Trunk Muscle Activity During Stability Ball and Free Weight Exercises

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Abstract

The purpose of this investigation was to compare trunk muscle activity during stability ball and free weight exercises. Nine resistance-trained men participated in one testing session in which squats (SQ) and deadlifts (DL) were completed with loads of approximately 50, 70, 90, and 100% of one-repetition maximum (1RM). Isometric contractions during 3 stability ball exercises (quadruped (QP), pelvic thrust (PT), ball back extension (BE)) were also completed. During all exercises, average integrated electromyography (IEMG) from the rectus abdominus (RA), external oblique (EO), longissimus (L1) and multifidus (L5) was collected and analyzed. Results demonstrate that when expressed relative to 100% DL 1RM, muscle activity was 19.5 ± 14.8% for L1 and 30.2 ± 19.3% for L5 during QP, 31.4 ± 13.4% for L1 and 37.6 ± 12.4% for L5 during PT, and 44.2 ± 22.8% for L1 and 45.5 ± 21.6% for L5 during BE. IEMG of L1 during SQ and DL at 90 and 100% 1RM, and relative muscle activity of L5 during SQ and DL at 100% 1RM was significantly greater ($P \leq 0.05$) than in the stability ball exercises. Furthermore, relative muscle activity of L1 during DL at 50 and 70% 1RM was significantly greater than in QP and PT. No significant differences were observed in RA and EO during any of the exercises. In conclusion, activity of the trunk muscles during SQs and DLs is greater or equal to that which is produced during the stability ball exercises. It appears that stability ball exercises may not provide a sufficient stimulus for increasing muscular strength or hypertrophy; consequently, the role of stability ball exercises in strength and conditioning programs is questioned. SQs and DLs are recommended for increasing strength and hypertrophy of the back extensors.

Key Words squat, deadlift, electromyography

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Introduction

Stability ball exercises have recently been recommended for inclusion into training programs aimed at stimulating the trunk muscles (7,9,15,30). These exercises have been considered for improving trunk muscle strength (7,15,32) and athletic performance (7). Structural free weight exercises, such as the back squat (SQ) and conventional deadlift (DL), have been shown to activate the trunk muscles (3,14,33) and have improved variables of athletic performance when included in training programs (6,8,16–18,22,26,27). Trunk muscle activity during stability ball exercises (4,5,13,20,21,24,27,31), the SQ (3,33), and DL (14) has been examined in separate investigations; however, a comparison of muscle activity between stability ball exercises and the SQ and DL has not yet been attempted within the context of a single investigation.

Numerous studies have examined stability ball exercises which are specifically designed to stimulate activity of the back extensor muscles (4,5,13,20,21,24,27,31). When back extensor electromyography (EMG) during stability ball exercises is expressed relative to back extensor EMG during a maximal voluntary contraction (MVC), researchers have reported values ranging from 5 to 60% (4,5,13,20,21,24,27,31). Marshal et al. (21) reported that muscle activity during the quadruped exercise (QP) was 31.7% of MVC when measured from the L5 vertebrae, and Souza et al. (27) reported that during the same exercise, muscle activity was 19.9% of MVC when measured from the L3 vertebrae. The stability ball pelvic thrust exercise (PT) has also been studied and has been found to stimulate muscle activity of 24.0% (31), 40.8% (24), and 60.0% (3) of MVC when measured from the L5 vertebrae, while Lehman et al. (20) reported 5.0% from the L3 vertebrae and Mori et al. (24) reported 16.2% from the T9 vertebrae. Additionally, the stability ball back extension (BE) has been studied by Drake et al. (13) and it was discovered that muscle activity was 36.7% of MVC at the L5 vertebrae, 40.7% at the L3 vertebrae, and 50.0% at the T9 vertebrae.

Previous investigations have also reported the amount of muscle activity produced during variations of the SQ and DL (1,3,12,14,33). During the concentric phase of SQs at 90% of one-repetition maximum (1RM), it was reported that the erector spinae at the L3–L4 level were stimulated at approximately 55.0% of peak EMG activity (33). When considering the DL, it was discovered that when lifting a load equivalent to a 12RM, muscle activity was 32.0% of MVC when measured from the L3 and T12 paraspinal muscles (14). Additionally, other investigations have measured activity of the paraspinal muscles during different lifting techniques used in the workplace (1,12).

While previous investigations have reported the amount of muscle activity produced during variations of either stability ball exercises, the SQ, or DL, no previous study has compared these exercises within the context of a single investigation. Thus, the purpose of this study was to compare trunk muscle activity during stability ball exercises to the muscle activity which is produced during submaximal and maximal SQs and DLs. This comparative data may provide a better understanding for the use of stability ball exercises, SQs, and DLs, in training programs designed to increase trunk muscle strength or improve athletic performance.

Methods

Experimental Approach to the Problem

Subjects participated in a single testing session in which EMG activity of the rectus abdominus (RA), external oblique (EO), longissimus (L1), and multifidus (L5) was measured during a back extension MVC, three stability ball exercises (QP, PT, BE), and submaximal and maximal SQs and DLs. After a 5 minute warm-up on a cycle ergometer, subjects completed warm-up repetitions on a back extension apparatus prior to completing a MVC. After an adequate rest period, 3 stability ball exercises were completed in a randomized order. Two isometric repetitions of 3 seconds were completed for each stability ball exercise. Then, the SQ and DL were completed in a randomized order. Muscle activity was measured during the concentric phase of SQs and DLs using submaximal (50, 70, and 90% of 1RM) and maximal (100% of 1RM) loads. Adequate rest was provided between all sets and exercises.

Subjects

Nine healthy, recreationally active male subjects (age: 23.78 ± 1.86 years; height: 179.17 ± 5.36 cm; mass: 86.33 ± 9.73 kg; % body fat: 12.36 ± 3.98%; SQ 1RM: 154.17 ± 30.10 kg; DL1RM: 170.00 ± 41.76 kg; SQ 1RM to body mass ratio: 1.78 ± 0.23; DL 1RM to body mass ratio: 1.98 ± 0.46) participated in this investigation. Prior to testing, all subjects were informed of the study procedures and were required to sign an informed consent. Approval from the Appalachian State University Institutional Review Board was obtained prior to the start of the investigation.

Stability Ball Exercises

The QP, PT, and BE were performed with a 65 centimeter stability ball. These exercises were completed in a randomized order, and were utilized based on their ability to stimulate the back extensor muscles in previous investigations (5,13,20, 21,24,27,31). For each exercise, two isometric repetitions were performed and these repetitions were held for three seconds. Repetitions and exercises were separated by a one minute rest period.

Quadruped. During the start position for the QP, subjects were positioned with the umbilicus over the center of the stability ball and with feet and hands in contact with the floor. After the test administrator's verbal instruction, subjects simultaneously raised their right leg and left arm so that both limbs were parallel with the ground surface. The left leg and right arm were to remain in contact with the floor during the repetition.

Pelvic Thrust. For the PT, subjects started by lying in a supine position on the floor. The subjects' upper-body and torso remained positioned on the floor while their heels were positioned on top of the center of the stability ball. After the test administrator's verbal instruction, subjects pushed into the ball with their heels so that only their shoulders and head were in contact with the floor. During the exercise, subjects were required to keep their feet positioned on the ball so that their toes pointed upwards. Additionally, flexion at the knees was not permitted.

Ball Back Extension. The BE required subjects to start in a position in which the umbilicus was over the center of the stability ball. Additionally, in the start position, the subjects' upper-body remained relaxed while lying on the ball, and both feet were in contact with the floor. During the exercise, both feet remained in contact with the floor but the upper-body was raised from the ball as extension at the lumbrosacral joint occurred. Both hands were placed behind the head throughout the movement.

Squat and Deadlift

Muscle activity was measured during submaximal (50%, 70% and 90% of 1RM) and maximal (100% of 1RM) sets of the SQ and DL. A 3 minute rest period was provided between all sets and a 10 minute rest period was provided between the SQ and DL. SQ repetitions were monitored and considered complete when a 70° knee angle was attained at the end of the eccentric phase and when the following concentric phase was completed. For the DL, all subjects utilized a conventional lifting technique in which the feet were shoulder-width apart. Additionally, subjects grasped the bar just lateral to the legs with an alternating grip. DL repetitions were monitored and considered complete when the subjects attained full extension at the hip and knee joints after lifting the load from the floor. Muscle activity was obtained from the concentric phases of the lifts as determined by the kinetic and kinematic data collected during each repetition.

Maximum Voluntary Contraction

A 3 second MVC back extension was performed on a standard back extension apparatus following two warm-up repetitions at a volitional 30 and 60% of maximal effort. Subjects were positioned on the machine so that their knees were fully extended and so that a 135° angle between the femur segment length and the upper-torso segment length was maintained. A strap was securely placed around the subjects' upper-chest and connected to an adjustable chain. The chain was then connected to a hook in the floor to ensure no movement at the given angle.

Kinetic and Kinematic Data

Vertical ground reaction forces during all repetitions of the SQ and DL were recorded using a force plate (AMTI, BP6001200, Massachusetts, Watertown, USA). Furthermore, kinematic data was recorded using two linear position transducers (LPT) (Celesco transducer products, PT5A-150, Chatsworth, CA, USA). The two LPTs, located anterior and posterior to the subject during the lifts, were attached to the barbell. This resulted in the formation of a triangle which allowed for the calculation of vertical and horizontal displacements through trigonometry involving constants and displacement measurements (11). Bar displacement and vertical velocity were used to determine the concentric phase for each lift. The concentric phase was determined from the bar's lowest and highest displacements and the points at which the vertical velocity became greater than zero and when the velocity returned to zero. Custom software created using LabVIEW (National Instruments, Version 7.1, Texas, Austin, USA) was used for recording and analyzing the data.

Electromyography

In order to determine muscle activity, surface EMG was collected from L1 and L5 during all exercises. The skin was shaved, abraded, and cleansed with alcohol prior to placing a disposable bipolar surface electrode (Noraxon USA Inc., Scottsdale, Arizona, USA; 2 cm inter-electrode distance, 1 square cm circular conductive area) over the muscle. Placement of the electrodes was based on a previous investigation which measured muscle activity from L1 and L5 (19). The myoelectric signal was transmitted through the use of a telemetry transmitter (eight channel, twelve bit analog to digital converter, Noraxon USA Inc., Scottsdale, Arizona, USA). The amplified myoelectric signal, recorded during the exercises, was detected by the receiver-amplifier (Telemyo 900, gain = 2000, differential input impedance = 10 MΩ, bandwidth frequency 10–500 Hz, common mode rejection ratio = 85 dB, Noraxon USA) and then sent to an A/D card (National Instruments, NI PCI-6014, Austin, Texas, USA) at 1000 Hz. The signal was full wave rectified and filtered (six pole Butterworth, notch filter 60 Hz, band pass filter 10–200 Hz). The integrated value (mV·s) was calculated and then averaged to determine average integrated EMG (IEMG) (mV) over the determined phase. A custom designed program created in LabVIEW was used for recording and analyzing the data. For the SQ and DL, muscle activity during the concentric phase of the first repetition was analyzed. The analysis for the stability exercises and MVC included the EMG during the isometric contraction lasting approximately 3000 ms.

Statistical Analyses

Data were analyzed with descriptive statistics, and results were summarized as mean ± standard deviation. A one-way repeated measure of variance (ANOVA) was used to detect any significant differences in muscle activity between the exercises. The level of significance for all data was set at $P \leq 0.05$. Typically, a statistical power greater than or equal to 0.80 is considered acceptable. The variables found to be statistically significant in this investigation had an average statistical power of 0.96 (range = 0.69–1.00). All statistical analyses were performed using SPSS Version 12.0 (SPSS Inc., Chicago, IL).

Results

No significant differences were found for RA and EO during the SQ and DL at any load when compared to the stability ball exercises. The activity of both L1 and L5 was always greater in SQs and DLs in comparison to the three stability ball exercises. Average IEMG values for the back extensors are reported in Tables 1 and 2. It was discovered that activity of L1 and L5 was greatest during DL at 100% of 1RM. For L1, DLs at 50, 70, 90 and 100% of 1RM and SQs at 70, 90 and 100% of 1RM were significantly greater ($P \leq 0.05$) than QP; DLs at 70, 90 and 100% of 1RM and SQs at 70, 90 and 100% of 1RM were significantly greater than PT; DLs at

Table 1. IEMG (mV) during the deadlift (DL) and stability ball exercises. Values reported as mean ± standard deviation.

Deadlift 100%	Deadlift 90%	Deadlift 70%	Deadlift 50%	Quadruped	Pelvic thrust	Ball back extension
Longissumus (L1)						
0.43 ± 0.11	0.38 ± 0.11	0.31 ± 0.11	0.27 ± 0.09*	0.07 ± 0.04†	0.13 ± 0.05‡	0.19 ± 0.06§
Multifidus (L5)						
0.31 ± 0.18	0.27 ± 0.13	0.22 ± 0.12	0.24 ± 0.12	0.08 ± 0.05*	0.11 ± 0.07*	0.10 ± 0.05*

*Significant difference ($P \leq 0.05$) from DL 100%.
†Significant difference ($P \leq 0.05$) from DL 50, 70, 90, and 100%.
‡Significant difference ($P \leq 0.05$) from DL 70, 90, and 100%.
§Significant difference ($P \leq 0.05$) from DL 90 and 100%.

Table 2. IEMG (mV) during the squat (SQ) and stability ball exercises. Values reported as mean ± standard deviation.

Squat 100%	Squat 90%	Squat 70%	Squat 50%	Quadruped	Pelvic thrust	Ball back extension
Longissumus (L1)						
0.35 ± 0.10	0.35 ± 0.14	0.29 ± 0.10	0.24 ± 0.10	0.07 ± 0.04*	0.13 ± 0.05†	0.19 ± 0.06‡
Multifidus (L5)						
0.30 ± 0.24	0.20 ± 0.09	0.17 ± 0.06	0.17 ± 0.08	0.08 ± 0.05§	0.11 ± 0.07	0.10 ± 0.05

*Significant difference ($P \leq 0.05$) from SQ 50, 70, 90, and 100%.
†Significant difference ($P \leq 0.05$) from SQ 70, 90, and 100%.
‡Significant difference ($P \leq 0.05$) from SQ 90 and 100%.
§Significant difference ($P \leq 0.05$) from SQ 100%.

90 and 100% of 1RM and SQs at 90 and 100% 1RM were significantly greater than BE. For L5, DLs and SQs at 100% were significantly greater than QP, while DLs at 100% 1RM were significantly greater than PT and BE.

When muscle activity was expressed relative to the muscle activity during DL at 100% of 1RM, significant differences were discovered between the stability ball and free weight exercises (Table 3 and Table 4). For L1, DLs at 50, 70, 90 and 100% of 1RM and SQs at 70, 90 and 100% of 1RM were significantly greater than QP; DLs at 50, 70, 90, and 100% of 1RM and SQs at 90 and 100% of 1RM were significantly greater than PT; DLs and SQs at 90 and 100% of 1RM were significantly greater than BE. For L5, DLs at 50, 70, 90, and 100% of 1RM and SQs at 70, 90 and 100% of 1RM were significantly greater than QP; DLs at 90 and 100% of 1RM and SQs at 100% of 1RM were significantly greater than PT; DLs at 90 and 100% of 1RM and SQs at 100% of 1RM were significantly greater than BE.

When muscle activity was expressed relative to muscle activity during the MVC, significant differences were discovered between the stability ball and free weight exercises (Tables 5 and 6). For L1, DLs at 50, 70, 90 and 100% of 1RM and SQs at 90 and 100% of 1RM were significantly greater than QP; DLs at 70, 90 and 100% of 1RM and SQs at 90 and 100% of 1RM were significantly greater than PT; DLs at 90 and 100% of 1RM were significantly greater than BE. For L5, DLs at 50, 70, 90, and 100% of 1RM and SQs at 100% of 1RM were significantly greater than QP; DLs at 90 and 100% of 1RM were significantly greater than PT; DLs at 100% 1RM was significantly greater than BE.

Discussion

The primary finding from this investigation was that back extensor muscle (L1 and L5) activity was greater in SQs and DLs when compared to stability ball exercises designed to stimulate the same muscles. Previous investigations have measured the amount of back extensor muscle activity during stability ball exercises (4,5,13,20,21,24,27,31), SQs (33), and DLs (14), but the current investigation is the first to make a direct comparison of these exercises. As a result, implications for the use of these exercises in training programs can now be made.

The amount of muscle activity during QP, PT, and BE has previously been expressed relative to muscle activity during a back extension MVC (4,5,13,20,21,24,27,31). In the current investigation, L1 and L5 during QP were stimulated at a level of 29.0 and 40.4% of MVC muscle activity, respectively. Similarly, Marshal et al. (21) reported that

Table 3. Relative muscle activity during the deadlift (DL) and stability ball exercises. All values reported as a percentage of muscle activity in the DL 1RM as mean ± standard deviation.

Deadlift 100%	Deadlift 90%	Deadlift 70%	Deadlift 50%	Quadruped	Pelvic thrust	Ball back extension
Longissumus (L1)						
100	89.2 ± 20.5	71.8 ± 19.9	70.2 ± 22.3	19.5 ± 14.8*	31.4 ± 13.4*	44.2 ± 22.8†
Multifidus (L5)						
100	93.2 ± 22.8	75.1 ± 13.4	81.3 ± 22.5	30.2 ± 19.3*	37.6 ± 12.4†	45.5 ± 21.6†

*Significant difference ($P \leq 0.05$) from DL 50, 70, 90, and 100%.
†Significant difference ($P \leq 0.05$) from DL 90 and 100%.

TABLE 4. Relative muscle activity during the squat (SQ) and stability ball exercises. All values reported as a percentage of muscle activity in the DL 1RM as mean ± standard deviation.

Squat 100%	Squat 90%	Squat 70%	Squat 50%	Quadruped	Pelvic thrust	Ball back extension
Longissumus (L1)						
83.0 ± 22.4	81.6 ± 31.0	61.8 ± 25.0	56.4 ± 21.1	19.5 ± 14.8*	31.4 ± 13.4†	44.2 ± 22.8†
Multifidus (L5)						
98.6 ± 41.8	85.5 ± 34.1	75.6 ± 31.1	62.4 ± 20.9	30.2 ± 19.3*	37.6 ± 12.4†	45.5 ± 21.6‡

*Significant difference ($P \leq 0.05$) from SQ 70, 90, and 100%.
†Significant difference ($P \leq 0.05$) from SQ 90 and 100%.
‡Significant difference ($P \leq 0.05$) from SQ 100%.

erector spinae muscle activity during QP was 31.7% of MVC. For PT in the current investigation, L1 and L5 were activated to a level of 48.9 and 48.7% of MVC, respectively. Similarly, when measuring L5 during the PT, previous investigations have found muscle activity to range from 24.0 to 60.0% of a MVC (5,24,31). For BE in the current investigation, muscle activity was 61.6 and 51.7% of MVC from L1 and L5, respectively. When studied by Drake et al. (13) it was discovered that muscle activity of L5 during BE was 36.7% of MVC. The lower muscle activity reported by Drake et al. (13) may have been the result of the exercise position which was utilized. Drake et al. (13) used a technique in which both the toes and knees remained in contact with the floor throughout the exercise, while the current investigation utilized a technique in which only the toes were contact with the floor. As a result, the greater muscle activity during BE in the current investigation is most likely due to an increased moment arm length and a subsequent increase in torque production needed to meet the demand of the exercise.

The current investigation appears to the first to have examined trunk muscle activity during SQs and DLs using various loads. It was discovered that muscle activity of the back extensors during DLs was always greater than in SQs at the same percentage of 1RM. One previous investigation reported that mean concentric phase muscle activity of the erector spinae was 55.0% of peak EMG activity during a SQ at 90% of 1RM (33). In the current investigation, it was discovered that when lifting 90% of 1RM in the SQ, muscle activity was 81.6 and 85.5% of peak EMG activity when measured from L1 and L5, respectively. The differences in the values reported may be attributed to the methods used for expressing peak EMG activity. Zink et al. (33) considered peak EMG activity as the greatest value attained during the lift at 90% of a 1RM, while the current investigation measured peak EMG activity as the average IEMG that was attained during the DL 1RM. When considering the DL, it appears that only one other investigation has measured trunk muscle activity during the lift (14). Escamilla et al. (14) discovered that when lifting a load equivalent to a 12RM, muscle activity was 32.0% of MVC when measured from the L3 and T12 paraspinal muscles. In the current investigation, DLs at 70% of 1RM most closely mimic the exercise intensity used by Escamilla et al. (14,23). However, in the current investigation, muscle activity of L1 and L5 at 70% of DL 1RM was 127.4 and 124.6% of MVC, respectively. The methodologies used for assessing MVC, and the analysis of EMG data may have attributed to the different values reported. Escamilla et al. (14) utilized a MVC technique which was volitional and

TABLE 5. Relative muscle activity during the deadlift (DL) and stability ball exercises. All values reported as a percentage of muscle activity in the maximum voluntary contraction (MVC) as mean ± standard deviation.

Deadlift 100%	Deadlift 90%	Deadlift 70%	Deadlift 50%	Quadruped	Pelvic thrust	Ball back extension
Longissumus (L1)						
163.2 ± 70.1	138.1 ± 50.8	127.4 ± 38.3	101.0 ± 21.5	29.0 ± 16.1*	48.9 ± 21.5†	67.6 ± 19.4‡
Multifidus (L5)						
162.9 ± 74.2	142.5 ± 55.1	124.6 ± 43.7	123.8 ± 47.8	40.4 ± 20.3*	48.7 ± 13.7‡	51.7 ± 21.2‡

*Significant difference ($P \leq 0.05$) from DL 50, 70, 90, and 100%.
†Significant difference ($P \leq 0.05$) from DL 70, 90, and 100%.
‡Significant difference ($P \leq 0.05$) from DL 90 and 100%.

TABLE 6. Relative muscle activity during the squat (SQ) and stability ball exercises. All values reported as a percentage of muscle activity in the maximum voluntary contraction (MVC) as mean ± standard deviation.

	Squat 100%	Squat 90%	Squat 70%	Squat 50%	Quadruped	Pelvic thrust	Ball back extension
Longissumus (L1)							
	128.7 ± 53.9	117.8 ± 38.1	86.9 ± 35.0	78.2 ± 20.5	29.0 ± 16.1*	48.9 ± 21.5*	67.6 ± 19.4
Multifidus (L5)							
	129.3 ± 81.4	112.4 ± 48.0	95.9 ± 32.1	92.7 ± 37.2	40.4 ± 20.3†	48.7 ± 13.7	51.7 ± 21.2

*Significant difference ($P \leq 0.05$) from SQ 90 and100%.
†Significant difference ($P \leq 0.05$) from SQ 100%.

required hyperextension at the lumbrosacral joint for a period of five seconds, while the current investigation required subjects to exert maximal force for three seconds against an immovable apparatus which was set at a 135° angle. Additionally, Escamilla et al. (14) analyzed only the greatest one second interval of muscle activity, while the current investigation analyzed muscle activity over the entire three second contraction.

Prior to this investigation, no previous study had attempted to compare trunk muscle activity in stability ball exercises to trunk muscle activity during the SQ and DL. The data from this investigation indicate that there are no significant differences in RA and OB muscle activity in these exercises. To further understand the intensity of stability ball exercises, muscle activity of the back extensors during QP, PT, and BE was expressed as a percentage of DL 1RM. Values were expressed relative to DL 1RM because it was the exercise which elicited the greatest amount of muscle activity for the back extensors. Furthermore, this method allows for implications to be made regarding training programs as most programs prescribe intensity as a percentage of a 1RM and not a percentage of a MVC. When expressed relative to DL 1RM, activity of L1 and L5 was found to be 19.5% and 30.2% during QP, 31.4% and 37.6% during PT, and 44.2% and 45.5% during BE. The level of stimulation of the back extensors during the SQ and DL was reliant on the percent of 1RM lifted and was between 56.4 and 98.6% for SQ and 70.2 and 100.0% for DL. Regardless of the load lifted, muscle activity of the back extensors was always greater during the free weight exercises.

A recent publication by Peterson et al. (25) analyzed the findings from two meta-analyses which included 177 studies concerned with the dose-response mechanisms for improving muscular strength. It was concluded that intensities of 60, 80, and 85% of 1RM are optimal for strength gains in untrained, recreationally-trained, and athletic-trained individuals. In the current investigation, it was discovered that muscle activity of the back extensors during the stability ball exercises ranged from 19.5 to 45.5% of that produced during DL 1RM. Since a direct relationship between the intensity of exercise and the percentage of maximal EMG activity has been previously established (2,10), it can be concluded that the stability ball exercises in this study may be of too low of an intensity to increase strength of the back extensors. Previous investigations have also concluded that the stimulus provided by stability ball exercises is of insufficient intensity to increase muscular strength (13,27), and as a result, they do not appear to provide a training advantage in healthy subjects (13). On the other hand, SQs and DLs, at the various loads lifted, stimulate the back extensors to an extent which may result in strength gains. The low amount of muscle activity during the stability ball exercises may also not be appropriate for muscular hypertrophy. When Campos et al. (8) examined the effects of resistance training programs of varied intensity on muscular characteristics, it was discovered that both low- and intermediate-repetition training groups experienced significant hypertrophy of Type I, Type IIa, and Type IIb muscle fiber types, whereas a high-repetition training group did not experience any hypertrophy. Since stability ball exercises are at an intensity which may allow for the completion of a high number of repetitions, they may not be appropriate for muscular hypertrophy of the back extensors. Furthermore, training programs consisting of stability ball exercises may not be effective in improving athletic performance (17). Stanton et al. (17) demonstrated that a 6-week stability ball training program did not significantly improve treadmill VO_2 max, running economy, or running posture. Conversely, the importance of structural free weight exercises, such as the SQ (6,8,16,17,26) and DL (26), in resistance training programs aimed at improving muscular strength (6,16–18,22,26), muscular hypertrophy (8,29), and running economy (18,22) has been previously established.

In conclusion, it was discovered that muscle activity of the back extensors was significantly greater in SQs and DLs when compared to stability ball exercises designed to activate the same muscles. Due to the low level of muscle activity in the stability ball exercises studied and because of the limited ability to load these movements, the role of stability ball exercises in training programs aimed at improving muscular characteristics of the back extensors and improving athletic performance is questioned. In order to determine the effectiveness of long-term stability ball and free weight training on muscular adaptations and athletic performance, further investigation is necessary.

Practical Applications

When the goal of a training program is to increase muscular strength and hypertrophy of the back extensors, strength and conditioning coaches and rehabilitators may find it more beneficial to include the SQ and DL exercises rather than stability ball exercises. It appears that SQs and DLs, at intensities as low as 50% of 1RM, are more challenging to the neuromuscular system than the stability ball exercises which were assessed in this investigation. Thus, it is recommended that strength and conditioning programs exclude, or limit the use of, stability ball exercises as they do not appear to provide a sufficient stimulus for improving muscular strength or hypertrophy and have not been found to improve measures relating to athletic performance (28). Additionally, the inability to increase the intensity of stability ball exercises, through external loading, may limit continuous muscular adaptations over an extended training period. Instead, strength and conditioning coaches should design programs which include structural multi-joint exercises such as the SQ and DL because the intensity of these two exercises can be continually altered through changes in external loading. Furthermore, since the SQ and DL are multi-joint exercises which require the work of several major muscle groups, it may also be more time efficient to prescribe these two exercises rather than numerous stability ball exercises.

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