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Original Article

Comparative evaluation of muscular activation and scapular kinematics in a chest press lever machine and a barbell bench press

EDUARDO BORGES[1]; HELENA DALLA[2]; LUCIANA MASTANDREA[3]; SANDRA NUNES[4]; JOSÉ SANTAREM[5]
[2,3,4,5] Instituto Biodelta - São Paulo, BRAZIL
[1] College of physical education YMCA of Sorocaba - São Paulo, BRAZIL

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Abstract:
We aimed to compare scapular kinematics and electromyographic activity of the sternocostal head of the pectoralis major, clavicular head of the pectoralis major, anterior deltoid and serratus anterior at the barbell bench press and at a chest press lever machine. Concentric and eccentric phases electromyographic activity were compared. Muscle activation was not statistically different between the barbell bench press compared to the chest press lever machine when the volunteers used weight to perform 10 maximal repetitions. But, with 50% of the weight of 10 maximal repetitions, the bench press showed greater activation for the serratus anterior and the clavicular head of pectoralis major muscles in relation to the chest press lever machine. The abduction mobility of the scapular cingulate was higher in chest press lever machine than in barbell bench press (19.8 ° vs 7.8 °) for both conditions. Such results should be taken into account to avoid mistakes in the electromyographic analysis of adjacent muscles and when it is necessary to choose an exercise with greater mobility of the scapular cingulate.
Key words: - Resistance Training, Electromyography, Shoulder, Pectoralis Muscles

Introduction

Generally, muscle activation is greater in free weights than in machines (Escamilla et al., 2001). In the barbell bench press the activation of the deltoid is greater than in the Smith machine (McCaw & Friday, 1994; Schick et al., 2010). Nevertheless, the pectoralis major is the main muscle requested in both exercises (Stastny et al., 2017). Although the current literature present several studies comparing activation of the muscles involved during barbell bench press exercise (Brennecke et al., 2009; McCaw & Friday, 1994; Saeterbakken & Fimland, 2013; Schick et al., 2010), including a recent systematic review (Stastny et al., 2017), no study has looked at the kinematics of the scapular cingulate and the activation of the anterior serratus on the barbell bench press or in the machines.

Resistance exercise devices with levers and free weights can be designed with the purpose of reducing joint overload and eventually increase muscular activation. In the practice of resistance training, many practitioners refer greater joint comfort with this type of equipment, and good sensation of muscular activation. More articular comfort could be explained by the mechanical system used which theoretically decrease the request of muscles and stabilizing ligaments. In the case of chest press movement the scapular kinematics could be another explanation for the supposed greater comfort in the devices with levers. With regard to muscle activation, it is expected that adequate variation of load and direction of the force vectors along the course of the movements in the devices with levers can produce a good muscular activation. It is possible to speculate that if these qualities are true, this type of equipment could be a good option for the training of athletes who work within their load limits and who desire a good feeling of muscular work associated with joint comfort. Another possible relevant application would be the muscular strengthening exercises in people with articular pain of diverse origins.

The aim of the present study was to compare scapular kinematics and muscular activation of the pectoralis major, anterior deltoid and serratus anterior muscles at the Barbell Bench Press and at a Chest Press Lever Machine.

Material & methods

Participants

Fifteen male volunteers with no history of diseases or musculoskeletal disorders, experienced in resistance training for more than 1 year, participated in this study. The descriptive data of the volunteers are

Corresponding Author: EDUARDO BORGES, E-mail: eduardo.borges2010@uol.com.br

presented in table 1. This research was approved in the Ethics Committee of the University of Sorocaba - SP under number 64976316.0.0000.5500.

Table 1. Descriptive data of subjects

Variables	Mean ± DP
Age (years)	30.6 ± 7.6
Height (cm)	175.3 ± 5.6
Body mass (kg))	82.1 ± 10.3
BMI (kg / m2)	26.7 ± 2.8

BMI = Body mass index

Procedures

Initially, 2 weeks before the main experiment, the subjects performed a familiarization in the exercises barbell bench press and chest press lever machine. Each subject performed 4 training sessions with the experiment exercises. Participants were asked to perform only two sets of ten repetitions in each of the exercises, with progressive loads, during these 2 weeks of familiarization. This procedure aimed to obtain a good familiarization and determination of the 10 maximal repetitions (RM) loads in the two exercises. To assist in the appropriate adjustment of load in each exercise, the volunteers referred the adapted Borg's subjective perception of effort scale (Day, McGuigan, Brice, & Foster, 2004) for each series of the exercise performed. The exercises were performed in a randomized and balanced manner. The speed of execution of the exercises was not controlled, but the volunteers were oriented to perform the concentric contraction and the eccentric contraction around 2 seconds.

After the familiarization with the exercises, they were used to Record surface EMG from 4 sites: over the bellies of the sternocostal head of the pectoralis major muscle, the clavicular head of the same muscle, the anterior deltoid and Serratus anterior. The subjects performed 4 repetitions of each exercise using 50% of the 10 RM load pre-determined in the weeks of familiarization and after 1 minute of rest they performed 4 repetitions with 10 RM load. The rest interval between exercises was 3 minutes (Escamilla et al., 2001). The order of the exercises was randomized and balanced.

Resistance training exercises

Barbell Bench Press: The exercise was performed in a horizontal bench with Olympic barbell and plates (Portico®). The hand spacing used to hold the barbell was 1.5 the bi-acromial distance of each subject. Exercise repetitions were started with the arm completely extended above chest, the eccentric phase finished when the barbell touched lightly in the chest, and the concentric phase finalized when the elbow was fully extended again, at the end of the horizontal adduction of the shoulder.

Chest Press Lever Machine*:* The exercise was evaluated in machines with levers and free weights (Biodelta®). As in the other exercise, the hands were apart 1.5 times the bi-acromial distance of each subject. Exercise repetitions started with extended shoulder and flexed elbows. The initial fase was the concentric, which finished with elbows straight in front of chest. The eccentric phase was the return to initial position.

Electromyography

The electromyographic signal was collected at 2000 Hz using the Mini DTS electromyograph (Noraxon USA Inc, Scottsdale, AZ). The data was sent in real time to a computer to MyoResearch 3.10 master software (Noraxon USA, Inc., Scottsdale, AZ). The preparation of the electrode placement site followed the recommendations of *Cram's Introduction to Surface Electromyography* (Criswell, 2011)

The collected EMG data were filtered using a low pass butterworth filter of 450 Hz and another high pass of 20 Hz. After that, a smoothing root mean square (RMS) smoothing was performed with 100 milliseconds of windowing. The highest RMS value obtained from two central repetitions of the supine exercise, from the concentric and eccentric phase was used to normalize the data. The 1st and 3rd repetitions were discarded. The treatments were carried out in the MR3 Master 3.10 software environment (Noraxon USA Inc, Scottsdale, AZ).

Surface EMG over the belly of the sternocostal head of the pectoralis major:

Electrodes were placed over the belly of the sternocostal head of the pectoralis major (SPM) 4 cm from and into the axillary field. For marking the central point of the electrodes a pen was used to evidence the axillary field and from it was measured 4 cm towards the sternum (Criswell, 2011).

Surface EMG over the belly of the clavicular head of the pectoralis major:

Electrodes were placed over the belly of the clavicular head of the pectoralis major (CPM) as described by Cram and Kasman. The electrodes were positioned 4 cm below the medial third of the clavicle, parallel to the muscle fibers (Criswell, 2011).

Surface EMG over the belly of the anterior deltoid:

The electrodes were placed over the belly of the anterior deltoid (AD) in the direction between the anterior line of the acromion and the thumb, 4 cm below the clavicle (Criswell, 2011).

Surface EMG over the belly of the serratus anterior:

Electrodes were placed over the belly of the anterior serratus (SA). With the arm abducted at 90o the electrodes were placed parallel to the muscle fibers of the anterior serratus in the 3rd rib line and positioned at

the midpoint between the anterior border of the latosus muscle and the posterior border of the pectoralis major (Criswell, 2011).

Kinematic

Kinematic parameters were obtained with a digital camera (LifeCam Studio - Microsoft) with reflexive markers placed in both lateral epicondyle of the humerus, estyloid process of the ulna and in the acromion. These data were synchronized with EMG data through Myo Research 3.6 Master (Noraxon USA, Inc., Scottsdale, AZ) allowing to separate concentric and eccentric phases and articulate angles. Standardization of the exercises (Figure1).

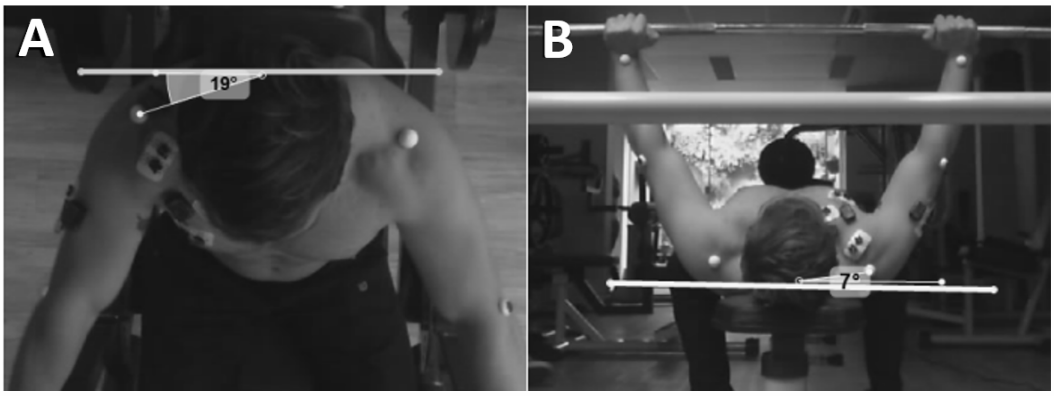

Figure 1. Kinematic analysis: A = Chest Press Lever Machine Biodelta and B = Barbell Bench Press

Statistical Analyses

The Kolmogorov-Smirnov test was applied to check the normality of the data. To compare the RMS value of each muscle between the exercises, the Student-Newman-Keuls test was used. The level of significance was set at 0.05. All analyzes were performed in software Minitab 17 (State College, Pennsylvania) and excel (Microsoft office).

Results

The normalized values in RMS percentage are shown in Tables 2 and 3 and the abduction joint mobility of the scapular cingulate in Figure 2.

The RMS muscle activation was not statistically different between the Barbell Bench Press compared to the Chest Press Lever Machine, when the volunteers used weight to perform 10 maximal repetitions (Table 2).

When the volunteers used 50% of the weight of 10 maximal repetitions, the bench press showed greater electromyographic RMS activation with statistical difference for the serratus anterior (SERR.A) and the clavicular head of pectoralis major muscles (Table 3) in relation to the chest press lever machine.

The abduction mobility of the scapular cingulate was statistically higher in the pectoral press with levers than in the free press (19.8 ° vs 7.8 °) for both weights of 10 maximal repetitions and 50% of 10 maximal repetitions (Figure 2).

Table 2. Mean and coefficient of variation of electromyographic comparison of Barbell Bench press versus Chest Press Lever Machine performed by 15 volunteers with weight equivalent to 10 RM.

	BARBELL BENCH PRESS				LEVER MACHINE			
MUSCLES	CONC. P.	CONC. M.	EXC. P.	EXC M.	P.CONC.	M.CONC.	P.EXC.	M.EXC
S.P.M	1.00 (.60)	0.64 (.59)	0.62(.61)	0.37(.66)	0.41(.67)	0.62(.61)	0.63(.60)	0.38(.63)
C.P.M	1.00(.58)	0.45(.55)	0.58(.53)	0.34(.55)	0.89(.51)	0.44(.52)	0.54(.36)	0.28(.41)
A.D	1.00(.41)	0.67(.45)	0.58(.64)	0.33(.63)	0.94(.45)	0.62(.43)	0.71(.58)	0.36(.47)
SERR.A	1.00(.65)	0.61(.63)	0.54(.78)	0.34(.83)	0.62(.42)	0.39(.47)	0.37(.49)	0.21(.65)

Percentual values root mean square normalized by the higher value of RMS of each muscle. CONC.P. = concentric peak; CONC. M. = concentric mean; EXC. P. = excentric peak; EXC. M. = excentric mean S.P.M. = sternal portion of the pectoralis major; C.P.M. = clavicular portion of the pectoralis major; A.D. = anterior portion of the deltoid; SERR.A = serratus anteiror. There was no statistical difference for none of the evaluated muscles.

Table 3. Mean and coefficient of variation of electromyographic comparison of Barbell Bench press versus Chest Press Lever Machine Biodelta performed by 15 volunteers with weight equivalent to 50% of the 10 RM.

	BARBELL BENCH PRESS				LEVER MACHINE			
MUSCLES	CONC. P.	CONC. M.	EXC. P.	EXC M.	P.CONC.	M.CONC.	P.EXC.	M.EXC
S.P.M	1.00 (.59)	0.62 (.62)	0.57(.75)	0.33(.74)	0.68(.57)	0.46(.63)	0.40(.60)	0.21(.54)
C.P.M	1.00(.48)	0.61(.49)	0.53(.67)	0.31(.56)	*0.59(.60)	*0.37(.55)	0.39(.62)	*0.19(.54)
A.D	1.00(.38)	0.67(.41)	0.49(.53)	0.28(.51)	0.75(.48)	0.49(.47)	0.49(.65)	0.25(.51)
SERR.A	1.00(.72)	0.66(.69)	0.68(.78)	0.40(.90)	*0.46(.53)	*0.30(.51)	*0.31(.54)	*0.17(.58)

Percentual values root mean square normalized by the higher value of RMS of each muscle. CONC.P. = concentric peak; CONC. M. = concentric mean; EXC. P. = excentric peak; EXC. M. = excentric mean S.P.M. = sternal portion of the pectoralis major; C.P.M. = clavicular portion of the pectoralis major; A.D. = anterior portion of the deltoid; SERR.A = serratus anteiror. * Statistically significant difference from supino with barbell (P≤0.05)

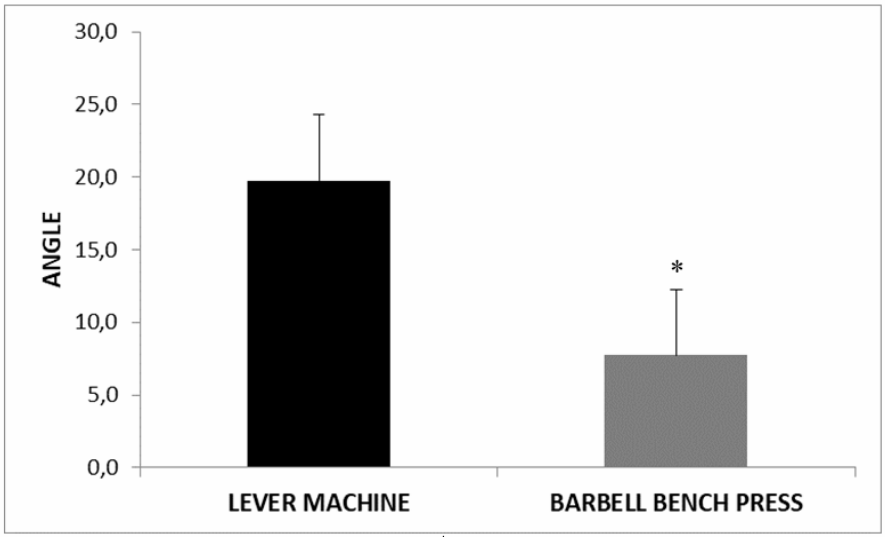

Figure 2. Mobility of the scapular cingulate during the realization of the lever machine compared to the barbell bench press. *statistically significant difference between exercises (P≤0.05).

Discussion

The present study did not present statistical difference for muscle activation between the barbell bench press exercises compared to the chest press lever machine for the condition in which the weight used in the exercises was 10 maximal repetitions. However, there was a significant difference in muscle activation when the load of 50% of 10 maximal repetitions was used. According to De Luca (de Luca, 1997) the EMG signal and the force are unstable above 80% of maximal voluntary contraction. Thus, our data with a lower percentage of weight probably resulted in a more stable EMG signal with less possibility of crosstalk. Using 50% of the weight of 10 maximal repetitions may have prevented crosstalk from adjacent muscles in our study. In this condition, statistical difference was observed for greater activation of the clavicular portion of the pectoralis major and of the anterior serratus in the barbell bench press in relation to chest press lever machine. This occurred in concentric and eccentric contractions, both peak and mean RMS (Table 3), with the peak and the concentric mean being 54 and 70 percentage points lower in the lever machine. It can be speculated that perhaps a guided exercise will generate greater joint stability and cause decrease of the activation of some muscle or muscular portion in exercises with similar movement (McCaw & Friday, 1994)

The articular mobility was 60 percent higher in the chest press lever machine than in the barbell bench press (Figure 1). This condition is probably due to the fact that in the barbell bench press the scapulae were more fixed due to the full support of the back and head in the bench. (Figure 1B). The movement of the scapular cingulate is fundamental to allow the correct alignment of the humeral head with the glenoide cavity of the scapula (Andrews, Harrelson, & Wilk, 2012). Thus, we believe that with the most fixed scapular cingulate in the barbell bench press the anterior serratus produced a greater activity, probably to try to move the scapular cingulate and allow the correct positioning of the humeral head in relation to the glenoid cavity. In our understanding, the greater freedom of movement allowed in the chest press lever machine (Figure 1A) favors a better arthrokinematics of the shoulder complex.

As seems to be consensual, (Adams et al., 2009), both free weight exercises and machine performed exercises can be efficient and the choice of one or other equipment depends on other factors to be considered as availability, risk of falls, previous experience and cognitive status.

Conclusions

With 10 maximal repetitions load the Chest Press Lever Machine presented electromyographic activation equal to the barbell bench press, suggesting training efficiency.

With a load of 50% of 10 maximal repetitions, the Chest Press Lever Machine presented lower electromyographic activation of the anterior serratus and the clavicular portion of the pectoralis major, compared to the barbell bench press, indicating better mobility and joint stability in the lever machine.

The mobility of the scapular cingulate was greater in the chest press lever machine than in the barbell bench press.

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