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The Relationship between Shoulder Prothusion and Neuromuscular Variables in Subject who Practice Strength Training

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ABSTRACT

Background: Maintaining an upright posture is an important and complex task for the human body because it involves the alignment and control of various parts of the body. The present study aimed to analyze the relationship between postural deviation of shoulder protrusion (SP) and different neuromuscular variables in subjects who practice strength training (ST).

Method: Twenty-two individuals between the ages of 18 and 45 years, and who practiced strength training, participated in the study. The individuals underwent postural assessments, using a photographic record in the sagittal and frontal planes, in which the SP level was noted. Strength was assessed via the one-repetition maximum test and flexibility was assessed by means of a goniometric test. Data were analyzed using the Pearson Correlation ($\alpha<0.05$).

Results: The present study did not find any significant relationship between SP and different neuromuscular variables in subjects practicing ST, indicating that being stronger or more flexible does not influence such deviation.

Conclusion: It is important for future studies that assess this population to include aspects in their assessment tests that are unrelated to sports and training.

Keywords: shoulder protrusion, flexibility, strength

INTRODUCTION

Body posture has individualized characteristics and is influenced by several factors (Kendall, McCreary, & Provance, 1995). In the last decade, several studies have demonstrated a high prevalence of postural alterations and back pain in various populations, and have shown that such problems are not limited to any specific profession or population (Elders & Burdorf, 2004; Ferreira et al. 2011; Siivola et al., 2004). Postural problems can range from relatively mild discomfort to severe injury (Paccini, Cyrino, & Glaner, 2007).

Shoulder protrusion (SP) is one of the best understood and investigated postural deviations. SP can be defined as a postural alteration in which, from the sagittal view in a relaxed orthostatic posture, there is anteriorization of the acromion in relation to the earlobe or an external reference (Kendall et al., 1995). One of the causes of this deviation may be related to the imbalance of strength between the protractor muscles of

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the scapula (the anterior serratus, pectoralis major, and pectoralis minor), which tend to be strong and short, and the retractor muscles of the scapula (the rhomboids and trapezius), which tend to be long and weak (Kendall et al., 1995). This imbalance can result in increased scapular protraction with consequent anteriorization of the acromion. Another possible cause for this change is that the static muscles, by maintaining constant tension and rarely relaxing, tend to shorten, whereas the dynamic muscles, by not maintaining constant contraction, tend to relax, leading to atrophy (Souchard, 2004). Thus, if the anterior musculature of the body experiences this shortening, it can curve the head and back toward the front, causing the shoulders to move forward along with them.

Studies indicate a high prevalence of postural deviations in the general population, with SP being one of the most common deviations. In a study by Griegel-Morris et al. (1992), the prevalence of SP was 66% on the left side and 73% on the right side in 88 healthy subjects. In relation to subjects practicing strength training (ST), Barroni et al. (2010) noted 87.6% of men and 77.2% of women with this deviation.

Although the prevalence of SP is common, studies regarding this condition in subjects who practice ST are limited. Paccini et al. (2007) performed a 16-week ST intervention with 21 young women to assess possible postural changes. At the end of the study, postural improvements were found only in the head/neck region and the heels from the dorsal view, and in the abdominal region from the sagittal view. No alteration was found to be associated with SP. Another study aimed to assess the association of postural changes with the type and volume of ST of the abductor muscles and of the horizontal adductors of the shoulders (Furlanetto, Gotze Candotti, 2014). The authors did not investigate how postural deviations might be associated with practice time and training volume. However, neither of these studies reported data on muscular strength or on the level of joint amplitude of the subjects, nor whether these variables could influence postural deviation.

Thus, in view of this gap in scientific understanding, the present study aimed to relate SP postural deviation with neuromuscular variables of maximum strength and flexibility in subjects practicing ST.

MATERIALS AND METHODS

The sample consisted of 22 men, with a mean age of 28.9 ± 6.9 years [18 to 42 years old], mean body weight of 77.2 ± 11.1 kg, and mean height of 1.75 ± 0.08 m. The sample was select by convenience. The subjects regularly practiced ST (4-6 time per week) with a goal of achieving muscle hypertrophy, over a minimum of 6 months. These individuals were invited by the researcher to voluntarily participate in the study. All participants signed the Informed Consent agreement, and the study was approved by the Research Ethics Committee (Nº 636.713). All assessments were carried out in a large, well-lit gym, with an air-conditioned environment (23º C).

PROCEDURES

The study was developed in three stages: (1) anthropometric assessment, (2) assessment of posture and flexibility, and (3) assessment of maximum strength (test and retest). All the assessment stages occurred in the same day, and the subjects were instructed to maintain their training routines during this period. To evaluate all men we needed over a period of 30 days.

Shoulder Protrusion Assessment

For postural assessment, two different types of protocols were used, both performed by computerized photogrammetry: assessment of the degree of SP and assessment of the relative distance between the scapulae. The individuals who were assessed maintained an orthostatic position and three photographs were taken in the posterior, right, and left lateral planes. The photographic record was taken with a Nikon® brand camera. The subject was positioned with a bare back, barefoot, and in an orthostatic position perpendicular to a wall. Subjects were asked to maintain their habitual and natural posture when photos were taken. Fixed reference points were determined with adhesive markers on the spinous process of the seventh cervical vertebra (C7), the medial lateral point of the acromion, the medial border of the humerus, and the lower edges of the scapulae. The camera was positioned 2 meters from the subject and 0.90 cm from the ground, on a tripod. The position of the feet was marked on a pattern arranged on the floor as a way of standardizing the position and distance of the feet. The Braun and Amundson protocol, which traces the angular measure characterized by an angle formed by a line in the sagittal plane connecting C7 to the lateral midpoint of the acromion, and another line

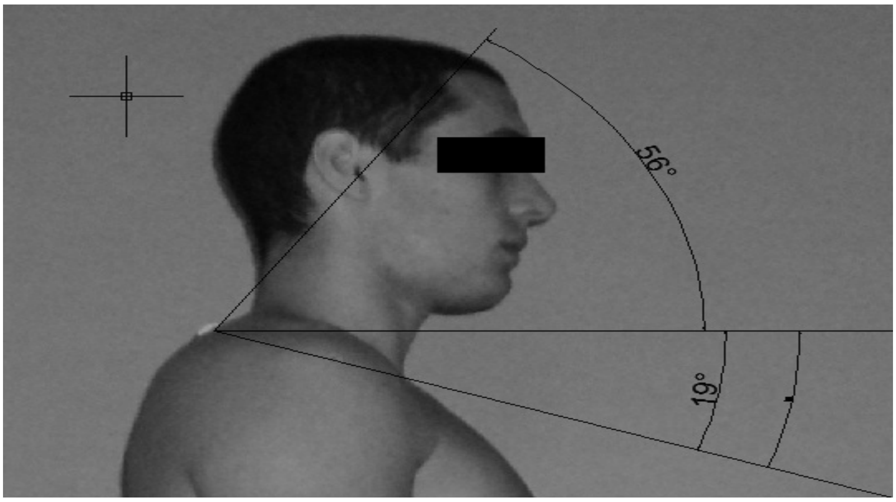

Figure 1. Assessment of the angle of shoulder protrusion (inferior angle)

parallel to the horizon (Braun & Amundson 1989). According to this measure, the lower the value, the greater the SP (**Figure 1**).

In order to assess the relative distance between the scapulae, the anatomical points of the inferior edge of the scapula were identified and adhesive markers were fixed to them, with another marker placed on the spinal process of the thoracic vertebrae (TV) located between the scapulae. The difference between the distance from the lower edge to the spinous process of the thoracic vertebra was calculated bilaterally, and later, these distances were added, as well as the distance between the acromia. The relative distance between the scapulae was determined by the ratio of the interscapular distance to the interacromial distance, and relativized according to percentages (**Figure 2**):

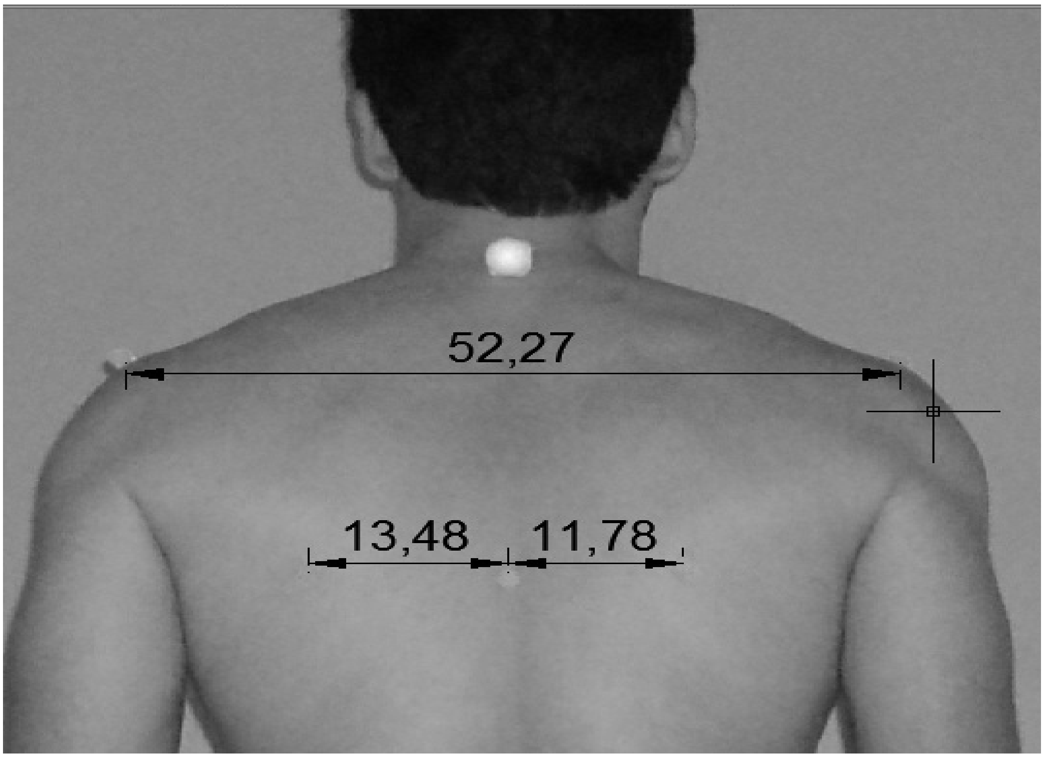

Figure 2. Interscapular and interacromial distance

[relative distance (%) = (inferior edge of the right scapula to TV + inferior edge of the left scapula to TV) / distance between acromia * 100].

All the data were analyzed and considered by a researcher who did not participate in data collection, and the analysis of the photos was performed with AutoCAD 2010 (Autodesk Inc., San Rafael, CA, USA). A known measurement (adhesive tape with 20 cm marking) was fixed on the wall as a reference for calibration.

Neuromuscular Assessment

Joint amplitude

Assessment of shoulder flexibility was performed via four goniometric analysis of the movements of shoulders: adduction of the (1) left and (2) right side and horizontal abduction of the (1) left and (2) right. For this procedure we used a Fibra Cirúrgica® brand goniometer, according to Kendall's protocol (Kendall et al. 1995). The subject was positioned standing while the assessor positioned himself lateral to the subject, and the subject was asked to flex his shoulder to 90º. The goniometer was positioned with the fulcrum above the midpoint of the subject's shoulder, and the zero point was determined on a degree scale. The fixed arm of the goniometer was positioned parallel to the sagittal plane and the movable arm was positioned parallel to the humerus. After the assessment, the patient was instructed to perform a horizontal adduction of one shoulder to the maximum active amplitude point, and was not assisted in any way other than by the contraction of the agonist muscles. The same strategy was followed on the opposite side and for the amplitude of horizontal abduction. This procedure was performed three times, and the highest value was used.

Assessment of maximum strength

The strength of the adductor and horizontal abductor muscles of the shoulder was assessed using the one-repetition maximum test (1RM) through bench-pressing and rowing exercises with a low-sitting pulley (towards the shoulder line), both performed using equipment from *Ajustmaq* (Caxias do Sul, Brazil). The test followed the protocol suggested by Brown and Weir (2001) and applied by Tiggemann et al. (2010), where the subject, after performing brief, low-intensity aerobic and joint warm-ups, performs a series of warm-ups on the equipment with progressive increases in weight, performing two repetitions with loads of 40, 60, and 80% of estimated 1RM. Thereafter, by trial and error, with progressive increases in weight, the subject performed only one repetition until the maximum weight for adequate performance (standard amplitude and rhythm) of a repetition was found. A maximum of five attempts was necessary in each exercise, with an interval of three to five minutes between attempts. After a period of 5 to 10 days, the test was performed again for both exercises (retest), in order to guarantee better reliability of the results (intraclass coefficient, $r > 0.94$). The values of the retest phase were used for the analysis.

In addition to the absolute values of maximum strength for each exercise, the ratio between the strengths, that is, the values of 1RM (kg) from the bench press divided by the rowing exercise was used, with the value relativized as a percentage. This strategy reveals the relationship between opposing muscle forces (agonists/antagonists) and aims to identify possible imbalances between them.

STATISTICAL ANALYSIS

The results of the characterization were processed using descriptive statistics, with mean, standard deviation, and frequency distribution. The correlation between the strength tests (test and retest) was conducted via intraclass correlation. We have realized the Shapiro-Wilk test before performed the correlations of Pearson. The association between posture and neuromuscular variables was evaluated using Pearson's correlation, and a significance level of $p < 0.05$ was adopted. SPSS 21.0 (IBM, Armonk, NY, USA) was used for the statistical analyses.

RESULTS

The descriptive values of the postural and neuromuscular variables are shown in **Table 1**.

Table 1. Mean, standard deviation, and minimum and maximum variables for the variables, protrusion angle, relative distance of scapulae, maximal strength on the bench press and rowing exercises, and ratio of strength to joint amplitude. 1RM = one-repetition maximum

	Mean	Standard deviation	Minimum	Maximum
1RM bench press (kg)	78.68	18.34	44.00	128.00
1RM pull exercise (kg)	78.43	11.14	54.73	100.83
Ratio press/pull (%)	99.84	14.61	68.20	126.95
Amplitude of right adduction (°)	27.41	5.92	20.00	45.00
Amplitude of left adduction (°)	27.50	4.04	22.00	36.00
Amplitude of right abduction (°)	96.86	10.29	86.00	128.00
Amplitude of left abduction (°)	96.18	9.24	86.00	122.00
Angle of protrusion - right (°)	37.27	15.19	13.00	66.00
Angle of protrusion - left (°)	39.41	12.23	16.00	66.00
Relative distance of the scapulae (%)	54.71	5.26	46.54	67.90

No significant correlation ($p > 0.05$) was found between the SP variables and the neuromuscular variables (**Table 2**).

Table 2. Correlation values (r) between neuromuscular variables and shoulder protrusion (SP). 1RM = one-repetition maximum

	Relative distance of scapulae	Angle of right SP	Angle of left SP
1RM Press	0.105	-0.021	-0.159
1RM Pull	0.351	-0.107	-0.070
Ratio of press/pull	-0.161	0.102	-0.144
Amplitude of right adduction	-0.187	-0.169	-0.068
Amplitude of left adduction	-0.259	-0.213	0.181
Amplitude of right abduction	0.011	0.298	0.247
Amplitude of left abduction	0.026	0.032	0.190

DISCUSSION

In this study, no relationship was found between the level of SP and flexibility and maximum strength. Our study did not aim to identify the prevalence of SP, but rather the possible relationships between neuromuscular variables and the level of SP. These findings can be explained by the fact that SP does not have a specific consequence, but can be caused by several factors that develop throughout life, such as through work activities, daily life activities, and genetic factors (Kendall et al., 1995). Changing a misaligned posture is difficult and requires extensive assessment and treatment, which may include exercises to increase the range of motion, stability, muscle strength, and endurance as well as training and the introduction of postural orientations. Factors related to daily life or work may have a greater influence on SP than neuromuscular factors, depending on the volume and intensity with which they are performed.

Postural alteration can be caused by an imbalance in the musculature that encompasses the particular joint complex, both on the level of agonist muscle strength and on the level of flexibility of antagonistic muscles [1]. The literature also suggests that unbalanced ST is one of the factors that cause postural deviations, which can have a positive impact on strength, endurance and flexibility, factors that contribute to the improvement of functional capacity and of posture, besides contributing to a reduction of the risk factors for low back pain.

Flexibility, or muscle length, is another important variable in adopting a balanced posture. Lee et al. (2015) found a strong negative correlation between the length of the pectoralis minor muscle and scapular abduction (i.e. SP). The authors measured the distance between the origin and insertion of the pectoralis minor muscle as a measure of muscle length. The same authors also found a positive and moderate correlation in relation to SP and thoracic kyphosis, and adverse posterior tension in the shoulders, through the length of the external rotators of the shoulders and tension in the posterior part of the joint capsule. In another study, Borstad (2006) found a strong correlation between shorter pectoral length and postural changes of the scapula.

Another aspect that has received considerable attention in the scientific literature concerns the ratios that exist between the strength of agonist and antagonist muscles for certain joints (Croisier et al., 2008). From these ratios, we can attempt to find values that may indicate which index could be more associated with muscle injuries or postural deviations. In a study by Croisier et al. (2008), it was found that the incidence of injuries to the hamstring muscles in professional soccer players was higher (16.5 vs. 4.1%) in subjects with a knee flexor strength ratio of less than 47% in relation to the extensors. In a study by Stickley et al. (2008) involving young female volleyball players, the prevalence of shoulder injuries among subjects with a greater or lesser ratio between the internal and external rotator muscles of the shoulders was not significantly different ($p > 0.05$). In our study, no prevalence was found between the strength ratios of the adductor muscles and horizontal shoulder abductors, and this result possibly indicates that balance between strengths is not a determinant in the emergence of SP.

Wong et al. (2010) reported that SP is associated with several factors, such as a relaxed posture associated with an increase in kyphosis and cervical lordosis, as well as abduction and inferior rotation of scapulae. In addition, muscle imbalances may also be factors in these misalignments. Lee et al. (2015) associated SP with insufficiency in the stabilizing strength of the inferior trapezius and serratus, as well as shortening of the pectoralis minor, which may also be considered a predisposing factor.

It is important to note that practitioners of physical and sports activities may acquire some postural deviation as a result of their activities. Baroni et al. (2010) assessed the postural patterns of men and women practicing bodybuilding and identified increases in curvature or rectification in the cervical, thoracic, and lumbar regions of the vertebral column. In addition, 48.0% presented a scoliotic attitude, and in 37.0%, gibbosity was observed. Oyama et al. analyzed athletes whose sports frequently used movements above the head, such as tennis players, volleyball players, and baseball pitchers. Alterations in the protrusion of the scapulae were verified. In these studies, different types of postural deviations were observed in different age groups and contexts, and there is no conclusive evidence about the factors that generate these deviations.

The relationship between SP and the influence of muscle tension in the pectoralis minor muscle was observed by Wong et al. (2010). In this study, the authors found that soft tissue movement directed to the pectoralis minor muscle provided an improvement in postures involving SP. The authors also did not rule out the influence of possible tension in the pectoralis major muscle, since in order to reach the pectoralis minor muscle, it is necessary to engage the pectoralis major muscle, which is more superficial.

A practical application of the results suggests that the level of strength and/or flexibility does not influence SP, however, this does not mean that ST does not need a balance in working the agonist/antagonist muscle groups, since our investigation was based on the study of a single postural deviation (SP) and a specific population. Thus, it is important to develop further studies on this subject, taking into account other factors not investigated in this study, such as work activity, daily life activity, and individual genetic factors, as well as the influence of resting muscle length, in determining a static postural profile.

CONCLUSION

The present study did not find any significant relationship between SP and different neuromuscular variables in subjects practicing ST, indicating that being stronger or more flexible does not influence such deviation. Thus, it is important for future studies that assess this population to include aspects in their assessment tests that are unrelated to sports and training.

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Disclosure statement

No potential conflict of interest was reported by the authors.

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