The effect of short duration high load strength training on international level long jumper

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BACKGROUND

Power is fundamental to elite athletic performance (J. Cronin & Sleivert, 2005; Frost, Cronin, & Newton, 2010). Increasing either maximum force or velocity, or both can increase maximum power. Strength training programs designed to increase maximum strength and power commonly last 8-12 weeks (J. Cronin & Sleivert, 2005). It is difficult to obtain information about effective maximum strength training programs for track and field athletes at the international level. The purpose of this case study was to study the effect of a high load short duration maximum strength-training program on power in an international track and field (long jump) athlete.

METHODS

One subject (31 years) international level long jumper, personal best long jump 8,25 m, participated in six training sessions over 3 weeks. The equipment used in the training was a 1080 Quantum Syncro (1080 Motion AB, Stockholm, Sweden), which includes two 1080 Quantum and a smith rack. The robotic technology embedded in 1080 Quantum allows for different resistance settings, and the ability set load and velocity independent in the concentric and eccentric phase of a movement, in this case a single leg squat. Concentric phase; (121 kg) and 4 m/s, eccentric phase 141 kg and 4 m/s. Force, velocity, power and distance measures were obtained with MuscleLab (Ergotest Innovation, Porsgrunn, Norway) and 1080 Quantum.

RESULTS

There was an increase in all dependent variables measured, in particular there was in increase in concentric power (15,8 and 12,1%) and a decrease in time to peak velocity (37,7 and 38,2%) left and right respectively. Overall, there was a greater improvement for the dependent variables in the left lower extremity.

DISCUSSION

Power increased, and time to peak velocity decreased as a result of max strength training program, 6 sessions in 3 weeks, in an international level long jumper. The increase in power seems to be due to changes in velocity and not force, since greater changes were found in velocity. The left lower extremity improved more than the right for most of the measurements. This could be explained by the right lower extremity being the dominant/jumping foot.

CONCLUSION

This case study shows that power can be improve by short intense maximum strength training in an international level long jump athlete.

1. BACKGROUND

Power is fundamental to elite athletic performance (J. Cronin & Sleivert, 2005; Frost et al., 2010). Both maximum force and velocity will increase power ($P=F\cdot v$), and it has been found that maximum power occur at about 25% and 33% of maximum force and velocity respectively (Frost et al., 2010). However, the interaction between force and velocity might be more complex with variable results found based upon singular or multiple joints, region or movement used (J. Cronin & Sleivert, 2005; Frost et al., 2010). Increasing maximum force or velocity, or both, can increase maximum power. Increasing maximum force will lead to a vertical shift of the power curve, whereas an increase in maximum velocity will not only shift the power curve vertically, but also horizontally to the right (Frost et al., 2010).

Maximum power in the lower extremity extensor apparatus has been found to be an important factor in power development with and important to athletic performance such first step quickness (0-5m), acceleration (0-10m) (Baker & Nance, 1999) and maximal top velocity (30m) (J. B. Cronin & Hansen, 2005). Consequently, finding effective maximum strength training programs that will enhance power is important. Training programs to increase maximum strength and power commonly last 8-12 weeks (J. Cronin & Sleivert, 2005). To the authors' knowledge, no studies on the effect of maximum strength training program on elite long jumpers have been published. The purpose of this case study was to study the effect of high load short duration strength training program on power in an international level long jumper.

2. METHODS

One male subject (31 years) with personal best long jump 8.25 m, right jumping foot, participated in six training sessions over 3 weeks. Training was conducted using 1080 Quantum Syncro (1080 Motion AB, Stockholm, Sweden). The robotic technology that this system is based upon allows for independent control of load and velocity in the concentric and eccentric phase of a given movement or exercise. Furthermore, the system offers accurate measures of distance, time, velocity, force and power (http://www.1080motion.com). This allows for highly accurate documentation of training load, time and linear distance for a given exercise.

1080 Quantum Syncro was used for single leg half-squats for both left and right lower extremity. The load was set to 121 and 141 kg in the concentric and eccentric phase respectively. Velocity was set to 4 m/s in both phases. 4 sets of 5 repetitions were performed on each leg, with 10 minutes rest between sets. There were a total of 6 training sessions over a 3-week period.

Force, power and velocity was measured using two MuscleLab 4010 units (Ergotest Innovation, Porsgrunn, Norway) and 1080 Quantum in each training session. All measures were calculated from the 20 repetitions, left and right, performed in each session. All dependent variables measured are presented in Table 1.

Table 1. Dependent variables

Measurement	Descriptions	Method	Unit	Equipment
AP	Average concentric power	Load: 121 kg; Velocity: 4 m/s; Measurement: average power of 20 repetitions	Watt (W)	MuscleLab 4010
APn	Average eccentric power	Load: 141 kg; Velocity: 4 m/s; Measurement: average power of 20 repetitions	Watt (W)	MuscleLab 4010
AF	Average concentric force	Load: 121 kg; Velocity: 4 m/s; Measurement: average force of 20 repetitions	Force (N)	MuscleLab 4010
AFn	Average eccentric force	Load: 141 kg; Velocity: 4 m/s; Measurement: average force of 20 repetitions	Force (N)	MuscleLab 4010
AV	Average concentric velocity	Load: 121 kg; Velocity: 4 m/s; Measurement: average velocity of 20 repetitions	Meter per second (m/s)	MuscleLab 4010
AVn	Average eccentric velocity	Load: 141 kg; Velocity: 4 m/s; Measurement: average velocity of 20 repetitions	Meter per second (m/s)	MuscleLab 4010
pV	Peak concentric velocity	Load: 121 kg; Velocity: 4 m/s; Measurement: average peak concentric velocity of 20 repetitions	Meter per second (m/s)	MuscleLab 4010
tpV	Time to peak concentric velocity	Load: 121 kg; Velocity: 4 m/s; Measurement: average time to peak concentric of 20 repetitions	Time (s)	MuscleLab 4010
D	Distance concentric phase	Load: 121 kg; Velocity: 4 m/s; Measurement: average distance 20 repetitions	Distance (cm)	MuscleLab 4010
Dn	Distance eccentric phase	Load: 141 kg; Velocity: 4 m/s; Measurement: average distance 20 repetitions	Distance (cm)	MuscleLab 4010

The training sessions were scheduled from 21.11.2013 (session 1) to 12.12.2013 (session 6)

RESULTS

Total training time for the six sessions was 174,6 seconds with total time of 29.1±2.2 seconds each session. Time was divided between the concentric (43,8 and 43,3 seconds) and eccentric phase (44.8 and 42.7 seconds) for the left and right lower extremity respectively. Average distance in the concentric phase, left 16.6±1.2 and right 15.4±1.7 cm, and eccentric phase, left 15.7±1.0 and right 14.7±1.3 cm, showed similar values. The total load lifted was 62880 kg, with 29040kg and 33840 kg in the concentric and eccentric phase respectively. Based upon total load lifted each session and time used per session the average kilogram lifted per second was 362±26.6 kg/s. There was a gradual increase in kg/s lifted from session 1 to 6 as depicted in Figure 1 below.

Figure 1. kilgram per second lifted in the different sessions

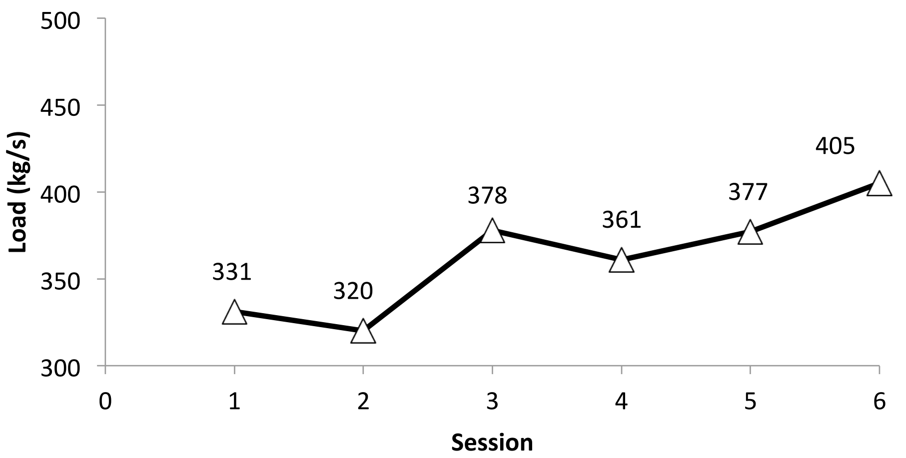


Figure 2 shows intra session variability of concentric power for 20 repetitions for the left leg (1035±63) in session 6.

Figure 2. Concentric power left in session 6

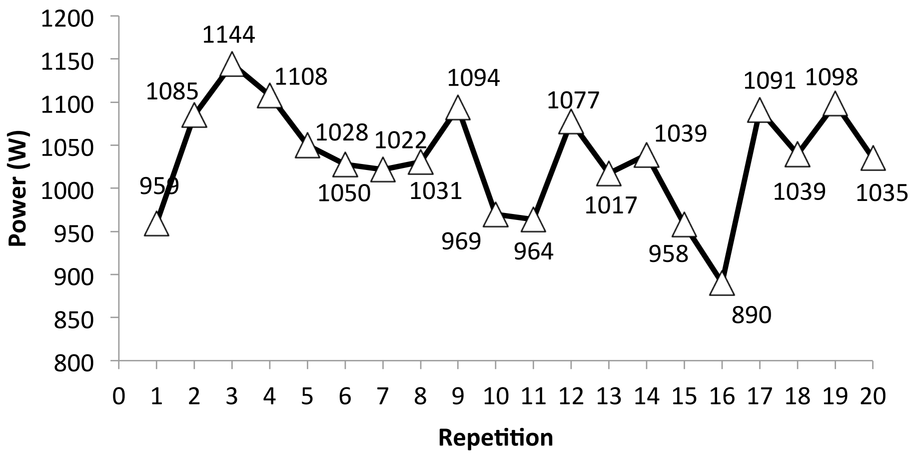


Figure 3-6 shows a consistent improvement of average concentric and eccentric power and force from session 1 to 6 in both left and right single leg squat.

Figure 3. Average concentric power

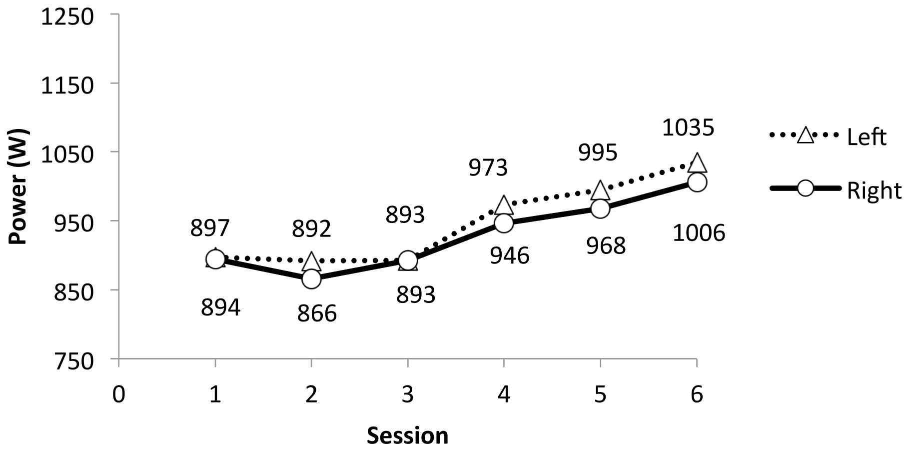


Figure 4. Average eccentric power

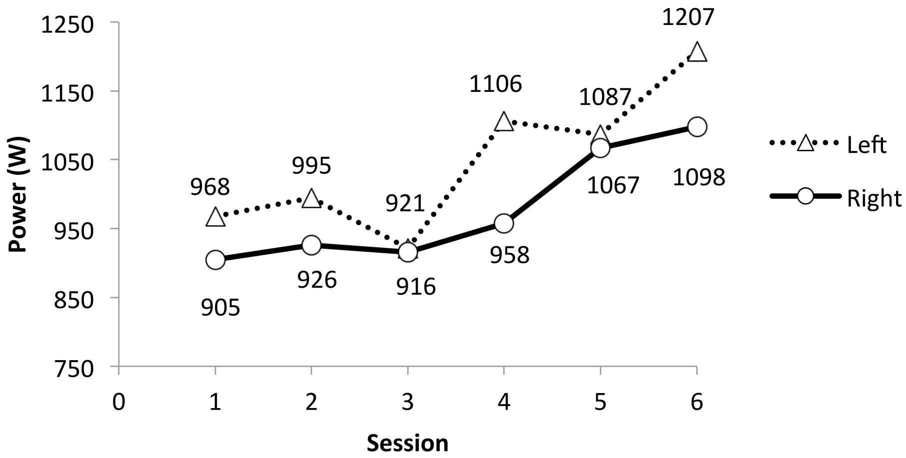


Figure 5. Average concentric force

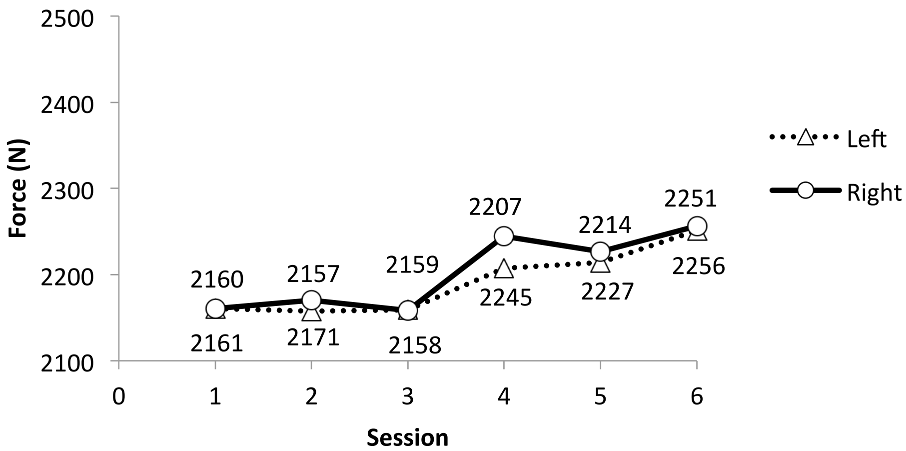


Figure 6. Average eccentric force

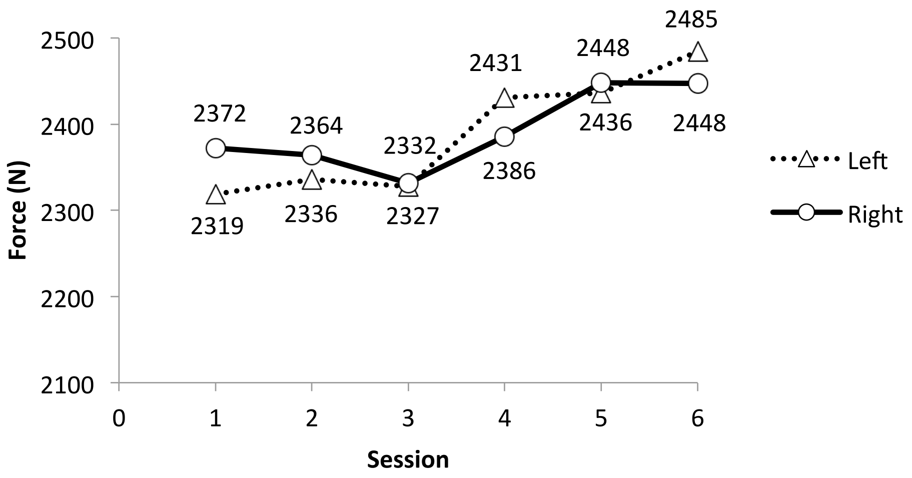


Figure 11 shows the percentage increase in concentric and eccentric power and force from session 1 to 6, with the left generally increasing more for both power and force.

Figure 7 and 8 shows how average velocity change for the concentric and eccentric phase respectively, where figure 11 summarize how velocity improved more for the left lower extremity.

Figure 7. Average concentric velocity

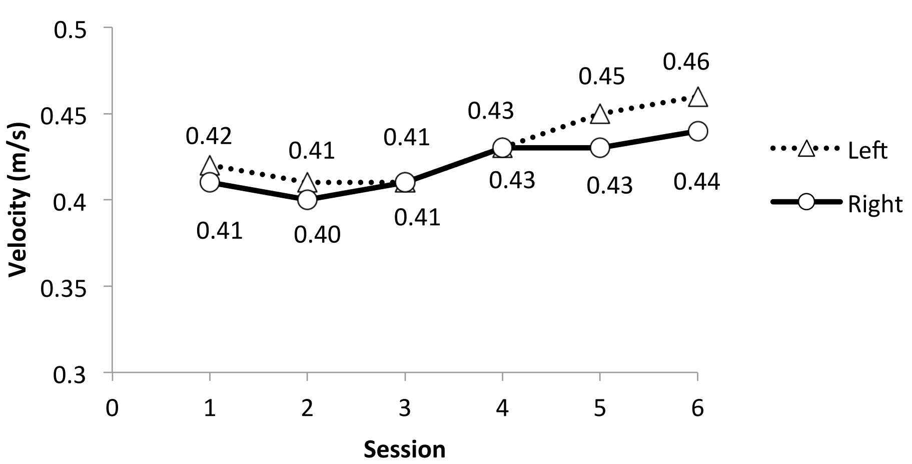
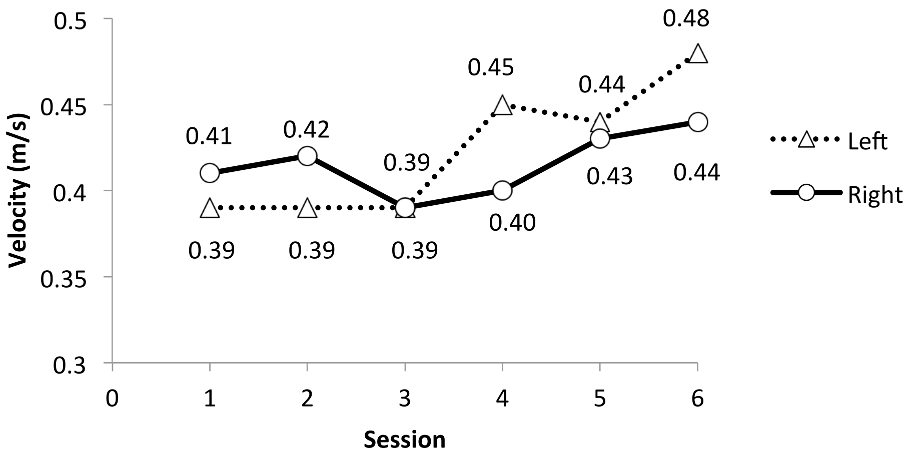
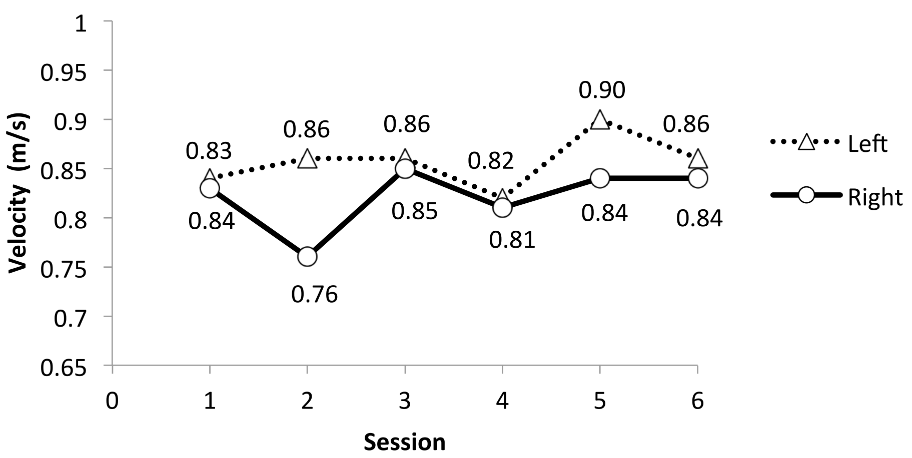


Figure 8. Average eccentric velocity



Peak velocity showed only had a minimal change (Figure 9), with the left showing a slightly greater improvement than the right (Figure 11).

Figure 9. Average peak concentric velocity



However, the time to peak velocity did decrease (Figure 10), with minimal difference in change for both the left and right lower extremity (Figure 11).

Figure 10. Time to peak concentric velocity

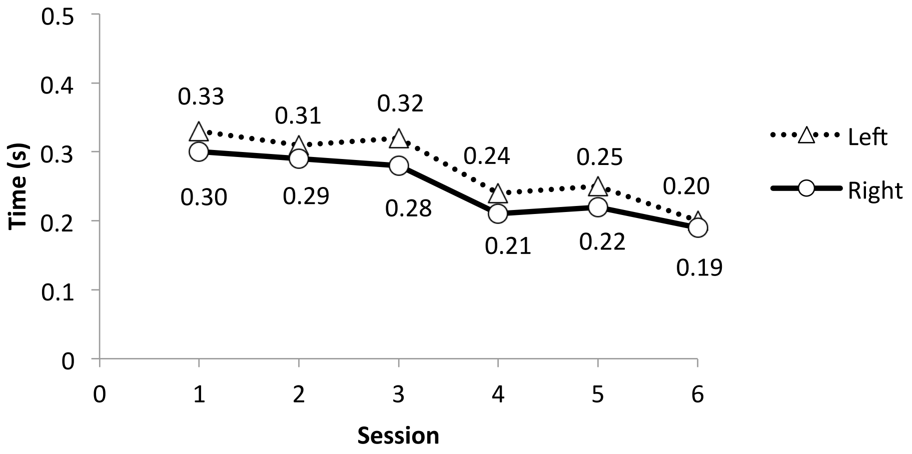
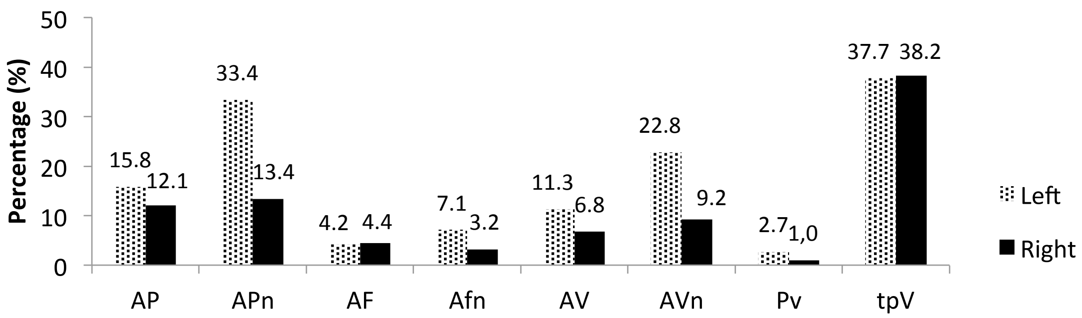


Figure 11. Effect of 3 weeks max strength training



AP=concentric power; APn=eccentric power; AF=concentric force; AFn=eccentric force; AV=concentric velocity; AVn=eccentric velocity; Pv=peak concentric velocity; tpV=time to peak concentric velocity

DISCUSSION

Both force and velocity, thus power increased, and time to peak velocity decreased as a result of a maximum strength-training program, 6 sessions in 3 weeks, in an international level long jumper. The greatest increases were found in both concentric (15.8 and 12.1%) and eccentric power (33.4 and 13.4%) and time to peak velocity (37.7 and 38.2%) left and right respectively. The increases in power seems to be due to changes in velocity and not force, since greater changes were found in velocity. Absolute changes in concentric velocity from session 1 to 6 showed small absolute values, 0.04 and 0.03 m/s left and right respectively, which requires excellent reliability of the measurement device. Reliability for force, velocity and power measures of the MuscleLab 4010 unit has been found to be excellent (Hilmersson, Edvardsson, & Tornberg, 2015)

The left lower extremity improved more than the right for most of the measurements. This can be explained by the right lower extremity being the dominant/jumping foot. This lower extremity might be getting more specific power training due to jumping practice, and might therefore not respond as much to this type of training. However, then one might expect the right lower extremity to show greater force, velocity and power at session 1, which was not found. The right lower extremity during the first session had similar values to that of the left with the exception of greater eccentric strength, less eccentric power and time to peak velocity was less. This symmetry can be explained by that much training is symmetrical, and that sprinting leading up to the jump has symmetrical requirements. The only asymmetrical behavior is the jump itself.

Furthermore, how the training was distributed, time and vertical displacement, on the left and right side could also influence the result. The time spent in the concentric and eccentric phase was similar. However, the vertical displacement in the right single leg squat during both concentric and eccentric phases were consistently less than for the left. The difference was on average 1.2 and 1.0 cm for the concentric and eccentric phase respectively, which is rather small and should not be able to account for the differences observed. The subject also has a long training history, which makes learning effect or technical execution of the single leg squat an unlikely contributor to the effects observed.

All measurements reported were obtained using MuscleLab. This was done in order to compare to values in an existing database existing prior to the installation of 1080 Quantum. The same measures are available in 1080 Quantum. These were used for comparisons to MuscleLab measurements.

No performance measures were documented in this case study. Performance measures, such as horizontal jump distance or sprint time, would have given this case study another dimension. Long jump performance would obviously be the best performance measure, however this is a complex athletic task dependent upon many variables. Regardless, vertical power development is known to be related to performance (Baker & Nance, 1999; J. B. Cronin & Hansen, 2005).

CONCLUSION

This study shows that power can be improve by short intense maximum strength training in an international level long jump athlete.

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