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The Effect of Heavy- Vs. Light-Load Jump Squats on the Development of Strength, Power, and Speed

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ABSTRACT

The purpose of this investigation was to examine the effect of an 8-week training program with heavy- vs. light-load jump squats on various physical performance measures and electromyography (EMG). Twenty-six athletic men with varying levels of resistance training experience performed sessions of jump squats with either 30% (JS30, $n = 9$) or 80% (JS80, $n = 10$) of their one repetition maximum in the squat (1RM) or served as a control (C, $n = 7$). An agility test, 20-m sprint, and jump squats with 30% (30J), 55% (55J), and 80% (80J) of their 1RM were performed before and after training. Peak force, peak velocity (PV), peak power (PP), jump height, and average EMG (concentric phase) were calculated for the jumps. There were significant increases in PP and PV in the 30J, 55J, and 80J for the JS30 group ($p \leq 0.05$). The JS30 group also significantly increased in the 1RM with a trend towards improved 20-m sprint times. In contrast, the JS80 group significantly increased both PF and PP in the 55J and 80J and significantly increased in the 1RM but ran significantly slower in the 20-m sprint. In the 30J the JS30 group's percentage increase in EMG activity was significantly different from the C group. In the 80J the JS80 group's percentage increase in EMG activity was significantly different from the C group. This investigation indicates that training with light-load jump squats results in increased movement velocity capabilities and that velocity-specific changes in muscle activity may play a key role in this adaptation.

Key Words: EMG, jumping, sprinting, agility

Reference Data: McBride, J. M., T. Triplett-McBride, A. Davie, and R. U. Newton. The effect of heavy- vs. light-load jump squats on the development of strength, power, and speed. *J. Strength Cond. Res. 16(1):75–82. 2002.*

Introduction

Numerous studies have examined the effect of voluntary control of movement speed during weight training and studies on the involvement of plyometric training on power development (1, 14, 20, 21, 31). One of the primary points of contention on the development of power through resistance exercise has been the type of loading to be used (23). According to Wilson et al. (30) there are 2 conflicting ideas: (a) the perception that it is necessary to use heavy loads (80–100% of one repetition maximum [1RM]) to induce recruitment of high-threshold fast-twitch motor units on the basis of the size principle (22, 24), and (b) to train at a speed that is closer to the actual speed of dynamic athletic performance movements (using light loads [30–40% of maximal isometric force or 1RM]) to maintain training speed specificity and maximize mechanical power output (15, 16, 19, 26). A few studies have shown that greater improvements in maximal power output and jumping using lighter loads (30–40% of 1RM) (15, 30). One study reported that heavy load (80–100% of 1RM) training resulted in greater increases in movement speed and rate of force development over lighter load training (24). Thus, this issue remains unresolved.

Behm and Sale (3) have proposed that it is the intention to move a given load quickly and not the actual load that determines the training response. On the basis of the size principle of motor unit recruitment it is suggested that training with lighter loads does not result in the generation of forces high enough to cause sufficient muscle recruitment (22). Therefore, Behm and Sale (3) suggest that attempting to move a heavy load quickly may be the best method for improving speed-strength related movements and thus dynamic athletic performance. However, the study by Behm and Sale (3) is in contrast to other studies that found no effect of isometric or low-velocity concentric training on high-velocity strength (15, 17, 19). However, these investigations did not ask the subjects to accelerate the resistance as quickly as possible. No known investigations have compared heavy and light load training in which each group attempted to move the weight as fast as possible without a significant deceleration phase as occurs in traditional weight training.

Table 1. Subject characteristics.†

	JS30 (n = 9)		JS80 (n = 10)		C (n = 7)	
	Pre	Post	Pre	Post	Pre	Post
Age (y)	24.2 ± 1.8	—	21.6 ± 0.8	—	22.3 ± 1.8	—
Height (cm)	181.7 ± 3.5	—	179.5 ± 2.0	—	176.5 ± 3.0	—
Weight (kg)	84.4 ± 4.6	84.6 ± 4.7	80.5 ± 3.8	80.6 ± 3.9	79.1 ± 4.2	81.1 ± 3.7
Body fat (%)	11.7 ± 1.2	11.1 ± 1.1	10.7 ± 1.5	10.8 ± 1.6	12.5 ± 2.4	13.5 ± 2.4
Thigh girth (cm)	56.2 ± 1.8	56.6 ± 1.9	54.5 ± 1.6	55.5 ± 1.4*	55.2 ± 1.4	55.8 ± 1.0

† Values represent mean ± *SE*. Pre = before training; post = after training; JS30 = jump squats at 30% of 1 repetition maximum (1RM); JS80 = jump squats at 80% of 1RM; C = control.

* Significant difference from Pre to Post for that group ($p \leq 0.05$).

Adaptation of the nervous system mediating increases in muscle power has been investigated, indicating a differential response as to the changes observed with increasing muscle strength (8). It has been suggested that explosive movements typically used for the development of power result in high-frequency discharge of involved motor units and selective recruitment of high-threshold motor units in comparison with slow movements (4, 6, 11). The differences in the development of strength and power are supported by observation of electromyography (EMG)-force curves associated with different types of training (7, 10). Some evidence exists for velocity-specific changes in EMG, indicating the possible differential response of the nervous system to changes in muscle strength vs. muscle power (8). The previously mentioned factor of the intention to move quickly in a given movement may play a vital role in this type of adaptation (3). However, the speed at which a movement is performed may also result in differential nervous system adaptation. Therefore, the purpose of this investigation was to compare heavy- vs. light-load explosive resistance training (jump squats) and their effect on both vertical- and horizontal-plane physical performance measures and associated changes in muscle activity (EMG).

Methods

Subjects

This study involved a total of 26 male athletic subjects between the ages of 18 and 30 with 2 to 4 years of resistance training experience. Most subjects were also involved in some type of club-level sporting activities. Subjects were chosen that were not taking, and had not previously taken, anabolic steroids, growth hormone, or related performance-enhancement drugs of any kind. However, individuals were not eliminated if taking vitamins, minerals, or related natural supplements (other than creatine monohydrate). Each subject was required to fill out a medical history questionnaire that was, if needed, screened by a physician to eliminate individuals with contraindications for participating in the investigation. Prior approval by the Ethics Committee of Southern Cross University was obtained for this experiment. All subjects were informed of any risks associated with participation in the study and signed an informed consent document before any of the testing.

Study Design

This was a longitudinal study involving 3 groups (Table 1). Two treatment groups performed jump squats using either 30% (JS30) or 80% (JS80) of their previously determined 1RM in the squat exercise. The third group served as controls (C). Subjects were matched and assigned to a group on the basis of their 1RM squat-to-body weight ratio, ensuring that the average for each group was not significantly different. There were 2 testing periods lasting approximately 2 weeks separated by an 8-week training phase. The testing periods involved 2 separate days of testing (day 1 and day 2). Day 1 involved body composition testing, an agility T-test, and a 20-m sprint. On day 2 a 1RM squat test and jump squat testing were performed. EMG was utilized during the 1RM and jump squat testing. Before each testing session subjects rode a stationary bike for 5 minutes at a standard light resistance setting (105 W, Monark Bicycle Ergometer, Monark-Crescent AB, Varberg, Sweden). Approximately 2 minutes later the testing began. Reliability data was collected for certain dependent variables 1 month before testing on a separate group of subjects not related to this investigation. Intraclass coefficient and technical error data is supplied with dependent variables below.

Training Protocol

All training was performed using a Smith machine similar to what has been previously described (30). This Smith machine was fitted with a braking system that minimized the eccentric load during the jump-squat training. In addition, a position transducer (Celesco Transducer Products, Chatsworth, CA) was attached to the bar to record bar displacement. The displacement measurements were used to determine peak power (PP) output, jump height (JH), and work for each repetition using a computer program written in Visual Basic (Microsoft Corporation, Seattle, WA). The training phase for the 2 treatment groups involved a one-on-one supervised workout twice per week. Both groups performed a warm-up stationary bike ride for 5 minutes at a standard light resistance setting (105 W, Monark Bicycle Ergometer). Approximately 2 minutes later the training began. The JS30 group then performed 1 warm-up set of jump squats of 6 repetitions with the bar (25 kg). The JS30 group then proceeded to perform a series of 5 sets of jump squats with 30% of their 1RM. The JS80 group performed 2 warm-up sets of jump squats, one with the bar and then another with 50% of their 1RM. In each warm-up set they performed 6 repetitions. The JS80 group then performed a series of 4 sets of jump squats with 80% of their 1RM. The number of sets for each group was chosen in an attempt to equate overall work loads at the end of the training period. The number of repetitions performed in each set after the warm-up sets was determined by a decrease in PP output of 15%. The cutoff level of 15% was chosen as an arbitrary point corresponding to a significant decrease in bar velocity consistent between both groups. Three minutes of rest was allowed between every set. Each repetition was performed by squatting to a knee angle of 80° and then exploding upwards and jumping to a maximal height. Subjects moved the bar as quickly as possible for each and every repetition, exerting as much force as possible as quickly as possible. The C group performed no additional training and were told to maintain their usual daily activity regimen between the testing periods. The 3 groups were instructed not to perform any specific explosive lower body training, sprinting, or jumping other than the training they had already been involved with as part of their ongoing athletic activities. Lower body activity logs were obtained from all the subjects to ensure that lower body activity patterns remained constant.

1RM Testing

This test was modified slightly from established protocols previously described (27). This test was performed using a standard Smith machine. A number of warm-up trials were given in the 1RM test protocol using 30% (8–10 repetitions), 50% (4–6 repetitions), 70% (2–4 repetitions), and 90% (1 repetition) of an estimated 1RM either from the subject's recommendation or 2–2.5 times the subject's body weight. From this point the weights were increased to a point where the individual had 3–4 maximal efforts to determine the 1RM (ICC [intraclass correlation coefficient] = 0.998, %TEM [technical error of measure percentage] = 1.66). Each subject was asked to lower the bar to the point where the knee angle was 80°, which was marked by adjustable stoppers. Adequate rest was allowed between trials (3–5 minutes).

Jump-Squat Testing

This testing involved performing a jump squat in a standard Smith machine over a force plate (Kistler type 9287, Kistler Instrument Corporation, Amherst, MA) with a position transducer (Celesco Transducer Products) attached to the bar. Two warm-up trial jumps, with only the bar, were completed. Test loads of 30% (30J), 55% (55J), and 80% (80J) of the individual's 1RM were used. Performance of the jump squat involved a rapid but controlled lowering of the bar to a knee angle of 80°, which was marked by adjustable stoppers. They were told when they reached the bottom portion of the movement to immediately accelerate upwards as fast as possible, attempting to jump for maximum height (JS30, ICC = 0.625, %TEM = 5.89) (JS55, ICC = 0.933, %TEM = 4.67) (JS80, ICC = 0.955, %TEM = 4.69). Two trials were performed for the jump squat at each given load, preceded by 4 warm-up trials with only the bar (25 kg). The force and displacement measurements were used to determine peak force (PF), peak velocity (PV) and PP output using a computer program (Visual Basic) applying standard biomechanical methods. The ICC for the calculation PF, PV, and PP are 0.989 (%TEM = 2.68), 0.560 (%TEM = 2.93), and 0.936 (%TEM = 6.14) respectively.

Electromyography

EMG was used during the 1 RM, 30J, 55J, and 80J. A silver/silver chloride preamplified surface electrode module (Quantec, Brisbane, Australia) was attached over the belly of the vastus lateralis muscle distal to the motor point. Each module contained 2 active electrodes and 1 reference electrode equidistant at 2 cm. All modules were appropriately applied to the target muscle with active electrodes aligned parallel to the muscle fibers. Electrode placement was carefully measured and marked to ensure placement in the exact same position for both before-training (Pre) and after-training (Post) testing. This laboratory has previously reported high levels of interday reliability for integrated EMG measurements (28). The amplified myoelectric signal was recorded using a computer and analog-to-digital card (C10-DAS80, Computer Boards, Mansfield, MA) and stored on a computer disk for later analysis. Average EMG (mv) for the 1RM and the jump squats (30J, 55J, 80J) was calculated by full-wave rectification and averaged over the concentric phase.

Agility T-Test and 20-M Sprint

The agility T-test (AGT) involved a series of forward, backward, and lateral movements to navigate a T-shaped course marked by cones (25) (ICC = 0.914, %TEM = 2.09). The 20-m sprint involved a standing start. The subjects were asked to accelerate as quickly

Table 2. Training protocol and squat strength (1RM).†

	JS30		JS80		C	
	Pre	Post	Pre	Post	Pre	Post
Workouts (no.)	—	13.7 ± 0.6	—	13.4 ± 0.5	—	—
Total sets (no.)	—	81.4 ± 3.2	—	80.1 ± 2.8	—	—
Total reps (no.)	—	529.9 ± 24.8	—	459.1 ± 23.2	—	—
Total work (J)	—	168,876 ± 15,011**		240,919 ± 21,590		—
1RM (kg)	145.8 ± 9.8	157.8 ± 10.2*	152.3 ± 10.1	167.8 ± 10.3*	146.8 ± 8.1	155.0 ± 7.5
1RM/weight ratio	1.74 ± 0.10	1.87 ± 0.09*	1.90 ± 0.10	2.09 ± 0.08*	1.89 ± 0.13	1.94 ± 0.11

† 1RM = 1 repetition maximum; JS30; jump squats at 30% of 1RM; JS80 = jump squats at 80% of 1RM; C = control. Values represent mean ± *SE.*

* A significant difference from Pre to Post for that group.

** A significant difference between the JS30 group and the JS80 group ($p \leq 0.05$).

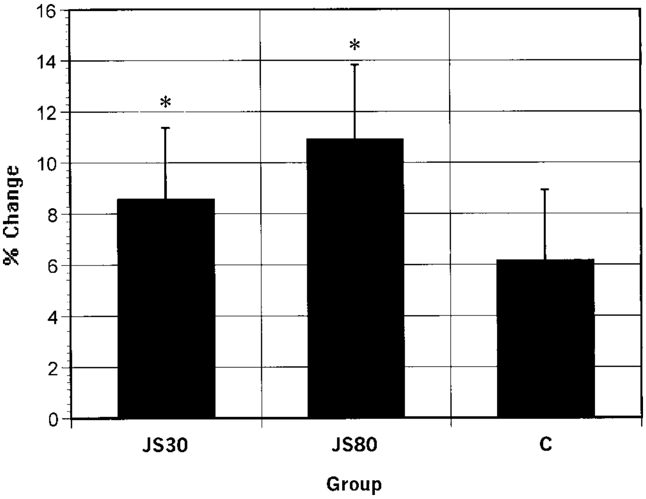

Figure 1. Percentage change in maximum squat strength (1RM) from before training (Pre) to after training (Post). * = significant difference from Pre to Post for that group ($p \leq 0.05$).

as possible through a series of 4 timing gates that instantaneously measured the time at 5 m (SPRG1), 10 m (SPRG2), and 20 m (SPRG3) (ICC = 0.847, %TEM = 1.98). Two minutes of rest was allowed between each trial and 5 minutes of rest was allowed between the different tests.

Body Composition

Skinfold measurements were obtained with Harpenden skinfold calipers (British Indicators Ltd., Herts, England) and estimates of percentage of body fat and lean body mass were determined (13). Thigh girth, height, and weight were also recorded for each subject.

Statistical Analyses

A general linear model–repeated-measures analysis with a Bonferroni post hoc test was used to determine between- and within-group differences. A one-way analysis of variance was used to determine significant differences between the groups in percentage change. Pearson correlation coefficients were determined for selected variables. The criterion α level was set at $p \leq 0.05$. An estimate of effect size $\eta^2 = 0.569$ at an observed power level of 1.0 for the 1RM. An estimate of effect size $\eta^2 = 0.387, 0.371, 0.164, 0.170$ at an observed power of 0.954, 0.941, 0.530, 0.547 for PF, PP, PV, and JH respectively for the 30J. An estimate of effect size $\eta^2 = 0.235, 0.441$ at an observed power level of 0.578, 0.931 for average EMG during the 30% and 80% jump squats, respectively. All statistical analyses were performed through the use of a statistical software package (SPSS, Version 8.0, SPSS Inc., Chicago, IL).

Results

Subject Characteristics

There were no significant differences between or within the groups for any of the subject characteristic variables, except for thigh girth, at Pre or Post (Table 1). Thigh girth significantly increased in the JS80 group from Pre to Post.

Training Protocol

There was no significant difference between the number of workouts or the total number of sets (including warm-up sets) or repetitions performed between the JS30 and JS80 groups (Table 2). There was a significant difference between total work performed between these 2 groups. However, no significant correlations between total work and changes in relevant performance variables were found.

Squat (1RM)

There was a significant increase in the 1RM for the JS30 and JS80 groups from Pre to Post (Figure 1). There was also a significant increase in the 1RM-to-body weight ratio (1RM/weight ratio) for the JS30 and JS80 group (Table 2).

Jump Squats

The JS30 group significantly increased PP, PV, and JH in the 30J (Figure 2). The percentage increase in JH in

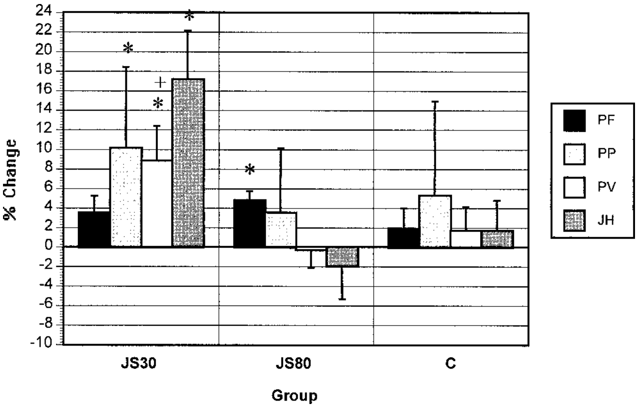

Figure 2. Percentage change in peak force (PF), peak power (PP), peak velocity (PV), and jump height (JH) from before training (Pre) to after training (Post) for the 30% jump-squat test (30J). * = significant difference from Pre to Post for that group. + = significant difference between the JS30 group and the JS80 group ($p \leq 0.05$).

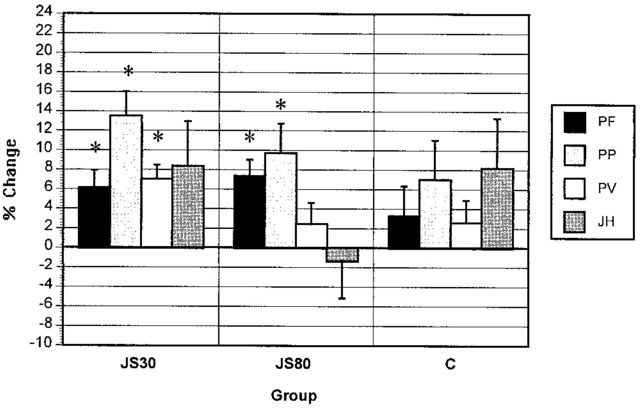

Figure 3. Percentage change in peak force (PF), peak power (PP), peak velocity (PV), and jump height (JH) from before training (Pre) to after training (Post) for the 55% jump-squat test (55J). * = significant difference from Pre to Post for that group ($p \leq 0.05$).

the JS30 group was significantly higher in comparison with the JS80 group. The JS80 group significantly increased PF in the 30J.

In the 55J the JS30 group significantly increased PF, PP, and PV, whereas the JS80 group significantly increased PF and PP (Figure 3).

In the 80J the JS30 group increased PF, PP, and PV, whereas the JS80 and C group increased in PF and PP (Figure 4).

There were no significant differences between the groups for PF, PV, PP, or JH at Pre or Post (Table 3).

Electromyography

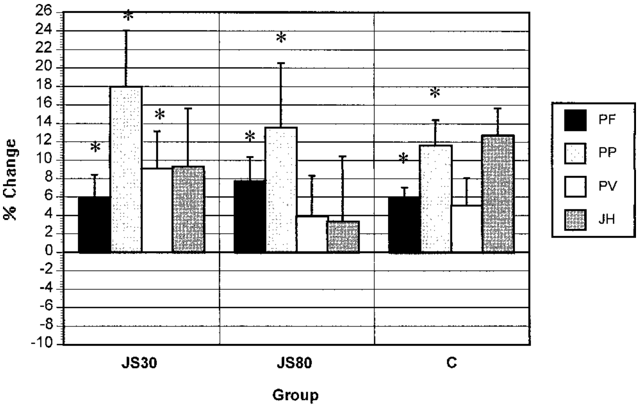

Figure 4. Percentage change in peak force (PF), peak power (PP), peak velocity (PV), and jump height (JH) from before training (Pre) to after training (Post) for the 80% jump-squat test (80J). * = a significant difference from Pre to Post for that group ($p \leq 0.05$).

The average EMG for the concentric phase significantly increased in the 55J, 80J, and 1RM for the JS30 and JS80 groups (Figure 5). However, the JS30 group also significantly increased average EMG during the 30J. There were no significant changes in average EMG during the concentric phase during any of the tests for the C group. The percentage change in average EMG was significantly higher in the JS30 in comparison with the C group for the 30J and was significantly higher in the JS80 in comparison with the C group for the 80J.

Agility T-Test and 20-m Sprint

The JS30 group significantly decreased AGT from Pre to Post (Figure 6). The percentage change in SPRG2 was significantly different between the JS30 and JS80 groups. The JS80 group significantly decreased AGT also. However, there was a significant increase in SPRG1 from Pre to Post for the JS80 group.

There was no significant difference in AGT, SPRG1, SPRG2, or SPRG3 between the groups at either Pre or Post (Table 4).

Discussion

The most significant finding in this investigation was that the speed at which an individual trains, as controlled by load, results in a velocity-specific change in muscle electrical activity. In addition, this load-controlled velocity training appears to have a differential effect on force, velocity, and power variables relating to physical performance.

Load-controlled velocity training means that the subjects, regardless of which training group they were in, tried to move the bar as quickly as possible for each repetition. The amount of weight on the bar therefore determined at what velocity the training would occur. The JS80 group had a heavy load on the bar so they trained at a much slower velocity than the JS30 group, which had a light load on the bar. The JS30 group had an overall trend of improved velocity capabilities regardless of the load in the jump-squat tests. Significant increases in peak bar velocity for the JS30 group oc-

Table 3. Jump squats.*

	JS30		JS80		C	
	Pre	Post	Pre	Post	Pre	Post
30J						
PF (N)	2151.3 ± 103.8	2227.4 ± 115.3	2158.9 ± 95.6	2263.3 ± 101.3	2155.1 ± 70.5	2191.3 ± 58.9
PV ($m \cdot s^{-1}$)	1.73 ± 0.65	1.87 ± 0.33	1.85 ± 0.40	1.84 ± 0.29	1.84 ± 0.31	1.86 ± 0.41
PP (W)	3554.0 ± 207.7	3908.8 ± 235.9	3748.4 ± 180.6	3858.9 ± 148.9	3699.4 ± 128.6	3873.9 ± 101.9
JH (cm)	20.3 ± 1.2	23.4 ± 1.0	21.9 ± 0.8	21.3 ± 0.5	23.3 ± 0.8	23.6 ± 0.7
55J						
PF (N)	2378.0 ± 117.9	2520.8 ± 125.3	2434.6 ± 107.7	2614.1 ± 122.1	2423.9 ± 94.1	2490.7 ± 76.3
PV ($m \cdot s^{-1}$)	1.37 ± 0.20	1.47 ± 0.23	1.41 ± 0.31	1.44 ± 0.37	1.42 ± 0.28	1.46 ± 0.30
PP (W)	3113.1 ± 178.1	3517.3 ± 180.3	3265.8 ± 129.7	3569.5 ± 139.9	3252.3 ± 11.4	3455.4 ± 74.8
JH (cm)	15.5 ± 0.7	16.6 ± 0.6	15.7 ± 0.5	15.4 ± 0.7	16.1 ± 0.9	17.3 ± 0.6
80J						
PF (N)	2653.1 ± 133.2	2801.9 ± 133.7	2697.7 ± 133.9	2891.5 ± 124.8	2651.6 ± 89.3	2805.1 ± 79.5
PV ($m \cdot s^{-1}$)	1.05 ± 0.40	1.14 ± 0.28	1.07 ± 0.39	1.11± 0.39	1.07 ± 0.23	1.12 ± 0.31
PP (W)	2635.3 ± 153.6	3067.3 ± 151.5	2766.9 ± 170.2	3050.7 ± 104.0	2704.3 ± 77.2	3010.4 ± 80.1
JH (cm)	11.3 ± 0.6	12.1 ± 0.5	11.2 ± 0.9	11.1 ± 0.6	11.6 ± 0.6	13.0 ± 0.6

* Values represent mean ± *SE*. Significant differences between Pre and Post are indicated in Figures 2, 3 and 4. JS30 = jump squat at 30 of 1 repetition maximum (1RM); JS80 = jump squats at 80% of 1RM; C = control; Pre = before training; Post = after training; 30J, 55J and 80J = agility test, 20-m sprint, and jump squats with 30%, 55%, and 80% of the 1RM.

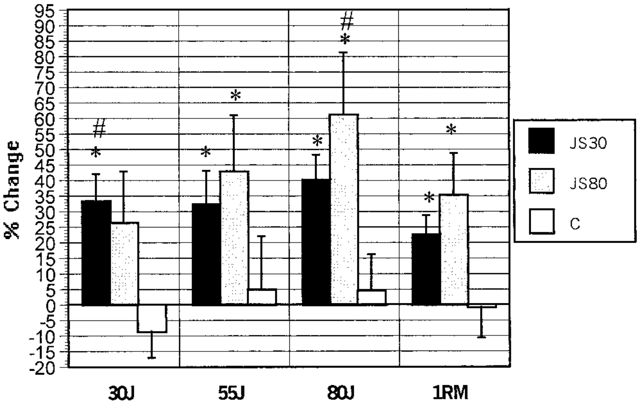

Figure 5. Percentage change in average electromyogram (EMG) from the vastus lateralis for the concentric phase of the one repetition maximum test (1RM) and the 30% (30J), 55% (55J), and 80% (80J) of the 1RM jump-squat tests. * = significant difference from before training (Pre) to after training (Post) for that group. # = significant difference from the control (C) group ($p \leq 0.05$).

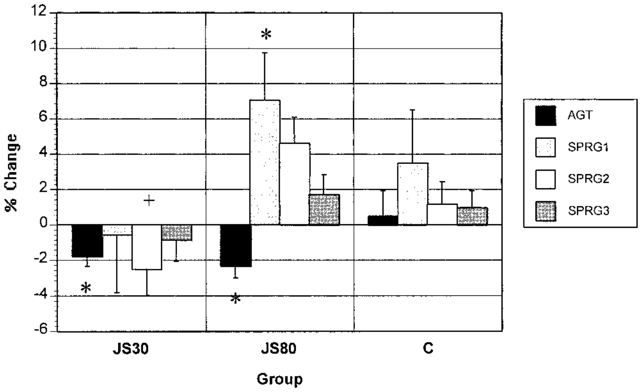

Figure 6. Percentage change from before training (Pre) to after training (Post) in the time to complete the agility test (AGT) and the time to reach gate 1 (SPRG1) (5 m), gate 2 (SPRG2) (10 m), and gate 3 (SPRG3) (20 m). * = significant difference from Pre to Post for that group. + = significant difference between the JS30 group and the JS80 group ($p \leq 0.05$).

curred at all of the testing loads (30J, 55J, 80J), which did not occur in the JS80 group. Alternatively, the JS80 group showed a trend toward greatly improved force capabilities but a negligible, and in some instances a negative, effect on velocity capabilities, again regardless of the load in the jump-squat test. The JS80 group had significant improvements in peak force at all the testing loads (30J, 55J, 80J); the JS30 group did not. Thus, the data from this investigation is in contradiction to velocity specificity, which has been largely supported by isokinetic data (see review, 4). One prior investigation also used load-controlled velocity in an elbow flexor exercise with training loads of 0, 30, 60, and 100% of maximum isometric force (15). The group that trained with 30% of the maximum isometric force showed improved velocity capabilities over the whole range of the testing loads (10, 20, 30, 45, 60% of maximum isometric force), similar to our investigation. The study also showed that only the 60% and 100% training groups significantly improved isometric force. However, it was unclear from the study if force output changed at each load tested in the 60% and 100% training groups.

It is acknowledged that in the load-controlled ve-

Table 4. Agility T-test (AGT) and 20-m sprint.†

	JS30		JS80		C	
	Pre	Post	Pre	Post	Pre	Post
AGT (s)	11.10 ± 0.16	10.91 ± 0.16	10.97 ± 0.20	10.71 ± 0.18	10.80 ± 0.19	10.84 ± 0.17
SPRG1 (s)	1.12 ± 0.03	1.11 ± 0.03	1.09 ± 0.03	1.16 ± 0.02	1.10 ± 0.04	1.13 ± 0.03
SPRG2 (s)	1.91 ± 0.04	1.88 ± 0.04	1.84 ± 0.03	1.93 ± 0.02	1.87 ± 0.04	1.89 ± 0.03
SPRG3 (s)	3.27 ± 0.05	3.24 ± 0.04	3.19 ± 0.05	3.24 ± 0.04	3.18 ± 0.05	3.21 ± 0.05

† Values represent mean ± *SE*. Significant differences between Pre and Post are indicated in Figure 6. JS30 = jump squats at 30% of 1 repetition maximum (1RM); JS80 = jump squats at 80% of 1RM; C = control; Pre = before training; Post = after training; SPRG1 = time measured at 5 m; SPNG2 = time measured at 10 m; SPRG3 = time measured at 20 m.

locity testing (jump squats with 30, 55, and 80% of the 1RM) the JS80 group had an opportunity at the beginning of the movement to generate force while the bar was moving slowly. This is in contrast to semi-isokinetic testing in which the velocity is more constant throughout the entire range of motion. However, the training and testing model used in this investigation is more applicable to dynamic athletic performance in which velocity changes over the course of a specific movement (12, 29). This may indicate why previous investigations have found both heavy and light resistance training to be effective in improving athletic performance (8, 9). However, closer analysis may reveal that heavy resistance training is effective at increasing initial acceleration while the movement velocity is slow, but light resistance training increases acceleration capabilities during the higher velocity component of the movement (20, 32). This may indicate why the JS80 group significantly improved in the agility test but performed significantly worse in the sprint. The T-test in this study consisted of frequent stopping and starting and thus the high velocity aspect of the sprint test was not present. It is acknowledged that some changes in these variables were also observed in the control group. However, this group was performing club sport-type activities that may have influenced these variables independent of the effects of the testing protocol itself. The lack of change in EMG in the control group supports this concept in that the changes in strength and power in the control group were not specific to the treatment but a result of outside activity.

The results of this investigation are supported by a previous cross-sectional analysis of various athletes (16). This study reported that sprinters had the ability to produce high velocities during testing. However, although power lifters had the ability to produce large forces, they had a relatively low ability to produce high velocities. The patterns of velocity and force capabilities were more pronounced between these groups at testing loads closer to the load at which each group trained. However, the pattern of velocity or force capabilities unique to each group was observable over all the testing loads. The current investigation also found associated patterns of velocity capabilities during the nonspecific testing of sprint times, with the JS30 group showing clear trends toward being faster and the JS80 group being significantly slower. The trend in sprint times found in this investigation is supported by a similar study involving sprint, high-velocity, and high-resistance training over a 9-week period (5). It was reported that whereas high-velocity training improved sprint times, high-resistance training had no effect.

Behm and Sale (3) have indicated that it may be the intention to move quickly and not the actual movement speed that determines the velocity-specific response. Therefore, it has been suggested that when training for dynamic athletic performance the movement speed is not important as long as the intent of the muscle action is explosive (2). The current investigation does not support that conclusion. Both groups in this study were given specific instructions to initiate the movement as quickly as possible. In addition, each group performed the movement with no voluntary deceleration in the concentric phase. Therefore, it appears that the actual velocity of training, as indicated by the JS30 group, is a vital component of producing high-velocity capabilities.

Practical Applications

Very little comparative literature exists concerning velocity-specific changes in muscle activity with resistance training. However, one of the primary investigations in this area reported differential velocity-specific changes in muscle activity between strength training and explosive high-velocity training (8). Increases in muscle electrical activity were seen primarily at the velocity of training (8). Another study has suggested the possible importance of high-velocity muscle activation capabilities and the ability to perform high-velocity activities (18). The findings from the current investigation are consistent with these previous findings. Training with a specific load and thus velocity results in velocity-specific increases in muscle activation. Thus, it appears that the velocity of the movement, as controlled by the load, plays a key role in improving high-velocity performance capabilities and possible neural mechanisms of adaptation. However, it cannot be determined from this investigation as to the specific mechanisms responsible for the observed patterns of velocity-specific increases in EMG activity. Mechanisms for velocity-specific responses in muscle electrical activity with exercise training must be further explored.

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