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The Effects of a Weight Training Belt on Blood Pressure During Exercise

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ABSTRACT

The purpose of this study was to determine the effect wearing a weight lifting belt (WLB) has on heart rate and blood pressure during aerobic bicycle ergometer, one-arm bench press, and isometric dead lift exercise. Open circuit spirometry was used to determine bicycle ergometer peak $\dot{V}O_2$ during a progressive bicycle ergometer test. One armed one repetition maximum (1 RM) bench press and maximal isometric dead lift were determined. Blood pressure (BP) was determined by auscultation. Six healthy subjects performed three types of exercise twice, once with a WLB and once without. After warmup, subjects either bicycled at 60 percent of peak $\dot{V}O_2$ for six minutes, performed three sets of 10 repetition bench presses with 60 percent 1 RM, or held an isometric dead lift for two minutes with 40 percent of maximal isometric dead lift. Assignment of WLB or no WLB exercise was random. Heart rate (HR), BP, and WLB pressure on the abdominal wall was monitored continuously both during exercise and during recovery. A two way (belt/no belt and time) repeated measures factorial design was used to analyze the date ($\alpha = .05$). WLB pressure on abdominal wall (measured using a rubber bladder) increased across exercise time in the bench press and back lift. After an initial significant increase in pressure during the first two minutes of the aerobic exercise, WLB pressure stabilized and remained steady throughout the exercise. Mean systolic BP was significantly higher with WLB use for the aerobic and isometric activities. A significant HR increase with WLB use was found for the aerobic exercise. Also with WLB use rate pressure product was significantly higher for all types of exercise (6 to 15 percent). It is felt that the use of a WLB can put an added strain on the cardiovascular system. Individuals that may have a compromised cardiovascular system are probably at greater risk when undertaking exercise with back support.

KEY WORDS: Blood pressure, peak $\dot{V}O_2$, weight lifting belt, heart rate

Introduction

Weight lifting belts are worn to prevent back hyperextension and to give added support to the lower back during certain weight lifting maneuvers. The belts also exert pressure on the abdominal cavity. Indeed this added pressure on the abdominal cavity is what may, in part, allow the belt to improve the support for the lower back. Several studies have shown a positive relationship between the magnitude of lumbar stress, accompanied by contraction of musculature surrounding the abdominal cavity, and the increase in peak level of intra-abdominal pressure (2, 3, 4). The increase in intra-abdominal pressure is probably caused by contraction of musculature. The added pressure may act as a splint on the lumbar spine thus decreasing the likelihood of injury to the lumbar spine (10). The belt pressure probably increases intra-abdominal pressure and thus increased lumbar spine support.

However, the added pressure on the abdominal cavity may have some effect on blood pressure. Recent research indicates increases in intra-abdominal and intrathoracic pressure caused by straining maneuvers may increase blood pressure in part due to a mechanical effect on the vasculature of the thoracic and abdominal cavities (14). This component of the blood pressure increase is independent of the central command component (14). It seems logical to hypothesize that belt pressure may have some similar effect on blood pressure.

It is already well established that blood pressure, heart rate, and rate pressure product increase significantly during exercise (5, 7, 8, 13). These increases can have implications for risk of stroke and myocardial infarction (12).

Since weight lifting belts may have an effect on heart rate and blood pressure during exercise and since belts are worn during a variety of exercises and activities, a study of the blood pressure response to exercise while wearing a weightlifting belt might provide useful information. The purpose of this study is to determine what effects wearing a weight lifting belt has on hemodynamics during aerobic bicycle exercise, one arm bench press exercise, and an isometric dead lift exercise.

Methods

Subjects

Five healthy males and one healthy female volunteered to

Table 1. Descriptive Data ± SD for Males

	#	Wt(N)	% Fat	Peak $\dot{V}O_2$ (ml $O_2 \cdot kg^{-1} \cdot min^{-1}$)	Max One Arm BP(N)	Max Isometric Dead Lift(N)
Male	5	639.6±108 (70.7 kg)	9.4 ±2	54.4±4	276.6±62.4 (28.2 kg)	1895.3±461
Female	1	579.8 (59.1 kg)	19.0	53.0	156.0 (15.9 kg)	1338.1 (136.4 kg)

be the subjects in this study. Their ages ranged from 23 to 42 years. **Table 1** shows descriptive data. Testing procedures were explained in detail to the subjects and informed consent was obtained from each.

Tests were performed on the subjects to assess capacity on each of the following parameters: (1) Peak oxygen uptake ($\dot{V}O_2$) during bicycle ergometer exercise; (2) Maximum one arm bench press; and (3) Maximum isometric dead lift.

Peak $\dot{V}O_2$

Peak $\dot{V}O_2$ values were determined using a Monarch bicycle ergometer. After the expired gases passed through a mixing chamber, O_2 and CO_2 fractions were determined on a Beckman OM-11 and LB-2. The OM-11 and LB-2 were calibrated prior to each test with Micro-Schollander analyzed calibration gases. Expired ventilatory volume was measured with a dry gas meter (Parkinson-Cowan). On-line determinations were made on an AIM65 computer by Rockwell.

Heart rate was monitored on a Burdick EKG unit. Each subject warmed up by pedalling at 60 RPM at zero load for two minutes. Sixty RPM was maintained while resistance was increased in 60 watt increments each minute until a heart rate of 150 beats per minute was reached. Thereafter, resistance was increased in 30 watt increments until failure.

1 RM Bench Press

Maximum bench press values were determined using dumbbells. The subjects were placed in a supine position and, starting with 98.1 neutons (10 kilograms), performed presses of increasing weight until a one arm maximum was achieved with the right arm. Two minutes of rest was allowed between each attempt. Maximum was reached within five trials in all cases.

Maximum Isometric Dead Lift

Maximum isometric dead lift values were determined using a shoulder harness and platform dynamometer. The harness was made from two 2.54 centimeter nylon straps which dropped over the shoulders and connected at a point just below and anterior to the pelvic girdle. At this connection, one end of a chain was attached. The other end of the chain was attached to the platform dynamometer. The subjects were positioned over the dynamometer with the hip angle at approximately 150 degrees and the knee angle at approximately 140 degrees. Each subject was then asked to relax his arms at his sides and to extend his hip and knees with maximal effort. Three trials were used with the best performance viewed as the maximum. Valsalva was allowed during the 1 RM bench press and maximum isometric dead lift.

Submaximal Procedures

Six submaximal tests were performed on each subject. Bike ergometer exercise, one arm bench press exercise, and isometric dead lift exercise were all tested twice, once while the subject wore a standard 10 cm weight lifting belt and once with no belt. The belt was tightened to the same notch for all tests. The belt/no belt conditions were random. No more than two tests were performed on one day. Bench press tests were performed on separate days. All leg exercises (bicycle and dead lift) were performed on separate days. On days in which a bench press and a leg exercise were performed, at least one hour rest was allowed between tests. No more than two tests were performed by any subject in one day. The subjects were asked to abstain from exercise and food intake for three hours prior to testing. Room temperature was kept at a constant 24 degrees C. In order to avoid valsalva during the bench press and dead lift, respiratory rate was kept at 20 respirations per minute by having subjects breathe in time with a metronome.

During all tests, non-dominant arm systolic blood pressures were monitored and recorded using standard auscultation techniques. Heart rates were monitored and recorded using a Burdick EKG monitor and a single bi-polar V5 lead. Rate pressure product was calculated by multiplying the heart rates by systolic blood pressure.

During the tests in which the subjects wore the weight lifting belt, pressures that the belt exerted on the abdomen were measured by placing a routinely calibrated 11.4 cm x 12.7 cm air filled rubber bladder between the subject's abdomen and the belt. This bladder was calibrated by placing known weights on the bladder and observing the amount of pressure measured on the sphygmomanometer gauge attached to the bladder. During the tests, changes in bladder pressure were monitored and recorded by sight from a mercury pressure gauge and then converted to kilopascals. No rapid pressure transients occurred. Pressure changed about 2.7 kilopascals (2 mm Hg) with respiration, but other than that, readings were very stable for each five to 10 second interval.

Submaximal Bike Test

During the submaximal bicycle ergometer test, the subjects pedaled a bicycle ergometer at 60 RPM for six minutes at 60 percent of calculated peak $\dot{V}O_2$. The belt and no belt tests were performed on separate days. Blood pressures, heart rates and bladder pressures were recorded pre-test, at

Table 2. Bladder Mechanism Pressures in Kilopascals (Mean ± SD)

	Pretest	1 min	2 min	3 min	4 min	5 min	6 min	Immediate Post Exercise	1 min Post Exercise	2 min Post Exercise	P
Bike	7.2 ±0.8	7.8 ±1.5	8.6 ± 1.4	8.9 ±1.5	8.5 ± 0.8	8.7 ±1.1	8.6 ±1.1	7.5 ±1.0	6.9 ±1.2	6.5 ±1.2	<.001
Dead Lift	7.7 ±1.5	9.6 ± 2.1	10.8 ±2.6	NA	NA	NA	NA	7.6 ±2.3	7.6 ±2.2	7.2 ±2.2	< .001
One Arm Bench Press	4.2 ±0.8	5.7 ± 1.7	8.5 ±2.3	10.7 ± 1.5	NA	NA	NA	4.3 ±0.8	4.2 ±0.7	4.1 ±0.8	<.001

NA - Not appropriate

Note: Tukey post hoc tests indicate significance for the following individual subsets:
Bike test - the second, third, fourth, fifth and sixth minutes of exercise are different from all other cells but are not different from each other.
Dead lift - the first and second minutes of exercise are different from all other cells but not different from each other
One arm bench press - the second and third minutes of exercise are different from all other cells but not different from each other.

Table 3. Systotic Blood Pressures in Kilopascals (mean ±.SD) Values in Parenthesis mmHg

		Pretest	1 min	2 min	3 min	4 min	5 min	6 min	IPE	P1 min	P2 min	P
Bike	Belt	16.4±1.8 (122.8)	20.2± 2.3 (151.8)	22.3±1.6 (167.2)	24.1 ±1.8 (180.5)	24.5± 2.0 (183.5)	25.5±1.8 (191.5)	25.8 ±1.7 (193.8)	21.1±1.9 (158.0)	19.6±1.9 (147.0)	17.7± 1.9 (132.7)	
	No Belt	15.2±1.3 (114.0)	19.7± 2.3 (148.0)	21.2±1.5 (159.3)	21.9 ±1.2 (164.7)	22.9± 1.9 (171.5)	23.1±1.9 (173.5)	23.0 ±1.6 (172.3)	20.4±10.7 (153.3)	18.8±1.5 (141.3)	17.3± 1.8 (129.5)	.034
Dead Lift	Belt	15.9±1.4 (119.7)	22.4± 2.4 (168.3)	23.8±1.6 (178.2)	NA NA	NA NA	NA NA	NA NA	17.7±1.0 (132.7)	17.2 ±1.7 (128.7)	16.5±1.1 (124.0)	
	No Belt	15.7±1.7 (117.5)	20.5± 2.3 (154.0)	22.7±3.3 (170.5)	NA	NA	NA	NA	16.5±0.9 (124.0)	16.1± 1.3 (121.0)	15.6±0.8 (117.3)	.001
One Arm Bench Press	Belt	14.5±1.5 (109.0)	17.4± 2.2 (130.7)	19.0±2.8 (142.3)	19.8 ±3.6 (148.3)	NA NA	NA NA	NA NA	15.7± 1.8 (118.0)	14.5±1.0 (109.0)	14.2 ±0.8 (106.5)	
	No Belt	14.3±1.7 (107.0)	15.8± 1.2 (118.7)	17.8±2.3 (133.3)	18.7 ±2.3 (140.7)	NA	NA	NA	15.4± 0.8 (115.8)	14.1±1.5 (105.5)	13.7 ±1.2 (102.7)	.129

Table 4. Heart Rate in BPM (Mean ± SD)

		Pretest	1 min	2 min	3 min	4 min	5 min	6 min	Immediate Past Exercise	1 min Past Exercise	2 min Past Exercise	P
Bike	Belt	67.83 ±13.59	118.33 ± 22.79	140.00 ±16.67	138.67 ±20.93	140.83 ±21.99	146.00 ±19.64	146.67 ±20.23	142.33 ±18.35	111.67 ± 33.11	95.67 ±26.00	
	No Belt	64.00 ±7.24	116.17 ± 18.55	128.67 ±18.32	132.50 ±23.08	134.67 ±24.25	135.50 ±21.94	137.00 ±22.48	124.50 ±27.70	94.67 ± 32.31	86.67 ±24.72	.029
Dead Lift	Belt	74.67 ±15.10	110.50 ± 12.77	123.50 ±13.20	NA	NA	NA	NA	122.17 ±13.12	88.00 ± 19.47	78.17 ±15.98	
	No Belt	72.67 ±14.64	107.00 ± 16.04	118.00 ±20.34	NA	NA	NA	NA	110.67 ±27.47	84.00 ± 22.13	70.17 ± 9.89	.197
One Arm Bench Press	Belt	63.50 +9.89	91.00 +15.21	92.50 +19.82	92.17 +19.17	NA	NA	NA	76.00 +9.19	66.00 +8.39	60.17 +5.67	
	No Belt	62.83 ±12.42	91.33 ± 11.09	90.67 ±14.00	93.50 ±15.69	NA	NA	NA	71.17 ±8.13	64.83 ±8.59	62.50 ± 10.77	>.750

P refers to belt versus no-belt effect

the end of each minute during the six minutes of exercise and during the first two minutes of recovery.

Submaximal One Arm Bench Press Test

During the submaximal one arm bench press test, the subjects performed three sets of 10 repetitions with 60 percent one repetition maximum using the dominant arm. Cadence for the repetitions was established using a metronome set at a rate so that each set took 30 seconds. One minute of rest was allowed between sets. The belt and no belt tests were performed on separate days. Blood pressures, heart rates and bladder pressures were measured pre-test, during the last 10 seconds of each set, immediately post exercise and at one and two minutes post exercise.

Submaximal Dead Lift Test

The submaximal isometric dead lift test required that the subjects exert force against the platform dynamometer for two minutes at 40 percent of their maximum lift. Subjects were able to maintain force by visual observation of a dial by utilizing a mirror. Reference markers were placed ±1 percent of 40 percent of the subjects maximum lift. All subjects were able to maintain force output within the confines of the marker. Blood pressures, heart rates, and bladder pressures were recorded pre-test, at the end of each minute for two consecutive minutes, immediately post exercise and for the first two minutes of recovery.

Statistics

A factorial design using a one-way analysis of variance with repeated measures was used to examine the bladder data. A factorial design using a two-way analysis of variance with repeated measures was used to examine the other dependent variables. The criterion for statistical significance was α = .05. Significant differences between bladder cell means were determined using Tukey's post hoc procedures (α = .05).

Results

As expected, blood pressure and rate pressure product increased significantly during exercise. During the belt test, an increase in the pressure exerted against the bladder mechanism was also observed during each of the three types of exercise (**Table 2**).

When comparing the belt and no belt conditions, the belt condition produced significantly higher systolic blood pressure during the bicycle ergometer and dead lift exercises (**Table 3**). When the belt and no belt conditions were compared with respect to heart rate, the belt condition produced significantly higher values during the bike ergometer exercise (**Table 4**).

Finally, when comparing the belt and no belt conditions, the belt condition produced a rate pressure product which was significantly higher than the no belt condition during the bike ergometer, one arm bench press and dead lift exercises (**Table 5**). Since no interactions were found between time and belt condition for the blood pressure, heart rate and rate pressure product, differences between belt and no belt conditions were consistent during the exercise and recovery.

Discussion

The results of this study show that blood pressure is affected by use of a weight lifting belt during both rest and exercise. These results tend to support the contention of Williams and Lind (14) that blood pressure increase during exercise is caused by both neural and mechanical factors. In addition to the decrease in vagal tone and increase in sympathetic activity that occurs in isometric work (6, 9, 15) and probably to some extent all heavy work, there seems to be an increase entirely due to the mechanical effect of vasoconstriction of the vasculature of the abdominal and, indirectly, the thoracic cavities. The results of this study seem to support this mechanical effect hypothesis because belt pressure would probably increase intra-abdominal pressure but should have no effect on either vagal or sympathetic activity.

The bladder mechanism pressure and, thus, belt pressure on the abdomen increased significantly during all three kinds of exercise, probably due to increased activity of lumbar, abdominal and thorax musculature. Although not significant with this small sample, the difference between belt and no belt systolic blood pressure also increased during the bench press exercise, further relating pressure of the belt with systolic blood pressure changes. Pressure of the belt tended to be lower in the bench press than the other exercises. It is presumed the lower belt pressure was due to the supine posture that may redistrubute the contents of the abdomen. The hemodynamic differences between belt and no-belt conditions were also much smaller during the bench press exercise further indicating belt pressure is at least highly related and probably causes the increases in heart rate and blood pressure associated with the belt.

Elevated systolic blood pressure probably increases the incidence of stroke (12). Since the systolic pressure is already elevated as a consequence of the high intensity exercise, further elevations from belt use are potentially even more harmful.

During the aerobic bicycle exercise, belt use increased the heart rate difference between belt and no belt conditions significantly with approximately a 10 beat per minute in-

Table 5. Rate Pressure Product in mmHG BPM/1000 (mean ± SD)

		Pretest	1 min	2 min	3 min	4 min	5 min	6 min	IPE	P1 min	P2 min	P
Bike	Belt	8.33 ±1.86	18.17 ± 4.72	23.42 ±3.35	25.09 ±4.71	25.97 ±5.43	28.08 ±5.12	28.55 ±3.24	22.46 ±5.12	16.51 ± 5.86	13.12 ±4.29	
	No Belt	7.30 ±1.09	17.20 ± 2.94	20.52 ±3.33	21.82 ±4.24	23.27 ±5.47	23.66 ±5.10	23.81 ±5.44	19.19 ±4.83	13.43 ± 4.85	11.38 ±4.11	.017
Dead Lift	Belt	8.99 ±2.36	18.63 ± 3.09	22.04 ±3.12	NA	NA	NA	NA	16.18 ±3.96	11.26 ±2.78	9.67 ±1.06	
	No belt	8.56 ±1.69	16.42 ± 2.59	20.12 ±3.76	NA	NA	NA	NA	12.67 ±3.96	10.18 ±2.78	8.21 ±1.06	.017
One Arm Bench Press	Belt	6.99 ±1.78	11.96 ± 2.97	13.08 ±3.15	13.43 ±2.66	NA	NA	NA	9.03 ±2.03	7.22 ±1.30	6.42 ± .87	
	No Belt	6.82 ±2.19	10.89 ± 1.97	12.04 ±2.05	13.18 ± 2.97	NA	NA	NA	8.22 ±1.15	6.81 ±1.44	6.49 ±1.69	.053

P refers to belt versus no-belt effect

crease found in the last two minutes. This increase occurred even though ergometer workload did not change. Workload has been shown to be linearly related to oxygen uptake (1). Exercise prescription for aerobic exercise is usually done either calculating the workload that would correspond to the appropriate $\dot{V}O_2$ (ie. 50-85% $\dot{V}O_2$ max) or calculating the training heart rate (ie. percent of maximum heart rate or percent Karvonen heart rate reserve). An elevated heart rate response can invalidate the exercise prescription with either technique. In the first case (workload) a much higher than expected (approximately 20 beats per minute) heart rate would be expected. This, of course, puts a greater than anticipated cardiovascular strain on the exerciser. In the second case (target heart rate) cardiovascular strain would not be increased but intensity of exercise and percent of $\dot{V}O_2$ max would be insufficient to create optimal improvements in aerobic fitness. Although weight lifting belts will probably not be worn tightly cinched during aerobic exercise, it is possible back support corsets that are designed to protect weak or injured backs may be worn tightly cinched during aerobic exercise. Research needs to be conducted to determine the heart rate and blood pressure response to exercise while wearing these apparatus.

Significantly increased rate pressure products were found with belt use for all three exercise modalities during exercise and recovery. Since rate pressure products can give good estimates of relative myocardial oxygen need (12), myocardial oxygen need may increase with belt use. Oxygen extraction rates in the heart are already very high, so the only way myocardial oxygen uptake can be increased is by increasing myocardial blood flow (1). This, of course, can be a problem for individuals that have compromised coronary arteries.

It should be pointed out that the weight lifting belt was cinched very tightly in this study. Much smaller belt pressures and presumably little or no effect on hemodynamics would have been found if the belt had not been cinched as tightly. However, weight lifters often cinch their belts very tightly. In addition, power lifters wear extremely tight elastic uniforms during competition and often during training. These uniforms need to be stretched so much that it often takes two assistants to put the uniform on. Although not observed in this study, it is felt pressures from the uniform on the thorax and abdominal cavity could cause heart rate and blood pressure changes similar to those found with the belt.

The results of this study are somewhat limited by the methodology. Continuous blood pressure monitoring on an electronic manometer may have picked up transient blood pressure changes that may have been missed in this study. The relative difficulty of the various exercises is not comparable. For example, one arm 60 percent 1 RM bench press is probably not comparable to 60 percent $\dot{V}O_2$ max cycling. Therefore, comparisons in blood pressure between exercise modes can not be properly made. Finally, weight training is often performed at intensities above 60 percent. The effect of a weight lifting belt on blood pressure during weight training at greater than 60 percent 1 RM is unknown.

Practical Applications

There is evidence that weight lifting belts may reduce stress on the lumbar spine (2, 3, 4, 10). Weight lifting belts, even when cinched tightly, have a place during movements in which lumbar torque and shear may be very high. However, it would seem that during movements in which the stress on the lumbar spine is low, little is gained in wearing a tightly cinched weight lifting belt which increases cardiovascular stress needlessly.

It is our observation that weight lifting belts are sometimes worn during aerobic activities. Because of the extreme heart rate and blood pressure changes and difficulty in exercise prescription, we recommend that belts or similar back corset devices not be cinched tightly while performing aerobic exercise. This would particularly be the case for individuals with known cardiovascular disease or anyone exhibiting any of the risk factors for coronary heart disease.

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