A Review of Resistance Exercise and Posture Realignment

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ABSTRACT

Exercise has been promoted in an attempt to correct postural deviations, such as excessive lumbar lordosis, scoliosis, kyphosis, and abducted scapulae. One of the assumed causes of these conditions is a weak and lengthened agonist muscle group combined with a strong and tight antagonist muscle group. Strengthening and stretching exercises have been prescribed accordingly. It is implied that strengthening exercises will encourage adaptive shortening of the muscle-tendon length, reposition skeletal segments, and produce static posture realignment. A review of the literature has found a lack of reliable, valid data collected in controlled settings to support the contention that exercise will correct existing postural deviations. Likewise, objective data to indicate that exercise will lead to postural deviations are lacking. It is likely that exercise programs are of insufficient duration and frequency to induce adaptive changes in muscle-tendon length. Additionally, any adaptations from restricted range-of-movement exercise would likely be offset by daily living activities that frequently require the body segments to go through full ranges of motion.

Key Words: strength, adaptive muscle shortening

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Introduction

Static posture refers to the alignment and maintenance of body segments in certain positions, such as standing, lying, or sitting (20). Considerable deviations from optimal posture may be aesthetically unpleasant, adversely influence muscle efficiency, and predispose individuals to musculoskeletal or neurological pathologic conditions (22).

It has been stated that if body segments are held out of alignment for extended periods, the muscles will rest in a shortened or lengthened position (4) and over time adaptive shortening or lengthening may result (22). Adaptive shortened muscles are described as tight and strong, maintaining the opposing muscles in a lengthened and weakened position (17). Such changes in resting muscle length may influence posture alignment.

It has also been postulated that adaptive muscle shortening may result from overuse of a muscle, particularly in a shortened range (11, 16, 24, 31). At times, claims are made that a muscular imbalance from excessively working one muscle group will lead to postural deterioration. An example is when the chest muscles are overworked and there is an imbalance with the back muscles, allegedly leading to poor, rounded posture (6).

Activity Type and Posture

There is a notion that certain activities or sports may predispose athletes to developing posture deviations; however, valid, objective data are lacking. In a cross-sectional study (29), the sporting status of 181 men aged 17–20 years was determined by an activity questionnaire. Ninety-eight were classified as soccer, Gaelic football, or rugby players, whereas the remaining 83 were classified as ''other sportsmen'' (track athletes, gymnasts, volleyballers, basketballers, swimmers, and racket sport players). Posture was visually (subjectively) rated according to a series of 5 drawings for a score of 1 unit (severe deviation) to 5 units (ideal posture) for each of the conditions: kyphosis, lordosis, scoliosis, and abducted scapulae (rounded shoulders). The validity of this procedure (i.e., comparison with an accurate and accepted standard such as measurements from radiographs) was not reported. Reliability trials conducted with 20 subjects found that 69% of the scores were within 0.5 unit, whereas 99% of the scores were within 1 unit. It was found that there was a significantly higher incidence of lordosis in the soccer and football players (mean, 3.54) compared with the other sportsmen (mean, 4.05). It was proposed that tightness of the quadriceps from strengthening associated with kicking might have influenced pelvic tilt and lordosis. Given the unreported validity and the fact that the dif-

ference in mean score for lordosis between the groups is within the error measurement for 30% of the reliability subjects, these findings are questionable. A second part of this study (29) included a prospective investigation throughout 21 months (2 playing seasons) on 11 Gaelic football and soccer players and 10 controls. Lordosis was assessed by positioning markers on the subjects, photographing, and then determining the angle (Wickens-Kiphuth procedure). A significant change from 165.9 (mean value) to 161.9° was found for the soccer and football players but not for the control subjects. An increase in this angle denoted an increase in lordosis. This longitudinal study also has the limitation of not establishing or reporting validity and additionally not reporting reliability. Since any postural changes reported are usually small, high reliability is essential to ensure that the changes detected are not just due to measurement error.

Muscular Strength and Posture

Strengthening exercises are often prescribed in an attempt to correct postural deviations. The assumption is that strengthening a lengthened weak muscle group will result in adaptive shortening and, along with stretching the short antagonist, repositioning of a skeletal segment (17).

Strengthening exercises have been prescribed in an attempt to correct a number of postural abnormalities: scoliosis, kyphosis, excessive lumbar lordosis, and abducted scapulae (4, 14, 17, 24, 33). For a condition such as abducted scapulae, the assumption is that the trapezius and rhomboids are weak and the anterior thoracic muscles (pectoralis major and minor) are tight; thus, the posterior muscles need to be strengthened and the anterior muscles stretched to reposition the scapulae. One cause of excessive lumbar lordosis is purported to be due to tight erector spinae and hip flexor muscles and weak abdominal and hip extensor muscles. To correct this condition, the erector spinae and hip flexor muscles allegedly need to be stretched while the abdominal and hip extensor muscles are strengthened to produce greater posterior pelvic tilt to reduce the lordosis.

Does an increase in muscular strength allow a better posture to be held? If this were the case, it would not be unreasonable to expect that individuals with poor posture had weak muscles; however, this is not the general finding. There have been some studies investigating the relationship between lumbar posture and strength. An early study (9) examined 31 women (age range, 19–22 years) subjectively rated as having exaggerated pelvic and lumbar posture. It was concluded after radiographic analysis of the lumbar spine posture that there was no significant relationship between lumbar lordosis and isometric strength of the trunk flexors and extensors and hip flexors and extensors (reliability data were not reported). Dynamic tests

of abdominal strength have also been used. In a study (27) that included 8 men and 23 women (mean age, 24 years), abdominal strength was assessed by the supine straight leg lowering test as described by Kendall et al. (17). This test determined the angle between the lower limbs and horizontal when the subject could no longer keep the low back and pelvis firmly against the surface. This test is commonly used, but its validity has not been established. A flexible ruler or curve was used to determine the contour of the lordotic curve, a method that reportedly had been previously validated against radiographic images ($r = 0.87$, $n = 8$). Intratester reliability for the measures of lordosis was considered high (0.90) but not for the abdominal muscle strength test (0.71). It was found that lumbar lordosis was not significantly correlated with the subjects' performance on the supine straight leg lowering test. Likewise, another study (32), examining 90 healthy older adults (45 men; mean age, 55 years; 45 women; mean age, 59 years), demonstrated that abdominal muscle strength (supine straight leg lowering test) was not significantly associated with lumbar lordosis. A flexible ruler was used to determine the standing lumbar curve angle. Intratester reliability was assessed using intraclass correlation coefficients (ICCs). The ICCs for the measures of lordosis and abdominal strength were determined in a pilot study of 10 younger subjects and found to be 0.82 and 0.93, respectively. The intratester reliability for abdominal strength was higher than the value of 0.71 found in the previous study (27).

Holding a posture for a long period requires constant low-level neural input to maintain a muscular contraction of the postural muscles (if indeed muscle activity is required). In light of this knowledge, it would seem that muscular endurance would be a more appropriate physical quality than maximal strength in the maintenance of "correct" posture (18). A recent study (19) investigated the association between abdominal muscle endurance and lumbar posture. No significant relationship was detected. However, the study was flawed by methodological limitations. Lumbar posture of 23 young elite gymnasts and 28 controls was subjectively assessed as lordotic, sway-back, or ideal. Isometric abdominal muscle endurance was measured as the time subjects could maintain certain supine postures while contacting their abdominals to press their lower back against a pressure cushion. Reliability and validity for the tests were not reported.

Muscle Length and Posture

If strength is not the primary determinant of posture, is resting muscle length? Muscle length is often approximated by measures of joint range of motion (ROM). The assumption is that muscle length is the limiting factor to the ROM but other structures, such as connective or bone tissue, may in fact be the limit-

ing components. One investigation (7) examined the relationship between abducted scapulae and the "tightness" of the pectoral muscles in 124 women (mean age, 20 years) using exterior anthropometric measures. The resting scapulae position in standing, relaxed subjects was determined by measuring the distance between the scapulae and the angle made by the outer tip of the shoulder with the frontal plane line intersecting the sternum (comparison with measurements from radiographic images was not attempted). An angle of 180° corresponded to the shoulder being in a straight line with the sternum in the frontal plane. Angles less than 180° corresponded to the shoulder being anterior to the sternum. Shoulder tightness was assessed by determining the active ROM of horizontal shoulder extension while standing and the passive ROM of horizontal shoulder extension while supine. Reliability correlation coefficients (Pearson) ranged from 0.80 to 0.89 for all measurements. It was found that the resting distance between the scapulae was not significantly associated with either left- or right-side active shoulder horizontal extension or with passive, supine lying shoulder horizontal extension for the left and right shoulders.

Another study (9) used a Leighton flexometer to determine the ROM of trunk flexion and extension and hip extension of women (reliability was not reported). No significant correlations with lumbar lordosis, as determined from radiographs, were detected.

It has been found (32) that an indirect measure of abdominal muscle length was significantly associated with lumbar lordosis for both older men and women ($r = 0.49$ and 0.64, respectively). Passive lumbar extension was used to indicate abdominal muscle length. Subjects lay in a prone position and were instructed to push upward into a hyperextended position until pelvis movement was detected. No validity was provided for this test. The reported intratrial reliability as determined by an ICC was 0.96. The length of the back extensor muscles was also indirectly measured using a flexible ruler with subjects in a seated forward flexed position (validity not provided). It was found that back muscle length was not significantly associated with lumbar lordosis for men or women. The intratrial reliability for this test was 0.90.

Many studies (particular the early ones) have looked at the relationship with only one variable at a time rather than a combination of strength and flexibility variables. A multivariate analysis has been performed (32), but this did not lend considerable support to the notion that lumbar lordosis is significantly associated with combined abdominal muscular weakness and tight erector spinae and hip flexors. Analysis did not reveal a multivariate model for women. For men, the multivariate analysis indicated that standing lumbar lordosis was weakly associated with length of abdominals (not abdominal weakness) and 1-joint hip

flexor muscle length (but not back muscle length) and physical activity level ($R^2 = 0.38$). The authors of this study concluded that the use of abdominal muscle strengthening exercises or stretching exercises of the back and 1-joint hip flexors to correct faulty posture should be questioned.

Adaptive Shortening and Immobilization

Data on immobilization by bracing, taping, or casting human body segments and subsequent adaptations of muscle-tendon length are sparse. Adaptive change in muscle fiber length has been demonstrated in animals using immobilization. A reduction in soleus muscle fiber length in cats immobilized by plaster cast for 4 weeks in a shortened position (ankle plantar flexed) has been shown (26). Conversely, an increase in fiber length in muscles immobilized in a lengthened position was also demonstrated. The mechanism for the change in fiber length was found to be either an increase or decrease in sarcomere numbers. It has further been shown (31) that the reduction in sarcomere number is even greater when a muscle is stimulated to contract while immobilized in a shortened position.

It has been suggested (13) that sarcomere number is regulated in such a way that "each sarcomere is near the optimum length on the active length tension curve at the joint position where most force is exerted on the fiber attachment." Therefore, fibers made to contract in a shortened position often enough should decrease in length by reducing sarcomere numbers to maintain optimal myofilament overlap for force production, making the working length of a muscle an important regulator of serial sarcomere number. It may be queried whether typical human exercise programs place the muscles in a shortened position for sufficient duration for adaptations to occur.

It should be pointed out that a change in sarcomere number or muscle fiber length might not be proportional to changes in the whole muscle-tendon length. This is crucial when considering the potential for postural realignment through adaptive changes. There may be no great change in muscle fiber length but a considerable change in tendon length. Results from animal research indicated that muscle-tendon shortening of rabbit soleus as a result of immobilization was primarily (73%) because of adaptations of the tendon rest length (12).

It would appear that immobilization can produce adaptive changes in muscle-tendon length. In relation to immobilization of human body segments to achieve postural realignment, there are 2 potential difficulties. It may not be practical for an individual to wear a brace or taping for a considerable period. The other potential problem is once the immobilization is ceased what prevents the muscle-tendon from returning to its original length? If an individual still has the ability to move the body segment throughout its full ROM dur-

ing daily activities, the ROM the muscle is subjected to would be counterproductive to the attempt to shorten the muscle. Support for this notion comes from the finding of the rapid readjustment of cat soleus muscle fiber length to normal after 4 weeks of remobilization (26). These muscle fibers had previously been shortened by 4 weeks of immobilization preceding the remobilization.

Prospective Intervention Studies

The most potent evidence for the effectiveness of "corrective" exercises for postural deviations is prospective intervention studies. A major issue is the reliability of the measure of resting skeletal alignment. Any detected postural realignment must be greater than the measurement error range to be conclusive. Often, correlation coefficients are reported as the index of reliability. A more complete picture of reliability is generated when the *SEM* is also provided (2, 25). The *SEM* has not been commonly reported. There have been a few prospective studies on the effectiveness of exercise on posture realignment associated with kyphosis, scoliosis, and lordosis. One study has looked at the influence of resistance exercise on resting elbow angle (10). There has also been a prospective study (28) on the effectiveness of "corrective" exercise and abducted scapulae.

A study was conducted to test the hypothesis that by increasing back extensor strength with exercise, kyphotic deformities would be reduced or their progression attenuated (15). Subjects were healthy, estrogen-deficient women between the age of 49 and 65 years. The exercise group was composed of 32 subjects and another group of 28 subjects served as the control. Maximum isometric prone back extension was determined with a dynamometer. The reliability of this test was not reported. The degree of thoracic kyphosis and lumbar lordosis was determined from radiographic images. Intraexaminer variability was 2.2%. The exercise prescribed consisted of prone back extension with a mass equal to 30% of the maximal isometric strength (maximal mass was set at 22.7 kg) 10 times 5 days per week. Strength was tested every 4 weeks for 2 years. The exercise group increased strength significantly more than the control. Before and after the 2 years, there was no significant difference in radiographic measurements between the groups except for the change in lumbar lordosis, which was smaller in the exercise group (mean, $-2.2°$) than in the control group (mean, $2.0°$). This conflicts with the notion that strengthening exercises can functionally shorten muscles. The prone back extension exercise did not increase lumbar lordosis as would be argued with stronger and "tighter" lower erector spinae muscles.

It has been purported that strengthening on its own may not be effective in postural correction unless the antagonist is also stretched (21). The effect of a combination of stretching and strengthening exercises on lumbar lordosis has been investigated (1). A flexible ruler was used to determine the degree of lumbar lordosis. Hip flexion ROM was measured with a goniometer, and the modified Schober test was used to measure lumbar flexion ROM. The experimental group was composed of 9 men selected because of an increased lumbar lordosis as determined from preliminary measures. The control group of 9 men had "average" lordosis. The ICCs for intratester reliability for lumbar lordosis for the experimental and control groups were 0.72 and 0.87, respectively. The stretching of the lumbar spine (seated hip flexion) and hip flexor muscles (lunge) was performed 3 times for 30 seconds. Curl-up exercises with resistance were used to strengthen the trunk flexors. The hip extensors were strengthened by resisted prone hyperextension. The exercises were performed 3 times per week for 4 weeks. The exercise group significantly decreased lordosis (mean, 46.26–40.89°), and there was no significant change in the control group. There was also no significant difference in hip or lumbar flexion. Since abdominal or hip extension strength was not monitored or recorded, it is unclear what was actually responsible for any change. Also, given the moderate correlation coefficient for the lumbar lordosis measure (particularly for the experimental group), along with the unreported *SEM*, this study is open to criticism.

A study in 1994 (8) compared 3 groups, exercise ($n = 10$), exercise with bracing ($n = 8$), and exercise with electrical stimulation ($n = 8$), for changes in idiopathic scoliosis. No control group was incorporated, and details of the exercises were not provided. The subjects were between 6 and 16 years of age. The degree of scoliosis was determined from moiré measurements. This involved an image of the body's contour generated by light beamed through a special screen. The correlations of this method with measurements from radiographs have been reported to be between 0.60 and 0.96; thus, the validity is questionable. No reliability data were reported. The subjects were reassessed 3 months later. All groups significantly decreased scoliosis (mean improvement of 3.6°), but no significant difference was detected between groups, possibly because of the small sample sizes. The duration of the study may not have been sufficient for large differences to occur.

The effectiveness of nonoperative treatments for idiopathic scoliosis has also been investigated by a meta-analysis of 20 studies (23). The number of patients managed with bracing, lateral electrical surface stimulation, or observation (control) were 1,459, 322, and 129, respectively. An exercise group was not included. It is unlikely that conventional exercises can isolate the specific region that requires attention. This is probably better achieved with electrical stimulation of the paraspinal musculature on the convex side of the major

scoliotic curve (usually during sleep). It could be reasoned that the electrical stimulation is intended to "overwork" the muscles and lead to adaptive shortening, which theoretically could correct the lateral curve. For the meta-analysis, failure of any treatment was considered as a progression of the scoliotic curve. It is generally realized that nonoperative treatments aim to prevent progression of the curve rather than complete correction (5). The results of the analysis demonstrated that bracing for 23 hours per day was significantly more effective at halting the curve than electrical stimulation or no treatment. Bracing in this instance involves immobilization combined with pressure pads applying "corrective forces." It would be interesting to look at any follow-up data months or years after the treatment to determine curve progression once "normal" activity was resumed.

In a review of intervention programs for scoliosis and kyphosis (30), doubt was cast on the usefulness of exercises to correct these postural deviations. It was suggested that the forces generated by corrective exercise are usually low in amplitude, frequency, and duration and therefore not sufficient to promote a permanent change in muscle length. A possible benefit of an exercise program may be to re-educate the patient to be able to adopt more optimal posture during daily activities. In turn, this may re-educate the muscles and place them in a better position for long periods, which may induce a change in muscle. This is somewhat related to the Alexander principle (3), which involves the enhancement of proprioceptive awareness of the body and inhibition of "inappropriate" muscle activity to establish certain postures and movement patterns. Unfortunately, there are a lack of objective data from controlled studies evaluating the effectiveness of this method for posture realignment.

With regard to the possible static posture adaptations from exercise, the vertebral column has been the most investigated. Only one study was located that looked at a joint in the limbs (10). Groups of 15 men (mean age, 20 years) performed 6 weeks of daily maximal isometric exercise (elbow flexed at 90°, 2 times for 6 seconds) or twice-weekly isotonic progressive resistance exercises (2 sets: 50% 10 repetitions maximum and 100% 10 repetitions maximum) using either full or partial (middle 50°) ROM. The result revealed no significant changes in elbow angle during quiet standing as determined photographically (reliability not reported). The exercise programs were of low volume and short training duration. The author contended that the time spent in static or limited ROM is a critical factor in adaptive shortening. Full ROM during daily living is probably achieved frequently and is not offset by the brief time spent in a shortened position while exercising.

A very recent study (28) investigated the influence of a 6-week strengthening and stretching program on scapula posture of 20 asymptomatic subjects with abducted scapulae. Subjects were considered to possess abducted scapulae if the shoulder joint was clearly anterior to a plumb line aligned with the ear lobe. The mean age of the subjects was 30 years and consisted of 9 men and 11 women. Scapula position and orientation were determined by a computerized 3-dimensional electromechanical digitizer (Metrecom). This device used a linkage arm with position senses and a probe tip. The probe was placed on landmarks on the scapula and vertebral column and captured location coordinate data. This information was used to define scapula position and orientation. The reliability of the Metrecom was determined by measurements taken on 14 subjects at least 7 days apart. The average ICC and SEM for measurements defining scapula position and orientation were 0.85 and 1.4°, respectively. The validity of the device was not reported.

Theraband rubber tubing was used to perform strengthening exercises for the scapular retractors and elevators and for the shoulder abductors and external rotators. Exercises were conducted 3 times per week. One set of 10 repetitions for one session was conducted in the first 2 weeks and 5 more repetitions were added every week. No strength measure of the scapular retractors was reported. It is unclear as to how much the exercise program influenced the strength of the retractors. The stretching consisted of bilateral horizontal shoulder extension. The stretch was performed 10 times for 10 seconds, adding 5 more repetitions every 2 weeks. No measures of flexibility were reported. After the 6 weeks, no change in scapula resting posture was noted. The findings of this relatively short-term study question the effectiveness of corrective exercises for abducted scapulae.

Conclusion

Future research should address the limitations identified in some of the studies. Given the available evidence, it is questionable as to whether resistance training alone will produce an adaptive shortening of a muscle and hence elicit postural changes. Even if the tight agonist is lengthened by a stretching program, there is minimal evidence to suggest that resistance training of the antagonist will cause adaptive shortening and a subsequent change in static posture. It appears that the frequency and duration of exercise programs are inefficient to produce adaptive shortening of muscles. Even if individuals could exercise long enough in a restricted ROM, any potential length adaptations would probably be offset by daily living activities that often require full ROM.

Practical Applications

Based on the review of existing literature, it is inadvisable to strongly promote strengthening exercises to

correct postural malalignments, such as abducted scapulae, excessive lumbar lordosis, scoliosis, or kyphosis. Furthermore, the fear of developing static postural deviations from exercising is not supported by objective data.

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Resistance exercise is any form of exercise that forces your skeletal muscles (not the involuntary muscles of your heart, lungs, etc.) to contract. An external resistance (such as heavy weights) is used to cause the contractions, and those contractions lead to increases in muscular mass, strength, endurance and tone. What can you use for that external resistance? Why, anything you want! You can use dumbbells, barbells, kettlebells, resistance bands, your body weight, bottles of water, bricks -- the list goes on and on! As long as the weight causes muscular contractions, it counts as resistance exercise. Types of Resistance Exercise. There are three basic types of resistance exercises: Bodyweight -- This uses only your body weight to force your muscles to contract. Posture training exercises that will take you to the next level. Learn about how to overcome kyphosis and other types of sagging. Posture-related back pain is often caused by the strength-to-flexibility ratio between the opposing muscle groups â€" all over your body â€" that hold you upright. Add to this the fact that in every area of the spine unique anatomical mechanisms are at work, and you may agree with me that achieving good posture requires technique.ï»¿ï»¿ Below are the basics on posture. The ideas presented here may help you correct yours with exercise and training. 1. Bring Your Head Over Your Neck and Shoulders. Hrysomallis C, Goodman C. A review of resistance exercise and posture realignment. J Strength Cond Res. 2001;15:385â€"390. Ihara H, Nakayama A. Dynamic joint control training for knee ligament injuries. Am J Sports Med. 1986;14:309â€"315. Janda V. On the concept of postural muscles and posture in man. Aust J Physiother. 1983;29:83â€"84. Janda V. Some aspects of extracranial causes of facial pain. J Prosthet Dent. 1986;56:484â€"487. Kelly BT, Kadrmas WR, Speer KP.