Cardioprotective Effect of a Helcometer Bar with Expander System

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Abstract

The study was carried out on 5 healthy volunteers with a mean age of *30.4±9.30 years, mean height of 180±0.02 cm, mean weight of 82.2±4.44 kg, and mean wingspan 180.6±3.78 cm. Each subject performed a set of pull-ups on the lat machine using the regular bar and the bar with an expander system (innovative system), as well as a barbell bench press set with and without added elastic resistance. Each set comprised 15 repetitions, and the total resistance was below 50% of 1 RM, in case of using the same gravitational resistance. A Beurer pulse oximeter was used to determine the heart rate and oxygen saturation during resting conditions, upon completion of the exercise and during the post-effort recovery period. The maximum heart rate recorded during post-effort recovery was most of the times lower when using added elastic resistance, and the same happened with heart rates recorded upon completion of the exercise sets. The interpretation of variations in oxygen saturation levels is indicative of an enhanced cardioprotection in case of using the lat machine bar with an expander system. This cardioprotective effect can be useful in the prophylaxis and treatment of certain heart diseases.*

Keywords: lat machine bar with an expander system, cardioprotection

Introduction

The concentric left ventricular hypertrophy occurring immediately after static exercise, such as weightlifting, has been associated with systolic ventricular dysfunction and possibly other adverse sequelae, and high intensity isometric training are contraindicated in patients with heart disorders (Lavie, Milani, Marks & de Gruiter, 2001). On the other hand, in patients with stable congestive heart failure there is a need for complementary strength training for the purpose of maintaining or increasing muscle mass (Meyer, 2006). Ideally, training for these patients should focus on the peripheral muscles without causing excessive cardiovascular strain, special programs of dynamic resistance exercise being deemed equally safe as the aerobic ones (Volaklis & Tokmakidis, 2005). Nevertheless, maintaining or increasing muscle mass in patients with heart failure is very challenging given that they can only safely carry out resistance exercises in sets with low numbers of repetitions and at 50-60% of their allowed weight for maximum repetition (1 RM) (Volaklis & Tokmakidis, 2005), while one study showed that in the case of isolated knee extensions, increasing the volume of the quadriceps requires sets of 8 repetitions at 70% of 1 RM (Holm et al, 2008). Muscle mass can also increase by using a gravitational resistance at 15.5% of 1 RM, but in this case each set must comprise 36 repetitions (Holm et al, 2008), but a fundamental condition of safe resistance training for heart failure patients is the small number of repetitions (Meyer, 2006).

Considering the aforementioned aspects, we have created innovative devices that combine elastic and gravitational resistance and are aimed at reducing cardiovascular strain during resistance training both for fitness and weight training practitioners, and for the therapy of certain cardiovascular disorders, namely a barbell-expander (Hagiu, Sandu & Sandu, 2012) and a dumbbell-flexor (Hagiu, 2014). Thus, at a work equivalent to barbell based exercise, there is a lower increase of the systolic blood pressure in the case of exercise performed with an innovative barbell-expander system (Hagiu, Luiuz, Birsan, Sandu & Sandu, 2012). Similarly, in the case of forearm curls using a dumbbell-flexor system (and engaging the flexor hand grip while lifting the dumbbell), the heart rates record a lower increase than in the case of an equal number of curls performed using a regular dumbbell with the same weight (Hagiu, Dima, Puni & Rezuş, 2015).

Considering the aspects presented above, this work focuses on investigating the effects of combined elastic and gravitational resistance on heart rate and oxygen saturation levels, particularly in the case of an innovative device: *lat machine bar with expander system* (Hagiu, Oprean, Iacob, Cojocariu & Vizitiu, 2013). Starting from the hypothesis that the cardioprotective effect is more pronounced if the two types of forces are oriented in different directions, the inovative device is compared with a system composed of a barbell and a resistance cable.

Methods

The research was conducted on 5 healthy male volunteers, either weight training instructors or practitioners of weight training as a leisure activity at the New Power Gym sports club in Iași, Romania.

The age and anthropometric characteristics of the subjects are collected in table 1.

Table 1. Age and anthropometric characteristics of the study subjects

Item	*Age (years)*	*Height (cm)*	*Weight (kg)*	*Wingspan (cm)*
1	*46*	*178*	*83*	*178*
2	*26*	*180*	*80*	*181*
3	*35*	*185*	*85*	*187*
4	*19*	*180*	*88*	*179*
5	*27*	*178*	*75*	*178*
Mean and standard deviation	*30.4±9.30*	*180±0.02*	*82.2±4.44*	*180.6±3.78*

The work protocol was developed considering the fact that recovery for heart failure patients is carried out using dynamic resistance exercises (Meyer, 2006), working at a maximum of 50-60% of 1 RM (Volaklis & Tokmakidis, 2005), and that in the case of healthy individuals the maximum number of repetitions carried out at a high speed and using low weights is 16.3±3.9 (Pereira, Gomes & Bhambhani, 2007).

Thus, following a prior adjustment to the work mode using the *lat machine bar with an expander system*, each of the subjects performed sets of 15 repetition, one set entailing lat machine pull-ups performed by the simultaneous lowering of the lat machine bar handles fitted with gripper springs (Figure 1), and the other set comprising lat machine pull-ups. Each subject was coached to scale the force so as to exceed 2 graduations bilaterally (Figure 2), corresponding to 20 kgf. The gravitational resistance was set at 20 kg, except in the case of subject number 3, where we used a 30 kg load. *A Beurer pulse oximeter was used to record the heart rate (HR) and peripheral* capillary *oxygen saturation (SpO_2) before starting the exercise, immediately after the completion of the exercise and during the post-effort recovery period (2 minutes), assessing the maximum heart rate level recorded in this time frame and the minimum and maximum levels of SpO_2 (adaptation from* Keller-Ross, Johnson, Joyner & Olson, 2014). A sufficient pause was observed between the two exercises in order to ensure post-effort recovery and reaching the same resting heart rate *to enable the comparisons.*

Figure. 1. P*ull-ups on the lat machine using the bar with an expander system*
(top - initial position, down - final position)

Figure 2. *Helcometer bar with an expander system (top* - gradation system, down - detail)

Following a similar work protocol, the study subjects performed bench presses with the bar – 15 repetitions at a 30 kg gravitational resistance and with additional elastic resistance (a resistance cable adjusted so as to *exerting a 10 kg force in the final position of the exercise) (Figure 3) and 15 repetitions using only gravitational resistance, respectively.*

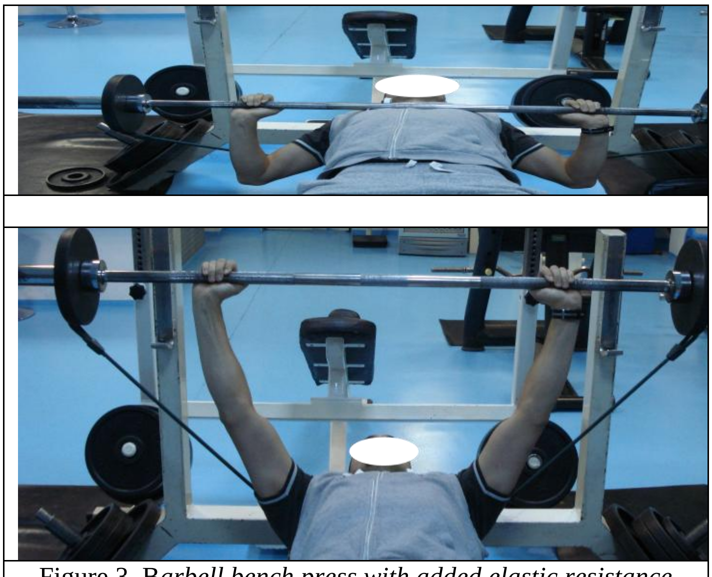

Figure 3. B*arbell bench press with added elastic resistance* (top - initial position, down - final position)

For both types of exercises the sum of the elastic and gravitational resistances was calculated so as not to exceed 50% of a maximum repetition (1 RM).

The exercises were performed at a 22-23 °C room temperature.

Results

The results are comprised in Tables 2-5. Significant values for discussion of the results are bolded.

Table 2. HR (beats/minute) and *SpO_2 in the case of the exercised performed using the* lat machine bar with expander system

Subject	*Resting levels*		Exercise completion		Post-effort recovery		
	HR (beats / minute)	*$Sp0_2$*	*HR* (beats / minute)	*$Sp0_2$*	Max. HR (beats/ minute)	*Min. SpO_2*	*Max. SpO_2*
1	80	98	**80**	97	**94**	**97**	**98**
2	70	99	**71**	99	**83**	99	99
3	67	98	**69**	99	**70**	**95**	**99**
4	71	98	70	99	77	99	99
5	88	99	**88**	98	101	**98**	**99**

Table 3. HR (beats/minute) and *SpO_2 in the case of lat machine pull-ups*

Subject	*Resting levels*		Exercise completion		Post-effort recovery		
	HR (beats / minute)	*$Sp0_2$*	*HR* (beats / minute)	*$Sp0_2$*	Max. HR (beats/minute)	*Min. SpO_2*	*Max. SpO_2*
1	80	98	**82**	98	**102**	**96**	**98**
2	70	99	**87**	99	**87**	99	99
3	67	98	**67**	98	**78**	**98**	**99**
4	71	98	70	99	77	99	99
5	88	99	**87**	98	101	**96**	**99**

Table 4. HR (beats/minute) and *SpO_2 in the case of bench presses with the bar and additional elastic resistance*

Subject	*Resting levels*		Exercise completion		Post-effort recovery		
	HR (beats / minute)	*$Sp0_2$*	*HR* (beats / minute)	*$Sp0_2$*	Max. HR (beats/minute)	*Min. SpO_2*	*Max. SpO_2*
1	72	99	**70**	99	**83**	98	98
2	65	99	**67**	97	**86**	99	99
3	72	98	**66**	99	**80**	99	99
4	58	99	**57**	74	**57**	**74**	**74**
5	88	99	88	99	**103**	**97**	**99**

Table 5. *HR* (beats/minute) and *SpO_2 in the case of bench presses with the bar*

Subject	*Resting levels*		Exercise completion		Post-effort recovery		
	HR (beats / minute)	*$Sp0_2$*	*HR* (beats / minute)	*$Sp0_2$*	Max. HR (beats/minute)	*Min. SpO_2*	Max. SO_2
1	72	99	**86**	99	**91**	98	99
2	65	99	**71**	99	**81**	99	99
3	72	98	**71**	98	**81**	99	99
4	56	97	**56**	97	**59**	**97**	**97**
5	88	99	88	99	**115**	**99**	**99**

Discussions

The analysis of the obtained data reveals that the maximum heart rate levels in all the tested subjects during post-effort recovery were at least equal, if not higher, in the case of the lat machine pull-ups as compared to exercise using the lat machine bar with expander system, although both types of exercises used the same gravitational resistance and the innovative device had an added elastic resistance. Similarly, in the case of bench presses with the bar, adding an elastic resistance led to recording lower maximum heart rate levels in most subjects during post-effort recovery than when they only used gravitational resistance. The same tendency became apparent in the HR values recorded upon completion of the exercises. This could be explained by a lower amount of blood being pumped into the muscles when adding elastic resistances, thus mitigating metaboreflexes, being a known fact that muscle mechanoreceptors play a part in triggering metaboreflexes (Xing, Lu, Li, Lu & Li, 2015). To this end, the enhanced cardiovascular protection provided by using the lat machine bar with expander system is probably due to the fact that the vectors of the two types of resistive forces are oriented in different directions. This fact probably also explains the differences in oxygen saturation levels recorded for the two types of exercises. Thus, if in the case of lat machine pull-ups the lowest levels of *SpO_2 during post-effort recovery were generally recorded when using the regular lat machine bar* (tables 2 and 3), in the case of bench presses with the bar the low levels of *SpO_2 were recorded exclusively during post-effort recovery period after the exercises performed with additional elastic resistance (tables 4 and 5). One possible explanation for these differences is that in the case of pull-ups performed using the lat machine bar with expander system, the resulting vector of the elastic and gravitational forces, respectively, is in a continuous movement during the execution of the exercise, engaging different muscle groups at a time.*

Preliminary studies conducted for the purpose of developing the work protocol indicated similar differences in the variations of physiological constants when reversing the exercise performance order (with gravitational resistance and mixed gravitational-elastic resistance, respectively), both for lat machine pull-ups and for bench presses with the bar.

Although the participants in this study were professional athletes and practitioners of sports as a leisure activity, the data in the specialty literature show that the results can be extrapolated to patients with various heart disorders.

Thus, during physical exercise the muscle metaboreflexes help adjust the cardiovascular activity to the effort, triggering a sympathetic hypertonia and increasing blood pressure (Boushel, 2010), such effects being more salient in patients with heart failure (Keller-Ross et al., 2014). Recent research revealed that this occurs as a result of enhanced involvement of the mechanoreceptors in the sympathetic tonus (Xing et al., 2015). Increased resting heart rates in patients with heart failure are a factor of adverse prognosis (Cowie & Davidson, 2012); however, it is generally indicated for these patients to increase their heart rates via physical exercise above resting heart rate levels in order to improve the maximum volume of oxygen (Piña et al., 2003). There are, however, cases of heart failure where it is desirable to limit the increase in heart rate levels during physical exercise, considering the fact that increased heart rate levels entail increased blood pressure, which is a causative factor for left ventricular hypertrophy, and that sodium restriction is one of the factors that induce left ventricular hypertrophy regression (Subramaniam & Lip, 2009). When determining the exercise program according to the stage of the disorder, attention should be paid to the fact that the characteristic sympathicotonia of heart failure is not thwarted at the onset of the disease by means of vagal tonicity, this phenomenon occurring in the final stages (Milicevic, Udiljak & Milicevic, 2013).

It is possible for added elastic resistance to have a more significant cardioprotective effect in patients with heart failure, given that the more salient metaboreflexes in these people are due to the increasing contribution of mechanoreceptors. The results of this study show that show that in this category of patients it is desirable for the elastic force to have a different orientation than the gravitational force so as to avoid the onset of hypoxia. I believe that in the case of the innovative device, a potential reduction of the preload could also contribute in the mitigation of cardiovascular strain because the same work as in the lat machine exercises can be obtained using a lower weight, but performing the pull-ups using the lat machine bar with expander system, and in addition to this the sympathicotonia seems to be less marked. Although the study protocol was developed for the purpose of creating therapeutic programs, I believe that the use of weight training machines which combine elastic and gravitational resistance can also induce muscle growth in athletes by means of a relative ischemia of active muscles (Demeter, 1981, p. 97, 98) in the conditions of an enhanced cardiovascular protection if the resistive forces have different orientations.

Conclusions

1. If the total resistance is below 50% of RM, 15 repetitions performed with systems that add elastic resistance to gravitational resistance induce a lower increase of the heart rate (both upon completion of the exercise and during the post-effort recovery period) compared to similar exercises performed using the same weight, but without adding the elastic resistance.
2. The recorded variations of oxygen saturation levels show that the risk of hypoxia arising in case of therapeutic use of the aforementioned devices is lower if the elastic and gravitational resistances are oriented in different directions.
3. Interpretation of the results obtained from the perspective of the specialty literature data suggests a lower blood flow to active muscles during exercises performed with systems combining elastic and gravitational resistance, which in its turn triggers less salient metaboreflexes (thus providing cardioprotection) and also creates the premises for building muscle mass.
4. As a result, this type of devices (such as the innovative lat machine bar with expander system) can be used both by bodybuilders for preventing the onset of heart disorders, and in the recovery for some of these disorders (for instance in certain cases of heart failure).

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