R. & HAKKINEN, K. (2001). Resistance training combined with bench-step aerobics enhances women's health profile. *Medicine and Science in Sports and Exercise,* 33(2): 259-269.

MARTEL, G.F.; HURLBUTT, D.E.; LOTT, M.E.; LEMMER, J.T.; IVEY, F.M.; ROTH, S.M.; ROGGERS, M.A.; FLEG, J.L. & HURLEY, B.F. (1999). Strength training normalizes resting blood pressure in 65 to 73 year old men and women with high normal blood pressure. *Journal of the American Geriatrics Society,* 47(10): 1215-1221.

MAZZEO, R.S. & TANAKA, H. (2001). Exercise prescription for the elderly: Current recommendations. *Sports Medicine of Auckland,* 31(11): 809-818.

McARDLE, W.D.; KATCH, F.I. & KATCH, V.L. (1991*). Exercise physiology: energy, nutrition, and human performance* (3rd ed.). Philadelphia, PA: Lea & Febiger.

McDOUGALL, J.D.; TUXEN, D.; SALE, D.G.; MOROZ, J.R. & SUTTON, J.R. (1985). Arterial blood pressure response to heavy resistance exercise. *Journal of Applied Physiology,* 58(3): 785-790.

MEYER, B.J.; VAN PAPENDORP, D.H.; MEIJ, H.S. & VILJOEN, M. (2004). *Human Physiology* (3rd ed.). Cape Town: Juta.

ORBACH, P. & LOWENTHAL, D.T. (1998). Evaluation and treatment of hypertension in active individuals. *Medicine and Science in Sports and Exercise,* 30(Suppl. 10): S354-366.

PLISK, S.C. (2001). Muscular strength and stamina. In B. Foran (Ed.). *High-performance sports conditioning* (63-82). Champaign, IL: Human Kinetics.

STONE, M.H.; FLECK, S.J.; TRIPLETT, N.T. & KRAEMER, W.J. (1991). Health- and performance-related potential of resistance training. *Sports Medicine of Auckland,* 11(4): 210-231.

VAN HOOF, R.; MACOR, F.; LIJNEN, P.; STAESSEN, J.; THIJS, L.; VANHEES, L. & FAGGARD, R. (1996). Effect of strength training on blood pressure measured in various conditions in

sedentary men. *International Journal of Sports Medicine,* 17(6): 415-422.

WALLACE, J.P. (2003). Exercise and hypertension: A clinical review. *Sports Medicine of Auckland,* 33(8): 585-598.

WAYNE, L. (1999). *Strength training and blood pressure response*. [http://www.naturalstrength.com/research/detail.asp?ArticleID=197]. Retrieved 10 March 2004.

WELTON, S.P.; CHIN, A.; XIN, X. & HE, J. (2002). Effects of aerobic exercise on blood pressure: A meta-analysis of randomized, controlled trials. *Annals of Internal Medicine,* 136(7): 493-503.

WILBORN, C.; GREENWOOD, M.; WYATT, F.; BOWDEN, R. & GROSE, D. (2004). The effects of exercise intensity and body position on cardiovascular variables during resistance exercise. [http://www.asep.org/FLDR/Jep/Doc/Aug2004/WilbornV2.doc]. Retrieved 7 August 2004.

YEATER, R.; REED, C.; ULLRICH, I.; MORISE, A. & BORSCH, M. (1996). Resistance in athletes using or not using anabolic steroids compared to runners: Effects on cardio respiratory variables, body composition, and blood lipids. *British Journal of Sports Medicine,* 30(1): 11-14.

Prof. Johannes M. van Rooyen: School of Physiology, Nutrition and Consumer Sciences, North-West University, Potchefstroom Campus, Potchefstroom, Republic of South Africa. Cell: 082 786 8193, Tel: +27 (0)18 299 2440, E-mail: johannes.vanrooyen@nwu.ac.za

(Subject editor: Prof. P.E. Krüger)