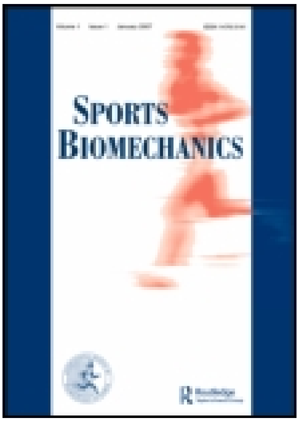

Sports Biomechanics
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/rspb20

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Published online: 06 Feb 2013.

To cite this article: Kenji Doma, Glen B. Deakin & Kevin F. Ness (2013) Kinematic and electromyographic comparisons between chin-ups and lat-pull down exercises, Sports Biomechanics, 12:3, 302-313, DOI: 10.1080/14763141.2012.760204

To link to this article: http://dx.doi.org/10.1080/14763141.2012.760204

Sports Biomechanics, 2013
Vol. 12, No. 3, 302–313, http://dx.doi.org/10.1080/14763141.2012.760204

Kinematic and electromyographic comparisons between chin-ups and lat-pull down exercises

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(*Received 14 August 2012*; *accepted 15 December 2012*)

Abstract
The purpose of this study was to compare kinematics and muscle activity between chin-ups and lat-pull down exercises and between muscle groups during the two exercises. Normalized electromyography (EMG) of biceps brachii (BB), triceps brachii (TB), pectoralis major (PM), latissimus dorsi (LD), rectus abdominus (RA), and erector spinae (ES) and kinematics of back, shoulder, and seventh cervical vertebrae (C7) was analysed during chin-ups and lat-pull down exercises. Normalized EMG of BB and ES and kinematics of shoulder and C7 for chin-ups were greater than lat-pull down exercises during the concentric phase ($p < 0.05$). For the eccentric phase, RA during lat-pull down exercises was greater than chin-ups and the kinematics of C7 during chin-ups was greater than lat-pull down exercises ($p < 0.05$). For chin-ups, BB, LD, and ES were greater than PM during the concentric phase, whereas BB and LD were greater than TB, and LD was greater than RA during the eccentric phase ($p < 0.05$). For lat-pull down exercise, BB and LD were greater than PM, TB, and ES during the concentric phase, whereas LD was greater than PM, TB, and BB during the eccentric phase ($p < 0.05$). Subsequently, chin-ups appears to be a more functional exercise.

Keywords: *Biomechanics, resistance training, calisthenics, open-kinetic chain, closed-kinetic chain*

Introduction

Lat-pull down exercises have been shown to significantly increase the strength of pulling manoeuvres about the glenohumeral joints (Kraemer & Fry, 1995; Elliot, Sale, & Cable, 2002). It was reported that lat-pull down exercises enhanced throwing performance for softball players (Prokopy et al., 2008) and significantly increased upper body exercise economy for cross-country skiers (Østerås, Helgerud, & Hoff, 2002). Although the long-term effects of lat-pull exercises following a resistance training programme have been demonstrated, there have been limited investigations of the acute effects (i.e. muscle activity and kinematics) of this exercise. Determining the acute effects of a resistance exercise is imperative in order to examine the mechanisms attributed to the type and extent of training adaptation.

Recently, research has been focused on the acute effects of lat-pull down exercises by examining the electromyography (EMG) responses of muscle groups responsible for the

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performance of the exercise. Such studies have investigated the EMG responses of lat-pull down exercises by altering grip width (Signorile, Zink, & Szwed, 2002; Lusk, Hale, & Russell, 2010), type of bar (Sperandei, Barros, Silveira-Júnior, & Oliveira, 2009), or the type of lat-pull down machine used (Koyama, Kobayashi, Suzuki, & Enoka, 2010). Collectively, the results demonstrated that differences in the technique and the type of equipment used during the performance of lat-pull down exercises significantly affects the EMG responses of the elbow flexors, shoulder adductors, and shoulder horizontal adductors. The authors generally concluded that the differences in EMG responses between the type of technique and equipment used for the lat-pull down exercise were due to altered kinematics of the upper extremity (Signorile et al., 2002; Sperandei et al., 2009; Koyama et al., 2010).

Furthermore, studies have investigated different types of resistance exercises that target the same muscle groups activated during lat-pull down exercises (i.e. elbow flexors, shoulder adductors, and shoulder horizontal adductors) (Lehman, Buchan, Lundy, Myers, & Nalborczyk, 2004; Honda, Kato, Hasegawa, Okada, & Kato, 2005). For example, Honda, Kato, Hasegawa, Okada, & Kato (2005) compared EMG responses between different resistance exercises that engaged biceps brachii (BB) and latissimus dorsi (LD) as primary muscle groups (e.g. lat-pull down exercise, seated-rows, and bent-over rows). The results showed that the LD and BB are affected by the type of exercise despite being the primary muscle groups for the exercises. Hence, regardless of whether similar muscle groups are engaged, different types of resistance exercises appear to significantly affect the level of muscle activity.

One calisthenic exercise that is analogous to the lat-pull down exercise is chin-ups (Johnson, Lynch, Nash, Cygan, & Mayhew, 2009). These exercises are considered comparable due to the similarity in the nature of the movement patterns of the upper extremity, provided that the forearm orientation and grip width are equivalent between the exercises (Signorile et al., 2002; Lusk et al., 2010). Although comparable movement patterns between chin-ups and lat-pull down exercises may induce similar effectiveness, these exercises are referred to differently. The external load (i.e. the bar) is pulled towards the chest whilst the lower extremity is held underneath knee restraints during lat-pull down exercises, affording an open kinetic chain manoeuvre. Alternatively, the bar is stagnant whilst the lower extremity is free to move in the vertical and horizontal planes, suggesting that chin-ups may be a closed-kinetic chain exercise. Subsequently, the question then is, will EMG responses differ between chin-ups and lat-pull down exercises when the movement patterns of the upper extremity are similar even though the exercises are categorized differently?

Unfortunately, the investigation on the acute effects of chin-ups is limited. Antinori, Felici, Figura, and Ricci (1988) did examine the kinetics of pull-ups and reported greater muscular moments at the shoulder joint than at the elbow and wrist joints. However, lat-pull down exercises were not incorporated in the study. Johnson et al. (2009) did compare the performance between chin-ups and lat-pull down exercises and demonstrated that both men and women performed their one repetition maximum (1RM) with a significantly greater load relative to body mass for chin-ups than for lat-pull down exercises. However, the EMG responses between the two exercises were not compared due to the nature of the study. Subsequently, although various studies examined the EMG responses of lat-pull down exercises (Snyder & Leech, 2009; Sperandei et al., 2009; Koyama et al., 2010; Lusk et al., 2010), little is known of the EMG responses during the performance of chin-ups. In fact, to our knowledge, no investigation has compared EMG responses between chin-ups and lat-pull down exercises.

The purpose of this study was twofold: (1) to compare the EMG responses of the selected muscle groups between chin-ups and lat-pull down exercises and to determine whether the

EMG responses were influenced by the kinematics of the exercises and (2) to determine the effectiveness of chin-ups and lat-pull down exercises by comparing the EMG responses between the selected muscle groups during the performance of the two exercises. It was hypothesized that (1) the muscle activity of the primary movers and core muscle groups and the displacements of the selected body segments would be greater for chin-ups than for lat-pull down exercises and (2) the primary movers (i.e. BB and LD) would produce a higher level of muscle activity over the non-primary movers during chin-ups and lat-pull down exercises.

Methods

Participants

Healthy males ($n = 9$, height $= 1.79 \pm 0.06$ m, weight $= 82.6 \pm 12.0$ kg, age $= 26 \pm 9$ years) with at least 12 months of resistance training experience participated in the study. Each participant provided informed consent prior to participation in any testing procedures. As part of the selection criteria, the participants were expected to perform six or more proper chin-ups. All procedures in this study were approved by the James Cook University Human Research Ethics Committee. *A priori* power calculation was conducted for the key dependent variables of resistance exercise performance based on previous studies (Sperandei et al., 2009; Koyama et al., 2010) and showed that a sample size of nine is sufficient to provide greater than 80% of power at an α level of 0.05.

Protocol

A familiarization session was carried out 1 week before testing. During this session, the participant's grip width was determined by measuring the distance between the participant's seventh cervical vertebrae (C7) and the first metacarpophalangeal joint in a flexed position whilst the elbow was fully extended and the shoulder joint was in an abducted position (Signorile et al., 2002). These anthropometric measurements were used to standardize the grip width between the chin-ups and lat-pull down exercises with the forearm orientation in a pronated position on the bar. A custom-built chin-up bar was secured to the top of a power rack (Maximum Power Rack, MF 720, Maxim Fitness, South Australia, Australia) to perform chin-ups (Figure 1). The same bar was then attached to a standard lat-pull down machine (Platinum Lat-pull Down/Cable Row, P5035, Maxim Fitness, South Australia, Australia) to perform the lat-pull down exercises (Figure 2). The participants performed a series of RM tests for the chin-ups and lat-pull down exercises in order to standardize the load between the two exercises. This was accomplished by obtaining the maximal number of repetitions a participant could perform in one set during the performance of chin-ups, then replicated to the lat-pull down exercise by ascertaining the load required for the participant to maximally perform the same number of repetitions as the chin-ups (e.g. if a participant performed eight repetitions of chin-ups to failure, then an 8RM test was conducted for the lat-pull down exercise). The participants performed 10 ± 3 repetitions of chin-up exercises and the lat-pull down exercises were performed at 79.5 ± 11.6 kg with equivalent repetitions as the chin-up exercises. A 5-min recovery period was provided between the attempts of the RM test for the lat-pull down exercise (Kraemer, 1997). A 10-min recovery period between the two RM tests was provided in order to limit any carry-over effects of fatigue (Kraemer & Fry, 1995). The participants were instructed not to flex their hips during chin-ups in order to encourage the use of upper back and arm muscles rather than relying on the momentum generated from the lower extremity.

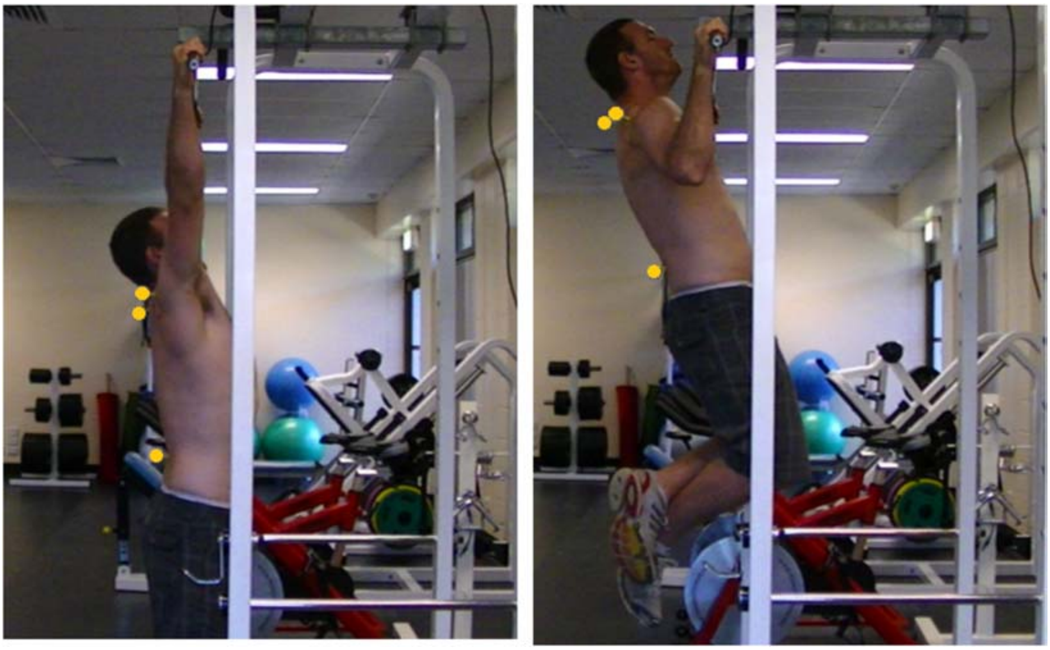

Figure 1. The starting and end positions of the chin-ups exercise with the bar attached to the power rack.

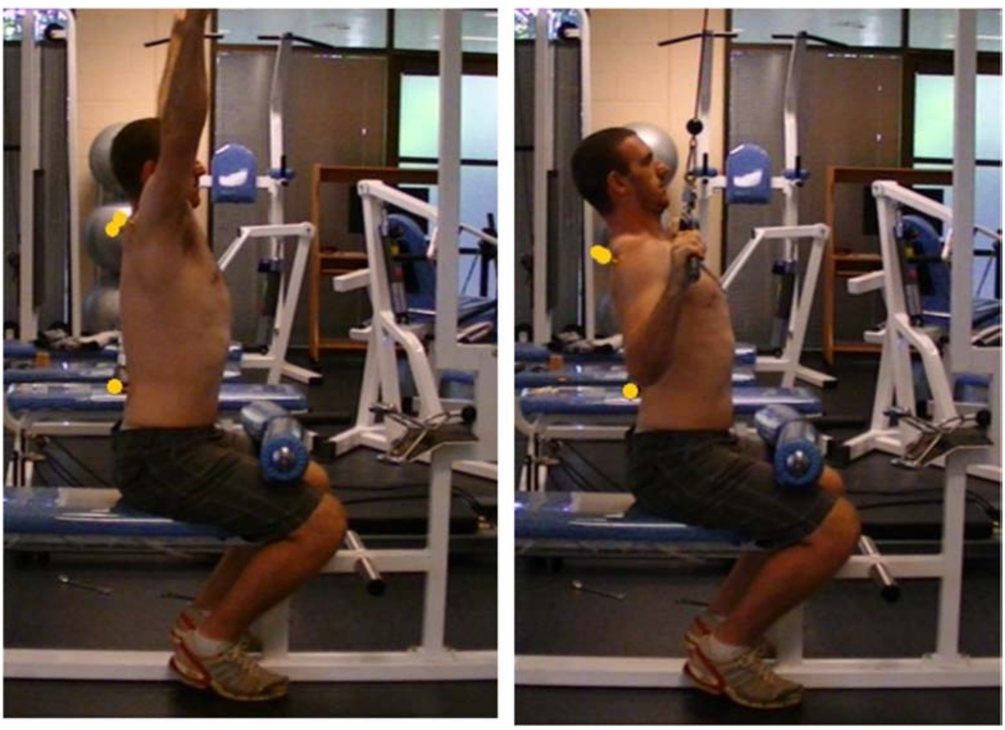

Figure 2. The starting and end positions of the lat-pull down exercise with the bar used identical to that during chin-ups.

The range-of-motion (ROM) of the chin-ups was measured via an accelerometer (Gymaware, Mitchell, Australia) not to quantify the acceleration of the movement, but to quantitatively assess the distance the participant travelled vertically. This was achieved by attaching the wire to a strap around the participant's waist, a function comprised within the system. The average ROM for all the repetitions during the RM test was then replicated by the lat-pull down exercise for standardization. This was conducted by a marker placed level with the top surface of the weight stack on the lat-pull down machine during the starting position, and another marker above it at the end ROM.

On the test day, a maximal voluntary contraction (MVC) was completed for each muscle group assessed prior to performing the chin-ups and lat-pull down exercises in order to normalize the EMG values obtained during the intervention exercises. Three contractions were executed for the selected muscle groups with each MVC held for 6 s, 90-s rest in between each contraction and 3-min rest in between each MVC exercise (Coburn et al., 2005; Riley, Terry, Mendez-Villanueva, Litsey, & Enoka, 2008). The chin-ups and lat-pull down exercises were performed 10 min after the MVC assessments to limit the effects of fatigue. The participants performed five repetitions of the chin-ups and lat-pull down exercises randomly to limit the effects of test order. Each concentric and eccentric repetition was executed in time with a metronome for 1 s, respectively, to standardize the cadence between the chin-ups and lat-pull down exercises. In addition to the sounds recorded by video cameras, a frame-by-frame assessment assisted in determining the concentric and eccentric points of the EMG data. From the five repetitions, the average level of muscle activity and body segment displacements of the middle three concentric and eccentric contractions were compared. The three middle repetitions were chosen in order to limit swaying movements that may have occurred at the onset or end of the exercises. A 5-min recovery period between each exercise was provided to limit the effects of fatigue (Kraemer, 1997).

Electromyography

EMG was recorded by use of Ag/AgCl bipolar surface electrodes (AMBU, Blue Sensor SP, SP-00-S/50, Ballerup, Denmark). After shaving and cleansing the skin with an alcohol wipe, the EMG electrodes were placed parallel to the muscle fibre on six locations. The sternal portion of the pectoralis major (PM), lateral scapulae of the LD, the long head of the BB, the long head of the triceps brachii (TB), rectus abdominus (RA) (2 cm lateral of umbilicus) (Andersen & Behm, 2004), and lumbosacral erector spinae (ES) (2 cm lateral of the L5-S1 spinous processes) (Behm, Leonard, Young, Bonsey, & MacKinnon, 2005) on the right side of the body. The inter-electrode distance between the recording electrodes was set at 20 mm. Raw EMG signals were recorded via a wireless telemetry system (ME6000, Mega Electronics, Ltd, Kuopio, Finland) with a common mode rejection ratio of 110 dB and were analog-to-digital converted with a 14-bit resolution at a sampling rate of 1000 Hz. The total gain was set at 1000 with band pass filtering between 8 and 500 Hz and the RMS was computed with a 1-s moving average filter (Megawin Software, Mega Electronics, Ltd, Kuopio, Finland) to allow analyses of each concentric and eccentric contraction and normalized to the peak MVC values.

Kinematic analysis

Kinematic analysis was conducted by positioning two video cameras for the chin-ups (DSR-400PL, Sony, Tokyo, Japan) and lat-pull down exercises (DSR-POX10P, Sony), such that their optical axes were perpendicular to the sagittal plane of the movement, and that the angular displacement of the back and the horizontal displacement of the shoulder and C7 were captured from the right side. The video was recorded at 25 frames per second and converted to digital format for analysis. The Ariel performance analysis system (APAS) (Ariel Dynamics, Inc., San Diego, CA, USA) was used for digitizing the exercise movements, whereby the motion was transformed into two dimensions via use of the transformation module. The positions were digitally filtered independently on the x and y axes with the filtering module, with a cut-off frequency of 10 Hz. Reflective markers were placed on the spine of C7, coracoid process, and the lumbar spine at level of the iliac crest. The coracoid process was used as a marker to determine the horizontal displacement of the shoulder. The back segment was determined by drawing a line between the reflective markers at C7 and lumbar spine on APAS. These reflective markers were placed 18 mm above the landmarks to enable the markers to be viewed without obstruction from other body parts.

Statistics

The histograms, normal probability plots, and Shapiro–Wilk's test for the normalized EMG values and the kinematic data showed that the normality assumption was not sufficed. Subsequently, the Friedman test was used to determine differences in normalized EMG activity between muscle groups (SPSS, version 17, Chicago, IL, USA). These results were followed with the Wilcoxon signed-rank test if a significant effect was found in order to identify the location of the difference. The Wilcoxon signed-rank test was used in order to determine the normalized EMG activity of the selected muscle groups and the displacements of the back, C7, and shoulder between chin-ups and lat-pull down exercises. The Mann–Whitney U-test was used to determine the effects of exercise order. All data are presented as mean with standard deviations. An α level of 0.05 indicated a level of significance.

Results

Normalized EMG

When compared between chin-ups and lat-pull down exercises (Figure 3), chin-ups was greater than the lat-pull down exercise for BB ($p = 0.008$) and ES ($p = 0.008$) during the concentric phase. However, the lat-pull down exercise was greater than chin-ups for RA during the eccentric phase ($p = 0.028$). When compared between muscle groups during the concentric phase (Figure 3), BB, LD, and ES were greater than PM ($p = 0.008$, 0.011, and 0.045, respectively), and BB and LD were greater than TB ($p = 0.012$ and 0.011, respectively) for chin-ups. However, BB was greater than TB and ES ($p = 0.033$ and 0.036, respectively), and LD was greater than PM, TB, and ES ($p = 0.011$, 0.011, and 0.021, respectively) for the lat-pull down exercise during the concentric phase. During the eccentric phase, BB, ES, and LD were greater than PM ($p = 0.021$, 0.038, and 0.011, respectively), and LD was greater than TB and RA ($p = 0.021$ and 0.036, respectively) for chin-ups, whereas LD was greater than PM, TB, and BB ($p = 0.015$, 0.011, and 0.011, respectively) for the lat-pull down exercise.

Kinematics

The chin-ups was greater than the lat-pull down exercise for the horizontal displacement of the shoulder ($p = 0.004$) and C7 ($p = 0.01$) during the concentric phase (Table I).

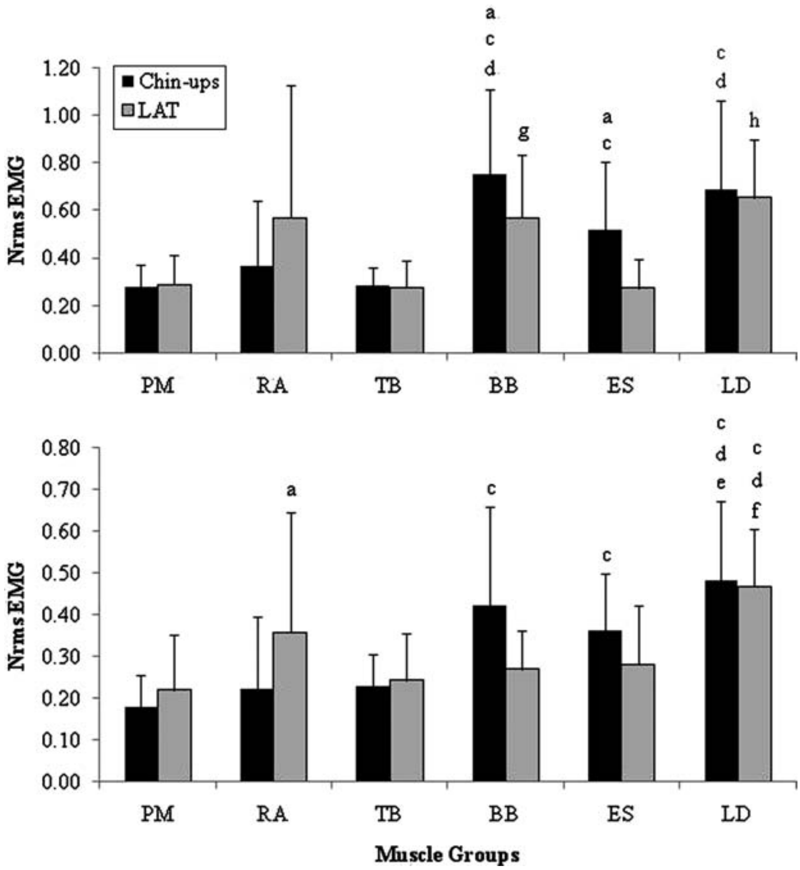

Figure 3. Normalized root-mean squared electromyography (NrmsEMG) values for pectoralis major (PM), rectus abdominus (RA), triceps brachii (TB), biceps brachii (BB), erector spinae (ES), and latissimus dorsi (LD) for the chin-ups and lat-pull down exercises during the concentric (top graph) and eccentric (bottom graph) phases. a, Significant difference between chin-ups and lat-pull down exercises ($p < 0.05$). b, Significantly greater than PM ($p < 0.05$). c, ($p < 0.01$). d, Significantly greater than TB ($p < 0.01$). e, Significantly greater than RA ($p < 0.05$). f, Significantly greater than BB and ES ($p < 0.05$). g, Significantly greater than PM, TB, and ES ($p < 0.05$); h ($p < 0.01$).

However, the chin-ups was greater than the lat-pull down exercise for the horizontal displacement of C7 ($p = 0.018$) (Table I).

Table I. Horizontal displacement of the shoulder and C7 and angular displacement of the back for chin-ups and lat-pull down exercises ($M \pm SD$).

	Concentric		Eccentric	
	Chin-ups	lat-pull down	Chin-ups	lat-pull down
Shoulder (cm)	12.7 ± 3.4*	10.1 ± 4.0	9.3 ± 3.9	7.4 ± 2.9
C7 (cm)	12.1 ± 3.3*	8.0 ± 3.4	9.3 ± 4.2*	6.1 ± 2.6
Back (°)	13.0 ± 5.2	11.4 ± 5.5	13.4 ± 6.5	9.1 ± 5.3

*Significant difference between chin-ups and lat-pull down exercises ($p < 0.05$).

Discussion and implications

Various studies have examined EMG responses of lat-pull down exercises (Snyder and Leech (2009), Signorile et al., 2002; Lehman et al., 2004; Honda et al., 2005; Snyder & Leech, 2009; Sperandei et al., 2009; Koyama et al., 2010; Lusk et al., 2010); however, there are limited data on the EMG responses of chin-ups even though both types of resistance exercises appear to have similar movement patterns. Subsequently, this study compared the EMG responses between chin-ups and lat-pull down exercises and examined whether the characteristics of muscle activity were dependent on the kinematics of the exercises.

This study identified greater normalized EMG values for the BB and ES during chin-ups than during the lat-pull down exercise, which accepts the first hypothesis. Such findings may be due to chin-ups creating an unstable condition versus a lat-pull down exercise being performed in a more stable condition. Although exercise balls were not incorporated in this study even though it is commonly employed to create an unstable condition during resistance training (Behm, Anderson, & Curnew, 2002; Marshall & Murphy, 2006; Norwood, Anderson, Gaetz, & Twist, 2007), chin-ups can still be considered unstable, whereby the lower extremity is capable of moving free from resistance along the horizontal plane which displaces the body centre of gravity from the vertical alignment with the grasp on the bar (Antinori, Felici, Figura, and Ricci, 1988). This is also supported by the greater horizontal displacement of the shoulder and angular displacement of the back found during chin-ups than during lat-pull down exercises, again partially accepting the first hypothesis.

In comparison, a lat-pull down exercise can be considered to be more stable as the lower extremity is motionless underneath the knee pads. Although the bar of the lat-pull down machine is not in a fixed position similar to that of a chin-up bar, the constant pull from the cable enhances the stability of the exercise condition by resisting upper extremity movements in the horizontal plane. Subsequently, it is arguable that the kinematic differences may have affected the stability between chin-ups and lat-pull down exercise conditions. However, the PM, TB, and RA muscle groups appear to have been unaffected by the differences in the stability of the condition. These results are consistent with several studies that found similarities in the level of muscle activity for certain muscle groups and no differences in others when performing exercises with similar movement patterns in stable and unstable conditions (Lehman, MacMillan, MacIntyre, Chivers, & Fluter, 2006, 2007; Marshall & Murphy, 2006; de Oliveira, de Morais Carvalho, & de Brum, 2008).

The difference in the degree of instability each muscle experiences has been proposed to be dependent on the anatomical orientation of the muscles (Lehman et al., 2006). Lehman et al. (2006) found a significantly higher level of muscle activity for the TB during push-ups performed on an unstable versus a stable surface. However, the PM was not influenced by the stability of the condition, though it is a primary mover for the push-ups. The authors speculated that the TB required higher stability and movement demands at the glenohumeral joints and elbow joints being a biarticular muscle and a prime mover for the push-ups as opposed to the PM as a monoarticular muscle though it is a primary mover. Although the stability of the condition during the performance of push-ups was not examined, the findings by Lehman et al. (2006) may still have implications for the muscle activity of the BB obtained from this study.

The BB may have experienced higher instability and movement demands during the performance of the chin-ups because it is both a prime mover and a biarticular muscle that crosses the glenohumeral and elbow joints. In comparison, although the LD was a prime mover, it was also a monoarticular muscle group for the chin-ups and lat-pull down exercises. The TB was a biarticular muscle; however, it was not a prime mover for the chin-ups and lat-pull down exercises. This lesser sensitivity to changes in the kinematics and the subsequent stability of the condition for the LD and TB further supports the findings by Koyama et al. (2010). These authors showed no significant differences in EMG activity of the LD and TB when performing lat-pull down exercises with different techniques despite significant differences in the kinematics at the upper extremity. Subsequently, LD and TB in this study may not have had to stabilize the glenohumeral joints during chin-ups to the extent of that by the BB which was biarticular as well as a prime mover for the exercises.

The normalized EMG for ES was significantly greater for chin-ups than for lat-pull down exercises during the concentric phase, and RA was significantly greater for the lat-pull down exercise than for chin-ups during the eccentric phase. Such findings imply that the core muscles are engaged during the performance of chin-ups and lat-pull down exercises, although the core muscles during the concentric phase may contribute to stabilizing the body to a greater extent during chin-ups due to a higher activation of ES. This is consistent with other studies that have shown significant contribution of RA and ES during exercises performed in unstable conditions (Gardner-Morse, Stokes, & Laible, 1995; Arokoski, Valta, Airaksinen, & Kankaapaa, 2001; Andersen & Behm, 2004). The ES may have shown greater activation during chin-ups to maintain a rigid spinal column throughout the movement due to the swaying that occurs during the performance of the exercise. In addition, the participants were instructed not to flex their hips during chin-ups to limit momentum being generated from the lower extremity, which may have encouraged ES activation. In comparison, as the lower extremity was positioned under the knee restraints in order to prevent the body from being lifted during the lat-pull down exercises, the torque that generated the angular displacement of the back would have been produced by the extension of the hips, which would alleviate the tension of the ES. These reasons regarding differences in the ES muscle activity are based on assumptions, and therefore, require further investigation of muscle activity of the lower extremity and kinematics of the curvature of the spine during the performance of chin-ups and lat-pull down exercises.

When comparing the normalized EMG between the muscle groups, the level of muscle activity for the LD and BB was significantly higher than for the PM and TB during the performance of chin-ups and lat-pull down exercises, accepting the latter hypothesis. These findings suggest that chin-ups and lat-pull down exercises are equally effective in activating the primary muscle groups and are consistent with other studies that have shown high-EMG responses of the LD and BB (Signorile et al., 2002; Snyder et al., 2009; Sperandei et al., 2009; Koyama et al., 2010). Although the normalized EMG values of the BB were significantly different when compared between the chin-ups and lat-pull down exercises, no significant differences were found for the LD. Such results may have been obtained due to similarities in the movement pattern of the upper extremity. Dillman, Murray, and Hintermeister (1994) and Blackard, Jensen, and Ebben (1999) also investigated two different types of exercises by comparing the acute responses of push-ups and bench press exercises and showed comparable levels of muscle activity for the primary muscle groups (i.e. PM and TB). These authors postulated that their findings were due to the load being standardized and similarities in the movement patterns (i.e. horizontal abduction/adduction and flexion/extension at the glenohumeral joints and elbow joints, respectively) between the two exercises. From the current findings and that by Dillman et al. (1994) and Blackard et al. (1999), it appears that two different resistance exercises can produce comparable EMG responses, provided that the load and the execution of movement patterns are similar.

The conjecture in the relationship between the kinematics of the upper extremity and the activity of the muscles crossing the glenohumeral joints during lat-pull down exercises has been supported by Signorile et al. (2002), showing significant differences in EMG response when the grip widths of the lat-pull down exercise were altered. Although the kinematics of the upper extremity were not investigated, the authors concluded that differences in grip width may have changed the degree of shoulder-external/internal rotation, -abduction/adduction, and -horizontal abduction/adduction which affected the recruitment patterns of muscles crossing the glenohumeral joints. Furthermore, Koyama et al. (2010) investigated the EMG responses and kinematics of the arms when performing exercises on a lat-pull down machine that allowed movements occurring along one, two, or three degrees of freedom. The results showed that the technique with greater degrees of freedom executed significantly greater wrist and shoulder displacement and produced significantly higher EMG values of the posterior deltoids than the technique that afforded less variability in movement patterns. Subsequently, the comparable levels of muscle activity between chin-ups and lat-pull down exercises found for this study may be attributed to the similarity in the movement patterns at the glenohumeral joints. In order to effectively determine this relationship, however, further investigation on the kinematics of the upper extremity during chin-ups and lat-pull down exercises is warranted.

Although chin-ups and lat-pull down exercises appear to be different according to the kinematic data, the biomechanical analyses were limited to two dimensions in this study (i.e. the saggital plane). However, movement occurs in varying degrees of freedom. Hence, analyses of upper limbs and thorax in three dimensions during chin-ups and lat-pull down exercises may enhance the understanding of the mechanisms associated with differences in EMG between the two exercises. Subsequently, further research examining these exercises using three dimensional motion analyses is warranted.

The practical applications that could be drawn from the current findings are twofold. First, chin-ups and lat-pull down exercises strongly engage the primary muscle groups (i.e. BB and LD) and that chin-ups are equally effective in activating the LD as lat-pull down exercises. Subsequently, chin-ups may be able to increase muscular strength and induce hypertrophic adaptations of the upper back and arm muscles similar to that of the lat-pull down exercise. As a result, chin-ups may be an effective alternative to a lat-pull down exercise, especially when the availability of training equipments is limited, as chin-ups can be performed with only a bar compared with a lat-pull down exercise which requires a sophisticated cable machine. Second, the greater level of muscle activity found for the BB and ES demonstrates that chin-ups is more functional in nature. Hence, chin-ups may be more effective than lat-pull down exercises for sports such as gymnastics and rock climbing which require the athletes to stabilize their body whilst hanging from their hands. It has been reported that elite climbers can significantly execute a greater number of repetitions of a chin-up exercise than recreational climbers (Grant, Hynes, Whittaker, & Aitchison, 1996). Subsequently, the findings from this study exemplify the acute mechanisms for the potential benefits of performing chin-ups.

Conclusion

This study compared the kinematics and muscle activity between chin-ups and lat-pull down exercises. Chin-ups produced a greater level of muscle activity for the BB and ES than the lat-pull down exercise which may be due to chin-ups allowing greater degrees of freedom as evidenced by the greater horizontal displacement of the shoulder and C7. Alternatively, the EMG responses of BB and LD were greater than those of non-primary movers, suggesting that both chin-ups and lat-pull down exercises may be similarly effective in activating the primary movers.

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