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Training with an elastic, supportive bench press device is not superior to a conventional training approach in trained men

Introduction

The bench press (BP) is a commonly used exercise in strength and conditioning programs for a variety of sports (Haff & Triplett, 2016). It is used to develop upper body maximal strength and power (Gavanda, Geisler, Quittmann, & Schiffer, 2019) and hypertrophy of the prime movers: pectoralis major, triceps brachii, and anterior deltoid (Ogasawara, Thiebaud, Loenneke, Loftin, & Abe, 2012). These adaptations may then contribute to improved sport specific movements, such as throwing (Ramos Veliz, Requena, Suarez-Arrones, Newton, & Sáez de Villarreal, 2014), or punching (Voigt & Klausen, 1990). Alongside the back squat and deadlift, the BP is also one of the competition lifts in powerlifting, in which athletes try to overcome the highest possible load within three attempts in accordance with competition rules (International Powerlifting Federation, 2021).

Many athletes aim to improve their 1-RM BP through resistance training (RT) for a variety of reasons. For this purpose, athletes use a broad range of RT methods, such as the use of unstable loads (Ostrowski, Carlson, & Lawrence, 2017) or surfaces (Saeterbakken & Fimland, 2013), chains (Godwin, Fernandes, & Twist, 2018), rubber bands (García-López et al., 2016), and elastic, supportive bench press devices (EBD) (Dugdale, Hunter, Di Virgilio, Macgregor, & Hamilton, 2019; Niblock & Steele, 2017; Ye et al., 2014). EBD are sold under names such as "Sling Shot®" (Sacramento, CA, USA) or "Hooke Strap" (Alpen, Germany). These devices are made of strong elastic bands with sleeves on each the end, so that athletes can put their arms through both sleeves and wear the device while bench pressing. EBDs are considered to mimic a bench press shirt, which is a specialized piece of equipment to increase competition performance and are only allowed in so-called "equipped" powerlifting events, with the advantage that the EBD is far easier to pull on and off (Ye et al., 2014). As the bar is lowered to the chest, the middle elastic part of the device is lengthened and stores elastic energy. This energy then can be used during the concentric portion of the bench press, as the EBD shortens to its initial length.

Manufacturers advertise on their websites that RT with EBD will reinforce better technique, leads to less joint stress and to greater strength gains through "overload training" (Mark Bell, n.d.; The Stronger Athlete, n.d.). Concerning technique, Green and Comfort (2007) recommend lowering the bar during the BP to the more caudal portion of the pectoralis, as well as instructing athletes

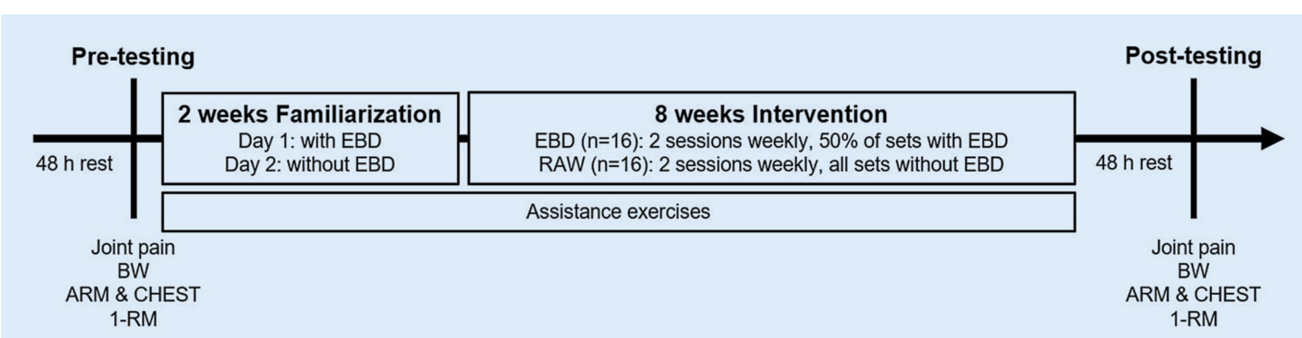

Fig. 1 ▲ Schematic representation of study design. Shoulder, elbow, and wrist pain was measures using a visual analogue scale. Body weight (BW) was assessed using an electronic scale. Arm and chest circumference were taken as a measure for hypertrophy. *1-RM* One-repetition maximum bench press, *EBD* Elastic bench press device

Table 1 Baseline group characteristics (bench press training without an elastic supportive bench press device [RAW] or with an elastic supportive device [EBD])

	RAW [$n=16$]		EBD [$n=16$]	
	Mean	±SD	Mean	±SD
Age [years]	25.4	±2.3	24.4	±34.0
Height [cm]	182.5	±8.4	182.8	±5.5
Weight [kg]	85.8	±14.5	87.7	±11.2
Relative 1-RM BP	1.1	±0.2	1.0	±0.2
Resistance training experience [years]	5.7	±3.0	3.8	±1.8
Recent resistance training frequency [1/week]	2.7	±1.1	3.0	±0.9

1-RM BP One-repetition maximum bench press, *SD* standard deviation

to take a more narrow grip width (≤1.5 biacromial distance) with the aim of reducing shoulder abduction and rotation, as 90° of shoulder abduction in combination with end-range external rotation has been suggested as a vulnerable position that might increase the risk of injury (Gross, Brenner, Esformes, & Sonzogni, 1993). According to Ye et al. (2014), use of EBD squeezes the elbows closer to the trunk, which helps athletes to maintain the aforementioned recommended position while pressing and, thus, may reduce the risk of injury and pain. However, at the time of this study, there is no empirical evidence from RT studies to test for this hypothesis. The same applies to the assumption that EBD RT leads to greater strength gains than conventional BP training regimes.

Recent studies have shown that, when wearing an EBD (Sling Shot®) a 15% higher load can be used compared to raw bench pressing (RAW) (Dugdale et al., 2019; Ye et al., 2014), but the chronic effects of such "overload training" have not yet been studied. Niblock and Steele (2017), however, theorized that a bench press RT regime using an EBD could be more effective for long-term adaptations in strength and hypertrophy, compared to a conventional RT approach, since higher absolute loads with equal volume can be used compared to RAW RT.

Therefore, the aim of this study was to investigate the effects of an 8-week powerlifting-type BP RT, either with or without using an EBD, on body weight (BW), 1-RM BP, and hypertrophic adaptations (arm and chest circumferences). Furthermore, subjective pain perception of the main joints involved in the movement before and after the intervention will be investigated to test manufacturers' claims of less joint stress, and, therefore, reduced sensation of joint pain by using an EBD.

Methods

Experimental approach to the problem

Following a 2-week familiarization period, a two-group matched pair parallel design based on initial BP one-repetition maximum (1-RM) was used to assess the effects of an 8-week twice weekly powerlifting-type upper-body RT either with (BPD) or without (RAW) an elastic bench press device on strength (1-RM), anthropometric data (arm and chest circumference), and joint pain in trained young male healthy adults (Fig. 1). During pre-testing, participants first completed a questionnaire about their recent RT history and current joint pain. Subsequently, BW, mid-upper arm- (ARM) and chest circumference (CHEST) was measured before 1-RM testing took place. Post-testing occurred 2 days (48 h) after the last training session. BW, ARM, CHEST, joint pain assessment, and 1-RM were then repeated identical to pre-testing. The independent variables consisted of two different bench press training modalities (BPD and RAW) and seven dependent variables: 1-RM, BW, ARM and CHEST, as well as joint pain assessments of the shoulder, elbow, and wrist.

Subjects

Before the investigation was carried out, ethical clearance was obtained from the University's Ethics Committee in regard to the Declaration of Helsinki. G*Power software (3.1.9.2, Universität Düsseldorf, Germany) was used a priori to determine sample size via power analysis using a medium effect size ($f=0.25$; $\alpha=0.05$; $1-\beta=0.80$) (Faul, Erdfelder, Lang, & Buchner, 2007). According to the analysis, a total of 34 subjects would have been sufficient. However, to account for possible dropouts, a total of 41 healthy men between the ages of 18 and 35, with no metabolic, respiratory, or cardiovascular disorders, no upper extremity injury in the 6 months prior to the intervention, and with a minimum of 1.5 year of experience with the bench press exercise were initially recruited for this study. Exclusion criteria were the use of nutritional supplements or illegal drugs, such as anabolic steroids. Of this initial number, data from 32 subjects were included for final analysis. Five participants missed their testing appointment or did not reach the minimum of 17 out of 20 training sessions (85% adherence). Four subjects got sick or suffered non-study-related injuries during the course of this study and were therefore eliminated. Baseline characteristics of the included subjects can be found in Table 1. All subjects were informed at the beginning of the study about the procedures, the methods used, and the potential risks. The participants agreed to abstain from any additional upper-body RT for the course of the study. In addition, subjects were instructed to maintain their normal dietary habits in order to minimize dietary bias. Written informed consent was obtained in advance.

Procedures

Testing

All tests were done in a local gym by the same researcher and utilizing the same equipment at the same time of the day. Subjects were instructed to refrain from any kind of exercise within 48 h prior to the start of the study.

During the first day of the study, subjects' RT history was assessed using a questionnaire. Shoulder, elbow, and wrist pain were measured using a visual analogue scale (VAS), as described by

Heller et al. (2016). BW was measured using an electronic scale (Seca 803; Seca GmbH & Co. KG, Hamburg, Germany). CHEST and ARM circumference were taken using a tape measure while subjects were topless and standing. CHEST was measured horizontally at the level of the acromastium following the end of normal expiration. For ARM measurement, the midpoint between the acromion and the olecranon was marked with a pen. Participants were then instructed to abduct their arm 90° in the shoulder joint, bend the elbow to 90° and contract the arm muscles to the maximum (Barbalho et al., 2018; Gentil et al., 2020). The circumference was then measured at the pen mark. Each measurement to the nearest half centimeter was done three times without compressing the underlying tissue. The average value of the three measurements was calculated for further analysis.

Five minutes of low-intensity rowing were completed on a rowing machine as general warm-up, followed by a specific warm-up, in which all participants completed 4 sets (10, 5, 3, and 1 repetition) of barbell bench pressing with increasing intensity (50%, 65%, 80%, and 90% of the participants' estimated 1-RM) interspersed with 1, 2, 3, and 4 min of rest between sets (Gavanda et al., 2019). The 1-RM was then tested by increasing the weight of a single repetition until no valid repetition could be performed. After each set, the subjects were instructed to take 4 min of rest. No more than six attempts were allowed to find the 1-RM. A repetition was considered valid if the bar was lowered from a locked-out arm position until it touched the chest with no bounce, and the subject then moved the barbell back to the starting position without assistance from the spotter. Participants' head, shoulders, buttocks were to maintain contact with the bench and their feet with the floor during the whole attempt. Strong verbal encouragement was given by the research team.

Familiarization and RT intervention

Both groups began the intervention with a protocol familiarization phase, lasting 2 weeks. A detailed description of sets, repetitions, intensity, and rest periods for the bench press across the duration of the study for both groups can be found in ▪ Table 2. The primary aim for all subjects was to become familiar with the elastic training device (Hooke Strap Level 1, The Stronger Athlete, Alpen, Germany). The size of the device was assigned to the subjects depending on the circumference of the upper arm, according to the manufacturer's specifications. The criteria of exercise execution were identical to those of the 1-RM test. Familiarization was conducted twice per week; the first session was done with and the second without the EBD.

In addition, after BP bent-over barbell rows (5 sets, 10–15 repetitions, 90 s rest), reverse fly with dumbbells (3 sets, 15–20 repetitions, 60 s rest), and dips (2 sets, 10–15 repetitions, 90 s rest) were performed each week during Session One, while in Session Two single-arm dumbbell rows (5 sets, 10–15 repetitions, 90 s rest), external cable rotation (3 sets, 15–20 repetitions, 60 s rest), and triceps cable push down (2 sets, 10–15 repetitions, 90 s rest) were completed. All exercises were done until voluntary concentric failure or when subjects failed to maintain proper exercise technique. If participants could complete more than the prescribed number of repetitions, they continued the set until concentric failure was reached. Resistance was increased when the upper limit of the specified number of repetitions was reached. The aim was to exercise the antagonistic, as well as the synergistic muscles of bench press. All exercises in this study were done over subjects' full range of motion, with the eccentric portion of each repetition lasting two seconds, no static hold at the top or the bottom, and a concentric phase executed with maximum speed. Training sessions were performed on nonconsecutive days with a minimum of 48 and maximum of 96 h between. All training sessions were supervised by a member of the research team. Prior to each session, a standardized warm-up was completed, consisting of 5 min low-intensity rowing on a rowing machine, followed by pushups (2 sets of 8 repetitions) and shoulder circles (2 sets of 10 repetitions).

Subsequently, the intervention period proceeded according to the assigned group (▪ Table 2). The warm-up was the same as during the familiarization phase. In the RAW group, all bench press sets were completed without the EBD. The EBD group completed more than half of

Abstract

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Abstract

The aim of this study was to investigate the effects of an 8-week powerlifting-type bench press (BP) resistance training (RT) program, either without (RAW) or with using a supportive elastic bench press device (EBD) on one-repetition maximum (1-RM), body weight (BW), mid-upper arm and chest circumference, as well as visual analogue pain scale (VAS) of the shoulder, elbow, and wrist. For this purpose, a matched pair parallel design based on initial 1-RM was used (BPD $n = 16$, age 24.4 ± 4 years, RT experience 3.75 ± 1.83 years; RAW $n = 16$, age 25 ± 2 years, RT experience 5.66 ± 3.00 years). Following two weeks of familiarization with the protocol , BP RT was carried out twice weekly. The EBD group completed more than half of their BP sets with elastic assistance and 10% higher training intensity than the RAW group. There was a significant time × group interaction in BW ($p = 0.008$). Post hoc analysis showed a significant loss of 0.92 kg in the EBD group ($p = 0.049$; effect size [ES] = –0.08; 95%CI [–1.80, 0.04]). A significant time effect for 1-RM was observed ($p < 0.001$). In both groups there was a significant change in 1-RM of 5.00 kg ($p < 0.001$; ES = 0.35; 95%CI [2.98, 7.02]). There was no significant change in any circumference or VAS measure. In conclusion, using an EBD leads to 1-RM gains similar to conventional RAW BP training. However, more studies are required with highly trained individuals, in particular female athletes. Practitioners may implement EBD training for reasons of variation.

Keywords

Powerlifting · Slingshot · Strength · Sling shot · Hooke strap

Table 2 Sets, repetition, intensity as percentage subjects' initial one-repetition maximum, and rest periods for the bench press during the familiarization and intervention period

Session	Week 1	2	Group	3	4	5	6	7	8	9	10
1	5×10 @ 77%	5×10 @80%	RAW	5×8@72%	5×8@75%	5×5@85%	3×6@65%	5×3@90%	5×3@93%	5×1@97%	3×6@65%
			BPD	2×8@72%	2×8@75%	2×5@85%	1×6@65%	2×3@90%	2×3@93%	2×1@97%	1×6@65%
				3×8@82%	**3×8@85%**	**3×5@95%**	**2×6@75%**	**3×3@100%**	**3×3@103%**	**3×1@107%**	**2×6@75%**
2	5×10 @ 67%	5×10 @70%	RAW	5×8@72%	5×8@75%	5×5@85%	3×6@65%	5×3@90%	5×3@93%	5×1@97%	3×6@65%
			BPD	2×8@72%	2×8@75%	2×5@85%	1×6@65%	2×3@90%	2×3@93%	2×1@97%	1×6@65%
				3×8@82%	**3×8@85%**	**3×5@95%**	**2×6@75%**	**3×3@100%**	**3×3@103%**	**3×1@107%**	**2×6@75%**
Rest	2 min	2 min	–	2 min	2 min	3 min	2 min	3.5 min	3.5 min	4 min	2 min
–	**Familiarization**			**Intervention period**							

RAW training group without an elastic, supportive bench press device, *BPD* intervention group with using an elastic, supportive bench press device. Cells in *bold* represent the use of the elastic, supportive bench press device

their sets with elastic assistance, as it is common practice to complete only part of the working sets using an EBD. A 10% higher training intensity was used in the EBD group than the RAW group; according to the manufacturer, up to 10% more weight is possible when bench pressing while wearing the "Hooke Strap Level 1". All other elements of the training session, such as sets, repetitions, tempo, and rest periods remained consistent between training groups. Training of the antagonists and synergists were also identical in both groups, as described above. In week six and ten, deload weeks with reduced training intensity were implemented in both groups to combat possible overtraining symptoms.

Statistical analysis

Statistical analyses were performed using SPSS (version 24; IBM Corp, Chicago, IL, USA). Data are presented as means ± standard deviation (SD). Statistical significance was defined as $p \leq 0.05$. All data were tested for normal distribution using the Kolmogorow–Smirnow test. Homogeneity of variances was checked using Levene's test. A 2×2 (time × group) analysis of variance (ANOVA) was used to assess differences in BW, 1-RM, ARM, CHEST, VAS shoulder, elbow, and wrist. Where necessary, Bonferroni post hoc analysis was performed. Effect sizes (ES) for RT studies were calculated according Rhea (2004) using the following formula: Pre–Post ES = (Posttest mean – Pretest mean)/Pretest SD. ES of <0.35, <0.8, <1.5, and ≥1.5 were considered trivial, small, moderate, and large, respectively (Rhea, 2004). In addition, 95% confidence intervals (95%CI) for mean differences and mean percentage changes were calculated. Intraclass correlation coefficients (ICC) estimates were calculated based on a mean-rating (k = 3), absolute-agreement, and 2-way random-effects model for ARM and CHEST.

Results

A high degree of measurement reliability was found for ARM (ICC = 0.994) and CHEST, respectively (ICC = 0.986).

There were no significant baseline group differences in subjects' age ($p = 0.359$), height ($p = 0.901$), BW ($p = 0.323$), and recent RT frequency ($p = 0.184$). RT experience was significantly higher ($p = 0.04$) in the RAW group (5.66 ± 3.00 years), compared to EBD (3.75 ± 1.83 years). Subjects did not differ at baseline in 1-RM ($p = 0.903$), CHEST ($p = 0.512$), ARM ($p = 0.912$), VAS shoulder ($p = 0.696$), VAS elbow ($p = 0.956$), or VAS wrist ($p = 0.669$). RT adherence of subjects who completed the study was 100% in both groups.

There was a significant time × group interaction in BW ($p = 0.008$; 1-β > 99%). Post hoc analysis showed a significant loss of 0.92 kg in the EBD group ($p = 0.049$; ES = −0.08; 95%CI [1, 80]). A significant time effect for 1-RM was observed (RAW: $p < 0.001$; 1-β > 99%; ES = 0.34; 95%CI [2.67, 6.08]; EBD: $p < 0.001$; 1-β > 99%; ES = 0.36; 95%CI [2.87, 8.38]). All results are summarized in **Table 3**. In addition, individual 1-RM gains can be found in **Fig. 2**.

Discussion

The primary finding of the present study is that EBD RT did not lead to higher 1-RM increments compared to RAW RT. On average, both groups increased their BP 1-RM by approximately 6% (4.87% in RAW and 6.27% in EBD, respectively). Measures of circumference (ARM and CHEST) and joint pain (shoulder, elbow, and wrist) did not change in the two groups as a result of the intervention.

Upper body strength increased on average by 5 kg, with a small ES of 0.35 and no significant difference between intervention groups (+4.38 kg in the RAW and +5.63 kg in the EBD group). One possible explanation for the lack in confirmation of the manufacturers' so-called "overload training" using an EBD could be that the higher loads lifted in the EBD group were only possible due to the external elastic force provided by the EBD (Ye et al., 2014); EBD participants' own strength qualities may not have been required to generate higher forces, although the resistance was higher compared to the RAW group.

Table 3 Pre-, and post-test values, absolute and relative change, 95% confidence interval, effect size, time and group effects, time by group interactions, as well as post hoc analysis

		Pre	SD	Post	SD	dTime	95% CI	% Change	Effect size	Time p	Time Partial eta-squared	Group p	Group Partial eta-squared	Time×group p	Time×group Partial eta-squared	Bonferroni post hoc p
BW	RAW	85.78	14.46	86.66	15.33	0.88	0.08 – 1.69	1.03	0.06	0.946	0.000	0.832	0.002	0.008**	0.211	0.060
[kg]	EBD	87.67	11.22	86.74	10.62	−0.92	−1.89 – 0.04	−1.06	−0.08							0.049*
1-RM	RAW	90.31	12.91	94.69	13.87	4.38	2.67 – 6.08	4.84	0.34	<0.001*	0.610	1.000	0.000	0.399	0.024	<0.001***
[kg]	EBD	89.69	15.81	95.31	15.94	5.63	2.87 – 8.38	6.27	0.36							<0.001***
ARM	RAW	36.78	3.53	37.00	3.26	0.22	−0.07 – 0.50	0.60	0.06	0.051	0.121	0.945	0.000	0.723	0.004	N/A
[cm]	EBD	36.66	2.79	36.97	3.10	0.31	−0.11 – 0.74	0.85	0.11							N/A
CHEST	RAW	101.03	8.27	102.31	8.32	1.28	0.35 – 2.22	1.27	0.16	0.110	0.083	0.601	0.009	0.350	0.029	N/A
[cm]	EBD	103.03	8.77	103.38	7.83	0.34	−1.35 – 2.02	0.33	0.04							N/A
VAS	RAW	0.39	0.84	0.51	1.30	0.12	−0.32 – 0.55	30.41	0.14	0.464	0.018	0.478	0.017	0.950	0.000	N/A
Shoulder	EBD	0.67	1.15	0.77	1.24	0.10	−0.28 – 0.48	14.95	0.09							N/A
VAS	RAW	0.08	0.25	0.03	0.10	−0.05	−0.19 – 0.09	−66.67	−0.20	0.804	0.002	0.338	0.031	0.367	0.027	N/A
Elbow	EBD	0.31	1.01	0.40	1.50	0.09	−0.17 – 0.35	27.80	0.09							N/A
VAS	RAW	0.23	0.65	0.19	0.65	−0.04	−0.16 – 0.09	−16.44	−0.06	0.768	0.003	0.198	0.055	0.572	0.011	N/A
Wrist	EBD	0.82	1.68	0.94	2.30	0.12	−1.01 – 1.25	14.53	0.07							N/A

BW body weight, *1-RM* one-repetition maximum, *ARM* arm circumference, *CHEST* chest circumference, *VAS* visual analogue scale, *RAW* training group without an elastic, supportive bench press device, *BPD* intervention group with using an elastic, supportive bench press device, *SD* standard deviation, *dTime* absolute change, *95%CI* 95% confidence interval, *%change* relative change, *N/A* not applicable. *$p < 0.05$. ***$p < 0.001$

Interestingly, this assumption is supported by studies using electromyography (EMG), showing no change in EMG amplitude of the prime movers between supramaximal 1-RM using an EBD and "true" RAW 1-RM (Dugdale et al., 2019; Ye et al., 2014). Furthermore, one study demonstrated triceps activity to be lower using an EBD (Dugdale et al., 2019). Thus, athletes' neuromuscular system likely never truly experienced an "overload", except for the end portion of the lift, where no more additional elastic force was provided by the device. Nevertheless, this "overload" at the end of the range of motion does not seem to confer an advantage for improving 1-RM BP and, as such, the claim that the BP RT in combination with an EBD leads to higher increases in strength appears currently unfounded for trained young men.

In general, the 1-RM improvements in this study were somewhat lower than strength gains in previous research using similar RT regimens. For example, Lasevicius et al. (2019) found an average increase in BP 1-RM of 8 and 9.6 kg following 10 weeks of split and total body RT respectively. Also, Colquhoun et al. (2018) found BP 1-RM mean improvements of 7.8 kg and 8.8 kg following a 6-week RT intervention period with a training frequency of three and six sessions per week, respectively, but equal volume between groups. There are several possible explanations for this discrepancy. First, previous RT experience may influence degree of adaptation, as it was demonstrated that trained athletes showed less improvements in strength during a given time period compared to novice lifters (Williams, Tolusso, Fedewa, & Esco, 2017). For this reason, the results by Colquhoun et al. (2018) could have been higher compared to those presented here, since, in contrast to this study, only untrained subjects participated. Lasevicius et al. (2019), however, only allowed trained individuals to participate, as was conducted here. The intervention period was 2 weeks longer than in the present study. This intervention length could also explain the observed differences; current findings support that, the longer the duration of RT protocols, the higher the

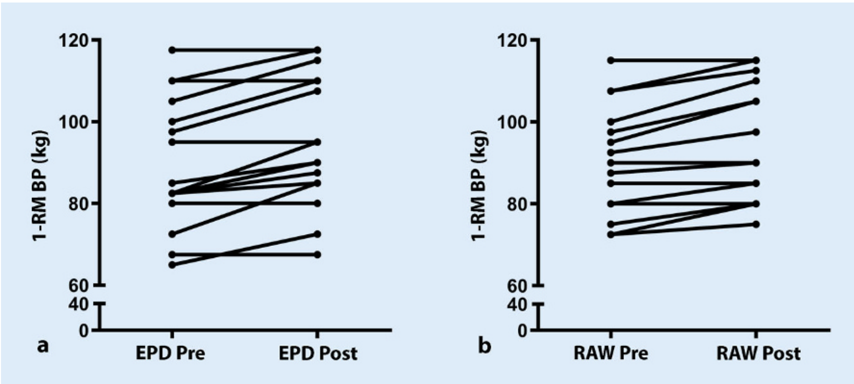

Fig. 2 ▲ Individual one-repetition maximum (1-RM) gains in the elastic, supportive bench press device-group (EBD) (**a**) and the group without an elastic, supportive bench press device (RAW) (**b**)

expected strength gain (Williams et al., 2017). Furthermore, any combination of frequency, volume, intensity, rest, and progression method influences the adaptation response. In this study, a typical, linear, powerlifting-type RT regime with set 1-RM percentage was used (10-1 repetition with a weekly progression of intensity of 3–10%) in order to replicate realistic strength training protocols with and without the use of an EBD. Whether higher strength increases or even differences between EBD and RAW would have been possible with a different regime (e.g., higher volume) leaves room for speculation. It is therefore necessary to conduct more studies with various RT protocols comparing EBD to RAW RT. Possible alternatives would be the use of repetition maximum targets instead of fixed intensity percentages (Thompson, Rogerson, Ruddock, & Barnes, 2020) or higher RT frequencies (Grgic et al., 2018).

An increase in circumference was neither detected for ARM nor CHEST. It is however possible that the measurement of circumferences was not capable of detecting muscle growth on a small scale. Nevertheless, circumference measurements were preferred over more sensitive measurements, such as magnetic resonance imaging (MRI), because they are much easier to perform, are less invasive, and require less time. Furthermore, an 8-week RT period with two sessions per week may not be long enough to elicit gains in muscle mass in trained subjects above the measurement error of the circumference measurement, although a high degree of measurement reliability was found in this study. For example, for ARM measurements in men, this error has been reported as 2.8% in the literature (Bishop & Pitchey, 1987). For these reasons, and since the focus of this study was directed toward strength increases, further studies using more sophisticated measures of hypertrophy like ultrasound or magnetic resonance imaging are necessary to clarify if EBD RT leads to higher hypertrophic response in the prime movers.

EBD manufacturers advertise less joint stress by reinforcing better BP technique (Mark Bell). In the present study, no measure of technique was used. Therefore, nothing can be concluded about the change in BP technique by training with an EBD. Studies using subjective (e.g., by official powerlifting judges or coaches) or objective assessments (e.g., camera systems) to investigate the influence of an EBD RT on BP technique are needed. However, an attempt was made to indirectly quantify joint stress by assessing subjective measures of joint pain. Because subjects had to be healthy with no existing injury in order to participate, the aim of the intention was not to reduce existing joint pain by using an EBD, but to detect any overuse symptoms due to heavier training weights in the EBD group ("overload training"). However, there were no significant changes in VAS values. The previously reported acute discomfort in the wrists when using an EBD and the concern this could lead to overuse during prolonged use (Niblock & Steele, 2017) could therefore not be confirmed in this 8-week study.

However, further studies using direct markers of joint stress (e.g., biomarkers) are necessary to draw concrete conclusions. Of note, the previously reported anecdotal evidence suggesting EBD reducing discomfort in the shoulder and elbow joints when heavy bench pressing (Ye et al., 2014), in accordance with manufacturers' claims of reduced joint stress, can be partially confirmed in the present study, since some participants with a history of shoulder injuries stated that bench pressing with an EBD felt "more comfortable". Thus, it would be worthwhile to further study athletes with existing symptoms of overuse of the shoulder joint (e.g., powerlifters, throwers).

There was a significant reduction in BW in the EBD group of 0.92 kg, and a small but not significant increase in the RAW group (+0.88 kg). However, these findings are probably without practical relevance to this study, due to their trivial ES of 0.06 and –0.08 in the RAW and the EBD group, respectively. Although all measurements were done at the same time of day, it is also possible that BW was affected by day-to-day fluctuations of fluid intake (Braun et al., 2019). In addition, because subjects were instructed to maintain their normal nutritional behavior, it is possible that participants exceeded or fell short of their daily calorie requirements; therefore, nutrition may have an impact on participant BW. Future studies, especially those focusing on hypertrophy, are advised to document subjects' food intake. Furthermore, assessments of body composition, such as bioelectrical impedance analysis or dual-energy x-ray absorptiometry, should be considered to measure changes in muscle and fat mass after RT using an EBD.

This is the first training study comparing the effects of BP RT with or without an EBD. However, the limitations of this study are worth mentioning. First, all previous research concerning EBD used the "Original Sling Shot®", while the present study used a product by a different manufacturer. The elastic properties could vary between products and make comparison difficult. Second in the present study, a 10% higher training intensity was used in the EBD group compared to the RAW group because, according to the manufacturer, up to 10% more weight is possible when bench pressing while wearing the EBD. However, previous research suggest absolute increments in RT load (e.g., 21 kg; Dugdale et al., 2019; Ye et al., 2014), instead of relative load (e.g., 15%). Further studies should take this into account. Third, anthropometric characteristics, such as chest width and height could affect the amount of elastic energy stored in the EBD (Dugdale et al., 2019). Future studies could take anthropometric data into account when assigning participants to intervention groups. In addition, not only RAW 1-RM but also EBD 1-RM or even 1-RM testing while wearing a BP shirt could be considered because there may be specific adaptations and different carry-over effects between conditions. Not only 1-RM, but tests of speed and power, deserve consideration. Finally, studies should consider trained and untrained, younger and older, as well as female participants.

In conclusion, RT using an EBD leads an increase in BP strength gains in young trained men similar to conventional BP training. Practitioners may therefore implement this device for reasons of variation in order to reduce RT monotony. Furthermore, it is possible that powerlifters can benefit from EBD RT to become accustomed to the use of a BP shirt without the time-consuming procedure of putting it on. However, this requires confirmation from further studies with trained powerlifters.

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Declarations

Conflict of interest. S. Gavanda, M. Wever, E. Isenmann and S. Geisler declare that they have no competing interests.

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

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