Effects of Weightlifting and Breathing Technique on Blood Pressure and Heart Rate

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Abstract

Lepley, AS and Hatzel, BM. Effects of weightlifting and breathing technique on blood pressure and heart rate. *J Strength Cond Res* 24(8): 2179–2183, 2010—Weight training is a method commonly used to increase strength. The purpose of this investigation was to examine the effect of breathing technique during weight training on heart rate (HR) and blood pressure (BP). After completing a health history questionnaire, 30 subjects (16 men: 21.25 ± 1.21 years, 180.26 ± 2.36 cm, 84.31 ± 19.32 kg; and 14 women: 21.29 ± 2.37 years, 170.08 ± 2.15 cm, 137.36 ± 62.31 kg) were familiarized and tested for an estimated 1 repetition maximum, on the chest press and leg press lifts using each of the 2 breathing techniques, hold breath (HB), and controlled breathing. Lifts were examined using each breathing technique with 1 set of 10 repetitions on separate days. Data were collected during the push phase on average of 3.72 times per set and again at 1 and 5 minutes post lift. Resting, during lift (peak, average); 1-minute and 5-minute post lift BP; and HR values were measured using the NIBP100A noninvasive BP system (Biopac Systems, Inc), for both breathing technique within each lift. The HB technique posted higher but statistically insignificant ($p < 0.05$) values for systolic BP ($p = 0.420$), diastolic BP ($p = 0.531$), and HR ($p = 0.713$) than the controlled breath technique. The HB technique used in this investigation produced minimal elevations in HR and BP and appears to be safe when performing the chest press and leg press lifts at a moderate resistance. Education on proper weight training techniques can help limit unwanted risks during these exercises.

Key Words cardiovascular effects, weight training, Valsalva maneuver, hold breath technique, controlled breathing technique

Introduction

Physical activity has often been a popular link to sustained health and well-being, physically, mentally, and spiritually. One common mode of physical activity is that of resistance training, which has been a proven method of increasing strength. Although the strength gaining effects of this mode of training are well known and appreciated, many participants may be unknowingly increasing their chances for cardiac episodes, such as stroke or myocardial infarction, due to increased blood pressure (BP) and heart rate (HR) (1).

Increases in systolic BP during physical activity may be precipitating factors in the development of hypertension and be a risk factor for future cardiac events (16,18,19,25). Resistance training has been shown to result in systolic and diastolic pressures of 350 and 200 mm Hg, respectively (13). Previous authors have observed that the specific factors that cause exaggerated increases in BP during this mode of exercise are not well documented (12). Identification of these factors may lead to their modification, and a consequent reduction in cardiovascular risk associated with abnormal rises in BP during exercise (16).

The present investigation is attempting to identify potential factors leading to significant increases in BP by identifying the influence on breathing technique during various lifting techniques. It is felt that many participants in resistance training may be inducing a Valsalva mechanism while participating in the activity. Valsalva is identified as a forceful exhalation on a closed glottis (20). This action has a significant impact on increasing intrathecal pressure leading to an increase in venous pressure and increased pressure response that creates a significant risk factor for cardiac pathology (14). It is not in our interest to look at the cardiovascular effects anaerobic activity has over periods rather during the one time lift. It has already been shown by Fleck (7) that resistance training does not result in adaptations of the cardiovascular system.

Previous authors (14) have identified significant contraindications when using a Valsalva breathing maneuver during resistance training. The present investigation has attempted to identify an appropriate breathing technique that will allow participation at moderate levels of resistance without producing significant increases in BP and HR. The hold breath (HB) technique has been developed in this study to mimic a Valsalva technique while eliminating a dangerous increase

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in pressure. The HB and controlled breathing (CB) techniques will be compared when using the chest press and leg press resistance training techniques. It is hypothesized that with any form of holding one's breath and containing pressure, such as in the HB and Valsalva techniques, BP will rise significantly.

Methods

Experimental Approach to the Problem

Individuals engaging in weight training may be dangerously increasing their BP during exercise. With the load of weight, one will use a Valsalva technique resulting in an increase in intrathecal pressure raising BP to extreme levels. The question in this study is to determine safe alternatives to using the Valsalva technique. In an attempt to identify the effects of breathing technique on HR and BP during resistance training, subjects were asked to complete chest press and leg press activities with moderate resistance while HR and diastolic and systolic BPs were measured. Subjects completed an orientation and 2 subsequent data collection days to control for extraneous factors leading to differences in these variables.

Subjects

Thirty subjects with recreational aerobic and weight training experience volunteered to participate in this investigation. Subjects consisted of 16 men and 14 women: (16 men: 21.25 ± 1.21 years, 180.26 ± 2.36 cm, 84.31 ± 19.32 kg; and 14 women: 21.29 ± 2.37 years, 170.08 ± 2.15 cm, 137.36 ± 62.31 kg). The Human Research Review Committee at the host institution approved this investigation. Once consent was obtained from each subject, a health history questionnaire was completed by each subject. Subjects identified as being at increased risk by the current American College of Sports Medicine guidelines were disqualified from investigation (1). Subjects who reported with 2 or more risk factors from their health history questionnaire were also excluded (1). Risk factors were identified as smoking, body mass index greater than 30, over the age of 45, do not exercise regularly (defined as at least 30 minutes for 4 days a week), or if the subject or relative currently has or has had a cardiac event or symptoms of a cardiovascular disease (1). All subjects reported being part of some type of structured weight training program at some points in their lives (most in high school), and all reported to be recreationally active in some form of anaerobic and aerobic activities. Subjects were automatically excluded if their resting BP fell within a range of hypertension, which is defined as equal to or greater than 140/90 mm Hg or if they recently suffered any injury to their lower or upper extremity (1).

Procedures

Once consent was obtained, subjects underwent an orientation session (day 1) that consisted of obtaining baseline physical characteristics (BP, HR), with breathing and lifting technique familiarization. Baseline BP and HR were recorded in the testing position by using the NIBP100A noninvasive BP system (Biopac Systems, Goleta, CA). This device was worn on the left wrist of each subject. Testing positions for baseline recordings mirrored that of positioning during testing, sitting in the chest press and leg press machines (see Figures 1 and 2 for testing positions) (10). The device required calibration with an increase or decrease in altitude from the subject's heart. Therefore to avoid recalibration, each subject held his/her left wrist level with his/her heart during each lift. This was also the reasoning behind selecting these 2 lifts, it allowed the subject's wrist to be in level with their heart at all times.

Once baseline BP and HR were recorded, subjects were instructed on and able to practice the 2 lifts and 2 breathing techniques. The breathing techniques consisted of a CB in which the subject exhaled on the concentric/push phase and inhaled on the eccentric/return phase. The second technique involved a controlledHB technique, where the subject did not bear down on a closed glottis such as in the Valsalva rather they simply held their breath on the concentric/push phase, exhaled at full extension, and inhaled during the eccentric/return phase. These techniques were chosen due to their close assimilation to actual practices during resistance training by participants. In addition, the 2 weightlifting methods of seated chest press and leg press were used to target large muscle groups and 2 of the more common machines found within a traditional weight room setting.

An estimated 1 repetition maximum (1RM) was completed to determine resistance during testing. Testing parameters required when performing an estimated 1RM assessment included consistent contraction duration of 3 to 5 seconds to complete each lift, a minimum rest period of 3 to 5 minutes between repeat attempts to minimize the effects of fatigue, and reaching the maximal load with minimal trials (3–6 trials). A submaximal load was selected, and the subject was asked to

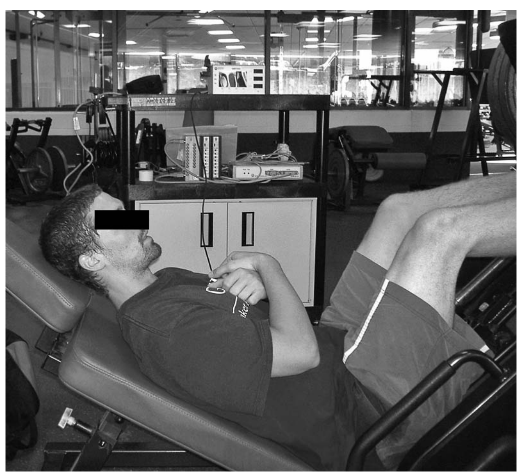

Figure 1. Leg press machine and resting position.

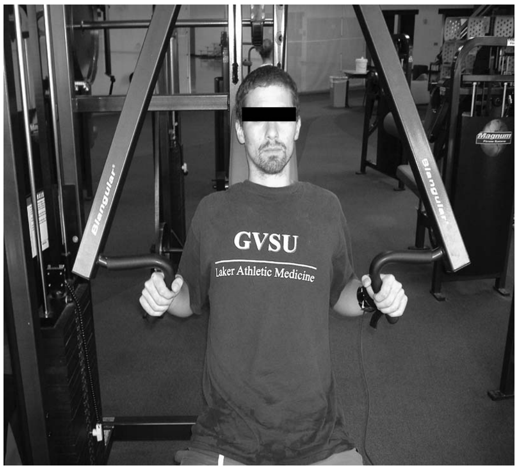

Figure 2. Chest press machine and resting position.

perform 10 repetitions. Depending on the subject's ability to lift the given weight, the load was increased or decreased accordingly. The subject then was asked to lift this load 10 times. Again, the new load was determined as above and the process continued until the subject arrived at a load that could only be lifted 3 to 6 times. The amount of weight to be used in determining the estimated 1RM was the weight that was lifted by the subject in only 3 to 6 repetitions. An estimated 1RM was then calculated by using the following equation: weight lifted/[1.0278 − (0.0278 × number of repetitions)] (4).

During orientation, subjects were also instructed on how to keep pace with a metronome, which was set at 40 $b \cdot min^{-1}$ to keep a controlled pace by the subjects and insure that the BP device would get at least 3 readings during exercise (17). This concluded the orientation session. Subjects returned to the laboratory for their next session after a 24- to 48-hour rest. On each of days 2 and 3, subjects were to perform 2 sets of 10 repetitions of one of the lifts, incorporating each breathing technique in that day. All aspects of the lifting techniques, including pace and number of repetitions, were determined to represent a typical workout performed by a recreationally active individual. The lift and breathing techniques were randomly assigned by a coin flip before testing. The weight used during the lifts was determined by the estimated 1RM test completed on the orientation day. Sixty percent (60%) of the subjects' estimated 1RM was used as the resistance during the testing to remain consistent with findings, indicating that strength gains are insignificant at loads less than 60% of the 1RM (6,8,23). Subjects did not go to failure during the lifts and were finished once they reached a set of 10 repetitions. The NIBP100A noninvasive BP system (Biopac) was secured around the wrist of the subject, and 1 to 2 readings were recorded as a pretest measurement. Once the subjects were comfortable, they were allowed to start their set of repetitions. The device measures BP on a continuous setting every 12 seconds. Three recordings were collected during each exercise set. Once the 10 repetitions were completed, subjects were instructed to stay in the resting position, which was the position of pretesting. Blood pressure and HR were continually measured and recorded for 1 and 5 minutes post exercise and monitored until the subjects returned to their resting values. Subjects were allowed to perform the second breathing technique or be released only after their resting values (BP, HR) returned to normal. The same methods were used on the following testing session, with each lift and breathing technique.

Blood Pressure/Heart Rate Measuring Device

The NIBP100A noninvasive BP measuring device was developed by BIOPAC (Figure 3). There have been multiple studies looking at the accuracy of the noninvasive measuring device, comparing it with an invasive arterial catheter. The research done by Belani et al. shows that the device measured BP and HR similar to direct radial arterial measurements. The research also states that the device provides a radial arterial waveform similar to a direct radial arterial waveform (3). In addition to these statements, this study reports values of a correlation with intra-arterial measurements as follows: systolic $r^2 = 0.93$, diastolic $r^2 = 0.89$, mean $r^2 = 0.95$, and HR $r^2 = 0.95$ (3). Other studies have also compared the NIBP100A device with invasive radial catheters in the emergency department (21), pediatric intensive care patients (24), post surgery monitoring (5), and out-of-hospital situations (22). All showed that the device had comparable accuracy to that of an invasive radial catheter.

Statistical Analyses

A 9 × 2 (breathing technique × lift) repeated measures analysis of variance was used to identify significance for HR

Figure 3. NIBP100A noninvasive BP system (Biopac, Goleta, CA). BP = blood pressure.

and diastolic and systolic pressure. (alpha ≤ 0.05). Within-subject factors consisted of resting, peak, post 1-minute, and post 5-minute HR and BP for each breathing technique, whereas between-subject factors were lifting technique (chest press, leg press). A log base ten transformation was performed on each data set before analysis to ensure normal distribution. Data were analyzed using the SPSS software 14.0 (SPSS, Chicago, IL).

Results

Average values were as follows: systolic BP: HB 157.9, CB 142.4; diastolic BP: HB 93.1, CB 88.2; and HR: HB 88.4, CB 83.3. These values, along with peak, and 1- and 5-minute post-exercise values were compared across lift and breathing technique. The HB technique posted higher but statistically insignificant values for systolic BP ($p = 0.399$), diastolic BP ($p = 0.594$), and HR ($p = 0.715$). Measurements were not compared between the 2 different exercises, only between breathing techniques of each exercise.

Discussion

It was hypothesized that subjects taking part in a resistance training exercise would significantly increase their BP and HR if using an HB technique. It was assumed that even if the subjects were not bearing down on a closed glottis but were exerting force without the release of pressure through breathing, increases in BP and HR would result. Many authors have identified a significant rise in pressure when participants used a Valsalva technique during weightlifting (9,13,14). Present authors speculate that many people do not actually perform a true Valsalva during lifting. However, they believe that the HB technique is more common and therefore was examined in the present investigation. Given the paucity of data in the open literature regarding the HB technique, it was theorized that the HB technique used in this study would show a significant increase in pressure during weight-lifting. The difference was that this investigation involved instruction to participants not to bear down rather to push the weight while holding their breath and exhaling once the weight was forced.

Elevations in HR and BP noted in the current examination are insignificant although an increasing trend was noted. MacDougall et al. (13) identified a percent change of 190% with systolic pressure and 150% with diastolic pressure when using a Valsalva breathing technique. This high percent change, when compared with our HB technique percent change of 89.8% systolic and 88.1% diastolic, shows that there is a rather large difference in the rise in BP. Also, Huggett et al. (11) identified percent changes of 40.0% systolic and 40.4% diastolic when their subjects were coached to avoid the Valsalva technique. Concluding that the HB technique raises BP greater than CB, however, both appear to be much safer than using a Valsalva technique.

One of the limitations of the present investigation was the means in which the BP monitor recorded data. The device was not time consistent, and each individual could give a different number of readings throughout the exercise and post exercise. It was not measured consistently every 12 seconds rather gave a reading about every 10 to 20 seconds, therefore giving more data points for some individuals than others. To help control for this, if the subjects performed a technique where only 2 or less measurements were given, they were asked to perform the technique again. Each subject in our study recorded no less than 3 and no more than 4 data points during exercise.

The test was also limited by the participant's age. The limited diversity of older subjects may have produced lower BP and HR, which in turn may have affected the significance of the data (2,11,15). The present investigation identifies results to a specific population using a specific testing protocol and measurement device.

Practical Applications

Many practical applications can be derived from the results of this, previous, and subsequent studies. Previous investigations have provided conclusion to a significant increase in BP and HR with a Valsalva breathing technique during lifting techniques. No other investigation was found that examined the HB technique. This investigation identified that using an HB technique did not significantly raise BP or HR while engaging in the chest press or leg press using moderate resistance using the NIBP100A noninvasive BP system (Biopac) for measurement of HR and diastolic and systolic BP.

In addition to identifying and making individuals aware that BP and HR can reach dangerous levels during resistance training, it is also important to educate them on the appropriate lifting and breathing techniques to use during exercise.

Acknowledgments

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