THE INFLUENCE OF A RESISTANCE TRAINING APPARATUS ON MAXIMAL
PARALLEL SQUAT POWER PERFORMANCE AND AGILITY

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Master of Science

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THE INFLUENCE OF A RESISTANCE TRAINING APPARATUS ON MAXIMAL PARALLEL SQUAT POWER PERFORMANCE AND AGILITY

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Thesis

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Athletes are constantly looking for an edge in training, subsequently; improving power is a way to progress in the performance enhancement facet of their expertise. With the help of a resistance band apparatus, putting the body under abnormal stresses, there is a strong inclination to believe that the aspect of power can be improved within an 8-week periodization. It is known that resistance and plyometric training, when combined, will yield the same results as a traditional or plyometric program (MacDonald, 2010 & Fatouros, 2000). This study seeks to establish if resistance and plyometric training when combined with another variable (i.e. resistance band apparatus), will yield even greater results.

There is a new piece of exercise equipment, named the FlexNimbo, a full-body athletic training system from the New Flex Generation speed and strength training gear. The device stretches resistance bands from the upper core to the extremities at a tune of 35 lbs. across the body’s extremities. These bands reportedly provide a positive-correlation to effectively exert forces on all phases of athletic movements. The inventors of FlexNimbo claim that the apparatus contributes to an increased range-of-motion, joint stability, power, speed, and strength, all relating to improvements in sport performance (FlexNimbo Training Facts, 2006). The hope is that the apparatus will activate more muscle fibers to establish more powerful movements for desirable results when combining it with the combination of a resistance and plyometric training
regimen. The back squat is deemed to be the best exercise to go about achieving maximum power (Chandler, 1991). There is no research using the *FlexNimbo* that targets gains in power with the back-squat within a lower-limb resistance training program as identified in this study method.
CHAPTER II
REVIEW OF LITERATURE

There is much research on the parallel squat and its influence on power output. The following studies express that gains in power are seen with the parallel squat in traditional resistance training and will contribute to performance enhancement (McBride, 2009, Sleivert, 2004, and Adams, 1992). However, when you add resistance bands to these typical parallel-squat methods, an even greater output is seen in power production (Wallace, 2006 and Anderson, 2008). The exact percentage increase varies but inevitably yields greater significant results in parallel squat maximum and other testing variables.

Having a more powerful squat can have its positive effects on performance. In a study with 17 Division 1-AA male football players, there was a significant correlation between squats and sprint times in five, ten and forty yard sprint times (McBride, 2009). As squat increased, so did quickness of the athlete in these sprint intervals. Another study that assessed maximal jump-squat power and sprint acceleration in athletes, found that propulsive impulse increased in thirty male athletes in a 5m sprint-start when performing 2 bouts of jump squats per week for six weeks at 30-70% of 1RM (Sleivert, 2004). In general, quickness and athletic movements are key and essential for success in sport. Doing motions to increase both the concentric and eccentric
contraction phases that involve the quadriceps, hips, hamstrings, ankle and calf muscles will increase power output which ultimately increases squat-maximum and other testing variables.

Adams et al. (1992) looked at power production and the relationship with the traditional back squat. The six week study looked at the effect of squat training, a simple plyometric regimen and a squat-plyometric program on power production (Adams, 1992). Using the vertical jump to assess power, it was found that all three training groups significantly increased, the squat-plyometric group improving the most (10.67 cm). In the squat group, vertical jump increased 3.30 cm. The results indicate that the squat is necessary to improve hip and thigh power production and by incorporating the duality of a plyometric program, the results will be more significant.

Some studies have used resistive elastic bands during the back squat and examined the effect. In conjunction with free weights, bands can significantly increase peak force and power during the back squat exercise on recreationally active subjects (Wallace, 2006). Wallace et al. tested the subjects with no bands, a band that provided 20% of the weight of the 1 RM (80% 1RM on the bar) and a band that provided 35% of the weight of the 1 RM (65% 1RM on the bar). It was found that the best increase in power and force occurred with a band using 20% of the 1 repetition maximum and was significant. This is important because it shows that less resistance with bands will yield a greater power output and provides backing that bands help with power production.

Anderson et al. (2008) examined back-squat resistance training with a bungee cord attached to a standard barbell loaded with plates for a group of 44 resistance-trained Division 1 athletes at Cornell University to assess power. It was found that compared to the control group,
the experimental group improved more than three-hundred percent in the back squat when performing the squat with a bungee cord. This happened over just a 7-week program that was aimed at increasing lower-body power. Again, this shows how band resistance during the concentric phase of the squat can be beneficial in astronomical ways in just a short period of time.

Because of that forceful concentric phase of the squat exercise that is needed with a flex band routine where a more dynamic explosion is going to be required, a relationship to squat will be used when determining loads. Some of the variables that need to be taken into account for squats are load on the bar and free weight repetition maximum (Dugan, 2004), as seen in a similar study determining loads for jump squat. Zink et al. (2006) looked at peak power during the squat exercise at different loads found that peak power values were associated with values at or around 40-50% of the 1RM of 12 experienced male lifters. These results are helpful as-well in determining loads when prescribing need-specific protocols areas of working in a fast-paced training and working on force production (i.e. the *FlexNimbo*).

The purpose of this study was to examine the effects of a lower-limb resistance strengthening and plyometric protocol while wearing the resistance apparatus on one repetition maximum in the parallel back squat and 20-yard short shuttle agility test. Squat is again a major determinant of power as previously stated. Pro agility is a major measure of agility, the changing of direction, in the football testing world. The hypothesis is that the resistance apparatus plus exercise group performing the strength and plyometric program will have a significant increase in parallel squat performance and pro-agility performance when compared to just the exercise group without the resistance apparatus during the 10 week time period.
CHAPTER III
METHODS

Participants: Twenty one (Male=17, Female=4), 18-25 years old, participated in a ten week study. Participants were recruited by email at Baldwin-Wallace College. The University of Akron Institutional Review Board approved the study and all participants signed an informed consent form before starting (Appendix A). Participants were eligible if they had no contraindications to exercise, were injury free, and within the past six months prior to the study participated in regular plyometric and resistance training. Plyometrics are characterized by “quick, powerful movements using a pre-stretch or countermovement that involves the stretch-shortening cycle” (Baechle and Earle, 2000). Regular resistance training is defined as 8-10 exercises, 8-12 repetitions, a minimum of two times per week according to the American College of Sports Medicine (ACSM) and American Heart association (AHA) recommendations (Haskell et al., 2007). Exclusion criteria consisted of orthopedic injuries including: shoulder, hip, knee, foot, ankle, and/or neck pain, and/or any sprains or strains in the three months preceding the study. Participants that missed > 3 sessions were excluded. Participation on an organized sports team within the two months preceding the study also resulted in exclusion. Participants were instructed to continue their normal daily activities outside of the study. It was also advised that all participants maintain their current diet and refrain from using any performance enhancing supplements (creatine, androstenedione, caffeine, steroids, ephedrine, etc.). Participants were not excluded if they had been taking vitamins, minerals, or other related natural supplements. Prior to participation in the study, participants were informed of the experimental procedures
and potential risks and benefits associated with the study, and signed an informed consent form (Appendix A). Additionally, participants completed a Physical Activity Readiness Questionnaire (Par-Q) (Appendix B) and a Godin Leisure-Time Exercise Questionnaire (Godin, 1997) (Appendix C). The Par-Q is used to determine if an individual requires medical clearance prior to participating in physical activity. The Godin Leisure-Time Exercise Questionnaire assesses leisure-time exercise habits and to see if the subjects met the guidelines for being recreationally active (Godin, 1997). Participants were randomly assigned to a control group ($n = 7$) that did not participate in any exercises, an apparatus + exercise group ($n = 7$), or an exercise group ($n = 7$) performing the same exercises without the resistance training apparatus.

*Program Design:* The design was an eight week plyometric and resistance training program (Appendix E and F). Pre- and Post-testing was completed during week one and ten respectively (Appendix D). Total body power was measured using the standard parallel squat with an estimated 1 rep maximum. The assessment also allows for safety as putting the body under a weight that has never been attempted before will be eliminated. To make sure the full parallel squat will be technique sound during maximal testing, a criteria sheet for qualitative analysis designed by Victor Pinheiro as displayed in Knudson and Morrison (2002) was used for recording. The goal of squatting is to have an effect on skill and power performances, so, as displayed in Domire and Challis (2007), squat depth does have an effect on vertical jump performance. Those subjects that consistently yielded at least a 90 degree squat angle tested higher in the vertical jump test. A criteria sheet will be inserted so that the constant 90 degree explosion angle was trained and analyzed (Appendix G). They will be instructed on the technique after warming up and were given time to practice with a barbell. The 1-RM of the parallel squat was determined by following the protocol established by Brzycki (1993). Each
participant performed three attempts, rotating through each participant after each attempt, which allowed for five minutes of rest between each attempt. Participants were instructed not to exceed five repetitions during their attempts. When measuring power output one should perform anywhere from 1-5 repetitions (Baechle and Earle, 2000). Once the participants’ amount of weight lifted and repetitions were recorded it was inserted into the formula from Brzycki’s (1993) protocol to determine their 1-RM. Weight / [1.0278 – (0.0278 x number of repetitions)] = 1-RM (Brzycki, 1993). All the subjects were closely monitored by the investigator and volunteers that helped with the study.

Along with the parallel squat, agility was measured using the 20 yard Short-Shuttle test. Subjects started in a 3-point stance with either their left or right hand on the ground and their body relaxed and not leaning right or left. The subjects started in the middle of a 10-yard space. On their movement, they ran 5-yards to left or right, touch the line, sprint 10 yards back from the direction they came from, touch the line, and again sprint 5 yards to the finish. Time started when the body moves and stopped when they finished the last five yard sprint. Each subject received two runs if desired, and these two were averaged for a score. It is important to note that time was measured by a standard stopwatch. Electronically measured times produce the most reliable results, because stopwatch measured times are up to 0.24 seconds faster or depending on how you look at it (Baechle and Earle, 2000).

Weeks two through nine consisted of two workouts per week with both the apparatus + exercise and exercise groups intermixed, meaning that during workouts some participants were wearing the apparatus while others were not. Sessions were divided into two groups, a morning and an evening Tuesday-Thursday group. Each group had approximately 48 hours in between workout sessions. Overall workout length was approximately 50 minutes, including a five
minute warm-up, 40 minute plyometric and resistance training workout, and a five minute cool down. The warm-up consisted of two laps around a 200-meter track and static stretching of all the major muscle groups including hamstrings, quadriceps, piriformis, groin, lower back, hip flexors, and calves. All stretches were completed once and held for 30 seconds. Plyometric workouts consisted of three sets of four plyometric exercises including: depth jumps, lunge jumps, squat jumps, and calf jumps. Previous studies used some of these plyometric exercises in their training programs (Mihalik et al., 2008 and Villarreal et al., 2008). A 30 inch box was used for the depth jumps and lunge jumps. The recommended height for depth jumps ranges from 16 to 42 inches, with 30-32 inches being the norm (Baechle and Earle, 2000). The format for the sets being performed for the plyometric exercises was two weeks of each 12, 10, 8, and 6 repetitions. Resistance training workouts consisted of four sets of parallel squat, hamstring curls, quadriceps extensions, and forward lunges. Hamstring curls and quadriceps extensions were performed on resistance training machines (Life Fitness, Schiller Park, IL). Forward lunges were performed with dumbbells. The format for the sets being performed for the resistance training exercises was two weeks of each 10, 8, 6 and 4 repetitions. The exercise group performed sets of the parallel squat at 50%, 55%, 60%, 65%, 70%, 75%, 80%, and 85% in successive weeks (weeks 2-8). The apparatus + exercise group performed sets of the parallel squat at 40%, 45%, 50%, 55%, 60%, 65%, 70% and 75% in successive weeks. The apparatus + exercise group performed sets of the parallel squat at a lower percentage of their 1-RM due to the added resistance provided by the resistance bands on the resistance training apparatus. The cool down followed the same protocol as the warm-up. Content of the workouts varied from week-to-week by using a variety of intensities and recovery times. For the plyometric exercises, as the number of repetitions decreased (12, 10, 8, and 6) the recovery times also decreased (45, 40, 35, and 30
seconds). For the resistance training exercises, as the amount of weight lifted increased, the number of repetitions decreased (10, 8, 6, and 4) and the recovery times remained constant (~3-4 minutes).

**Statistical Design:** Pre-Post test, quasi-experimental design. Pre-Post test differences between and within groups over time were analyzed using Repeated Measures ANOVA with SPSS V.18.0 software. A post-hoc, paired samples T-test was used to confirm the differences that occurred. Statistical significance was set *a priori* at $p < 0.01$. This was used because the sample size of the number of subjects was too small.
CHAPTER IV
RESULTS

At the beginning of the training program, no significant differences were observed between groups and within groups in the pre-testing maximal squat performance output \( (p = .501) \) and 20-yard short shuttle agility test \( (p = .034) \). Statistical analysis was performed using a Repeated Measures ANOVA, assessing differences within groups over time and between groups over time. Results showed no significant difference from pre- to post-test in maximal squat performance output \( (p = .487) \) and 20-yard short shuttle agility test \( (p = .078) \) between groups.

The mean pre-test maximal squat output in the apparatus + exercise group was 226 pounds, while the mean was 258.14 pounds during the post-test, a 12.45% difference. The mean pre-test maximal squat output in the exercise group was 167.14 pounds, while the mean was 194.86 pounds during the post-test, a 14.23% difference. The mean pre-test maximal squat output in the control group was 220.29 pounds, while the mean was 228 pounds during the post-test with a 3.38% difference, as illustrated in Figure 1 (Mean Estimated Maximal Squat for Each Group Pre and Post Test) and Figure 2 (Average Maximal Post-Parallel Squat Performance Increase Percentage By Weight). The mean pre-test 20-yard Short Shuttle time in the apparatus + exercise group was 5.47 seconds, while the mean was 5.54 seconds during the post-test, a difference of 2.5%. The mean 20-yard Short Shuttle time in the exercise group was 5.94 seconds, while the mean was 6.05 seconds during the post-test, a difference of 1.27%. The mean pre-test for 20-yard Short Shuttle time in the control group was 5.64 seconds, while the mean
was 5.64 seconds during the post-test, a 0% difference, as illustrated in Figure 3 (Mean 20-Yard Short Shuttle Time for Each Group Pre and Post Test) and Figure 4 (Average Post-20 Yard Short Shuttle Performance Percentage Enhancement By Seconds).
Figure 1. Mean Estimated Maximal Squat for Each Group Pre and Post Test

Figure 2. Average Maximal Post-Parallel Squat Performance Increase Percentage by Weight Lifted

Figure 2. Average Maximal Post-Parallel Squat Performance Increase Percentage By Weight
Figure 3. Mean 20-Yard Short Shuttle Time for Each Group Pre and Post Test

Figure 4. Average Post-20 Yard Short Shuttle Performance Enhancement Percentage By Seconds
The paired samples T-test confirmed that the mean Maximal Squat Output (pre-test = 204.48 pounds and post-test = 227 pounds) and mean 20-Yard Short Shuttle time (pre-test = 5.75 seconds and post-test = 5.69 seconds) were not significant from pre- to post-test. Descriptive statistics displaying pre- to post-test results and the change in from pre- to post-test for maximal squat output and 20-yard Short Shuttle in each subject are illustrated in Table 1 (Descriptive Statistics Maximal Squat Output) and Table 2 (Descriptive Statistics 20-Yard Short Shuttle).
Table 1

*Descriptive Statistics Maximal Squat Output*

<table>
<thead>
<tr>
<th>Subject</th>
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<th>Pre Squat</th>
<th>Post Squat</th>
<th>Δ Squat (lbs.)</th>
</tr>
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<tr>
<td>1</td>
<td>Control</td>
<td>270</td>
<td>287</td>
<td>+17 lbs.</td>
</tr>
<tr>
<td>3</td>
<td>Control</td>
<td>377</td>
<td>380</td>
<td>+3 lbs.</td>
</tr>
<tr>
<td>5</td>
<td>Control</td>
<td>287</td>
<td>287</td>
<td>0 lbs.</td>
</tr>
<tr>
<td>6</td>
<td>Control</td>
<td>143</td>
<td>152</td>
<td>+9 lbs.</td>
</tr>
<tr>
<td>7</td>
<td>Control</td>
<td>143</td>
<td>152</td>
<td>+9 lbs.</td>
</tr>
<tr>
<td>20</td>
<td>Control</td>
<td>249</td>
<td>259</td>
<td>+10 lbs.</td>
</tr>
<tr>
<td>21</td>
<td>Control</td>
<td>73</td>
<td>79</td>
<td>+6 lbs.</td>
</tr>
<tr>
<td>2</td>
<td>Apparatus + Exercise</td>
<td>73</td>
<td>139</td>
<td>+66 lbs.</td>
</tr>
<tr>
<td>10</td>
<td>Apparatus + Exercise</td>
<td>152</td>
<td>208</td>
<td>+56 lbs.</td>
</tr>
<tr>
<td>11</td>
<td>Apparatus + Exercise</td>
<td>267</td>
<td>270</td>
<td>+3 lbs.</td>
</tr>
<tr>
<td>12</td>
<td>Apparatus + Exercise</td>
<td>417</td>
<td>425</td>
<td>+8 lbs.</td>
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<tr>
<td>16</td>
<td>Apparatus + Exercise</td>
<td>208</td>
<td>225</td>
<td>+17 lbs.</td>
</tr>
<tr>
<td>17</td>
<td>Apparatus + Exercise</td>
<td>291</td>
<td>335</td>
<td>+44 lbs.</td>
</tr>
<tr>
<td>18</td>
<td>Apparatus + Exercise</td>
<td>174</td>
<td>205</td>
<td>+31 lbs.</td>
</tr>
<tr>
<td>4</td>
<td>Exercise</td>
<td>253</td>
<td>291</td>
<td>+38 lbs.</td>
</tr>
<tr>
<td>8</td>
<td>Exercise</td>
<td>73</td>
<td>107</td>
<td>+34 lbs.</td>
</tr>
<tr>
<td>9</td>
<td>Exercise</td>
<td>34</td>
<td>45</td>
<td>+11 lbs.</td>
</tr>
<tr>
<td>13</td>
<td>Exercise</td>
<td>208</td>
<td>215</td>
<td>+7 lbs.</td>
</tr>
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<td>14</td>
<td>Exercise</td>
<td>253</td>
<td>276</td>
<td>+23 lbs.</td>
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<td>15</td>
<td>Exercise</td>
<td>147</td>
<td>185</td>
<td>+38 lbs.</td>
</tr>
<tr>
<td>19</td>
<td>Exercise</td>
<td>202</td>
<td>245</td>
<td>+43 lbs.</td>
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## Table 2

**Descriptive Statistics 20-Yard Short Shuttle**

<table>
<thead>
<tr>
<th>Subject</th>
<th>Group</th>
<th>Pre SS</th>
<th>Post SS</th>
<th>Δ SS (Secs)</th>
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<tbody>
<tr>
<td>1</td>
<td>Control</td>
<td>5.64</td>
<td>5.69</td>
<td>+0.05</td>
</tr>
<tr>
<td>3</td>
<td>Control</td>
<td>6.06</td>
<td>6.08</td>
<td>+0.02</td>
</tr>
<tr>
<td>5</td>
<td>Control</td>
<td>5.29</td>
<td>5.16</td>
<td>-0.13</td>
</tr>
<tr>
<td>6</td>
<td>Control</td>
<td>6.01</td>
<td>5.65</td>
<td>-0.45</td>
</tr>
<tr>
<td>7</td>
<td>Control</td>
<td>5.50</td>
<td>5.27</td>
<td>-0.23</td>
</tr>
<tr>
<td>20</td>
<td>Control</td>
<td>5.12</td>
<td>5.25</td>
<td>+0.13</td>
</tr>
<tr>
<td>21</td>
<td>Control</td>
<td>5.85</td>
<td>6.37</td>
<td>+0.52</td>
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<td>5.60</td>
<td>5.44</td>
<td>-0.16</td>
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<td>Apparatus + Exercise</td>
<td>5.43</td>
<td>5.23</td>
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<td>+0.06</td>
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<td>5.52</td>
<td>-0.04</td>
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<td>Apparatus + Exercise</td>
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<td>5.53</td>
<td>-0.07</td>
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<td>Apparatus + Exercise</td>
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<td>5.56</td>
<td>+0.04</td>
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<td>18</td>
<td>Apparatus + Exercise</td>
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<td>5.45</td>
<td>-0.10</td>
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<td>6.32</td>
<td>6.28</td>
<td>-0.04</td>
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<td>8</td>
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<td>6.01</td>
<td>5.65</td>
<td>-0.36</td>
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<tr>
<td>9</td>
<td>Exercise</td>
<td>6.84</td>
<td>6.41</td>
<td>-0.43</td>
</tr>
<tr>
<td>13</td>
<td>Exercise</td>
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The Maximal Squat Output from pre- to post-test, the control group as a whole increased by an average of 7.71 lbs. per person, the apparatus + exercise group increased by an average of 32.14 lbs. per person, and the exercise group increased by an average of 27.72 lbs. per person. In the 20-yard Short Shuttle from pre- to post-test the control group as a whole did not change, the apparatus + exercise group decreased by 0.07 seconds per person, and the exercise group decreased by 0.11 seconds per person. Figure 5 (Maximal Squat Output: Average Increase per Subject) and Figure 6 (20-Yard Short Shuttle: Average Increase/Decrease per Subject) illustrates each individual increase or decrease in the maximal squat output and 20-yard short shuttle respectively. The descriptive statistics for overall increase or decrease for each group in maximal squat output and 20-yard short shuttle is illustrated in Table 3 (Average Increase or Decrease in Maximal Squat Output and 20-Yard Short Shuttle per Subject).

![Figure 5. Maximal Squat Outputs (Average Increase per Subject)]
Table 3

Average Increase or Decrease in Maximal Squat Output and 20-Yard Short Shuttle per Subject

<table>
<thead>
<tr>
<th>Group</th>
<th>Maximal Squat Output</th>
<th>20-Yard Short Shuttle</th>
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<tr>
<td>Control</td>
<td>+7.71 lbs. (3.38%)</td>
<td>0 Secs. (0%)</td>
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<tr>
<td>Exercise</td>
<td>+27.72 lbs. (14.23%)</td>
<td>-0.11 Secs. (1.27%)</td>
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<tr>
<td>Apparatus + Exercise</td>
<td>+32.14 lbs. (12.45%)</td>
<td>-0.07 Secs. (2.50%)</td>
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</table>
CHAPTER V
SUMMARY

The purpose of this study was to examine the effects of a lower-limb resistance strengthening and plyometric protocol while wearing the resistance apparatus on one repetition maximum in the parallel back squat and 20-yard short shuttle agility test focusing on power alone.

As a result of the study, it can be determined that future studies must be longer and have more participants. Results in the study concur that differences between groups over a 10 week period were not significant. As a result of having a low number of participants, significance was not achieved. When training for power it is important to stay consistent on the continuum of repetition ranges associated with various training goals. Baechle and Earle (2000), suggest that repetitions for power be in the range of 1 to 5. Although this was achieved by weeks 7 and 8 for load ranges of 75 to 90% of 1 repetition maximum, the first 6 weeks according to Baechle and Earle (2000) had repetition and load ranges more consistent with hypertrophy and muscular endurance. Power is usually measured by speed with low reps and lower estimated load ranges. Future studies should work on staying in this power repetition range when working with experienced participants. As seen in the studies by Dugan (2004) and Zink et al. (2006), load is an important factor when prescribing power. Zink et al. (2006) points out that ranges from 40-50% were associated peak power with experienced lifters. All of the participants were physically
active prior to the initiation of the study and were familiar with plyometric and resistance
training because of previously participating in organized sports. This suggests that the current
protocol may not have been a strong enough stimulus to elicit changes in the trained participants.
Future research should include untrained and informed individuals to determine if greater
improvements in the performance measures would be observed with this protocol.
Hypothetically speaking, highly trained participants would exhibit less improvement than
untrained subjects with this type of training.

Program design is the idea that training principles be adhered to during a program period.
The three training principles that should be incorporated in all training programs are specificity,
overload and progression. A lack of attention to any one of these principles often produces less
than desirable training outcomes (Baechle and Earle, 2000). Specificity is doing the exact skill
that is set out to be improved upon. It states that you are doing the exact skill or not at all.
Overload refers to stressing a muscle or energy system with a workload that is beyond its present
capacity. Effort must be great enough to exceed this threshold for muscular or metabolic fatigue
to trigger an adaptive response. Gradually increasing the intensity of a training program is
referred to as progression. Future studies should incorporate all three training concepts with
much more detail when designing a training program to optimize power and agility.

Immediately, this is where some of the flaws come into the scope of the program.
Specificity was not utilized for agility training. The only time the open skill was practiced was
during pre and post testing. Although muscle groups were trained with the resistance and
plyometric program, the skill itself was not specifically trained. So in future studies, practice
skills that will be tested as-well-as incorporate lateral movements into the training protocol.
Movements in all three planes of movement must be practiced to achieve a maximal functional
capacity. Also, since the squat is a total-body power exercise, a total-body training protocol must be used in future studies. The quote, “Your only as strong as your weakest link” is true in this case. If you do not have maximum flexibility in joints, core strength and overall body strength, the back squat will be a tough exercise to measure total-body strength if the body is not trained in other ways.

Progression was seen in this design as decreased rest intervals and increased intensity were used. Despite this, there was a lack of increasing the volume (sets and reps), increasing the number of exercises and exercise selection. The same exercises were consistently used, the same amount of exercise reps and ranges were used and there was really no increase in volume throughout. A recent article suggests an increase in volume may not be necessary for future studies as increasing the time under tension may be an optimal way to increase strength and power. Stoppani (2006) suggests that increasing time under tension for reps of 1 to 6 will from anywhere from 1 to 20 seconds will increase power and strength.

Using the overload principle is equally important as using specificity and the progression principle. In this study, the apparatus + exercise group performed sets at the tune of 10% less than their estimated one rep maximums then the exercise group due to the added resistance the apparatus provided with bands. Doing the study with both the exercise group and apparatus + exercise group doing the same percentage by weight could have shown significance difference between groups. When using a bungee cord for resistance during squat training, compared to no bungee cord use, the experimental group improved more than three hundred percent when compared to the control group in back squat, as displayed in the study by Anderson et al. (2008). Future studies need to have groups performing the exact same percentage of one rep maximum’s to see if the variable truly works. You can see by the results that the exercise group improved by
1.78% more than the apparatus + exercise group when looking at percentage of estimated 1 RM weight lifted. Even though not significant, you draw the conclusion that the apparatus did not work. One of the things you can draw from this is that 10% reduction in the apparatus + exercise accounted for about the same increase in max squat output in percentage by weight. A future study could go as far as hypothesizing that wearing the apparatus will significantly (by about 10%) increase maximal squat output compared to a group using the same protocol without an apparatus.

With this estimate of 10%, it is important to note the focus of the study which is power. Power is the time it takes to move a weight across an error. The study of Wallace et al. (2006) points out that a band that provides 20% of the 1RM is best for increasing power and force compared to a band that provides 35% of the 1 RM when performing back squat in recreationally active adults. That being said, again with this only 10% estimate accounting for that missed weight in this study, maximum results were not achieved in this study if you employ what was found by Wallace et al. (2006). Maybe an increase in the amount of resistance with the apparatus would be sufficient. FlexNimbo produces bands that reportedly give resistance at the tune of 50 lbs. and 75 lbs. Studies need to be done on exactly how much force is exhibited throughout the body while wearing the apparatus. The elasticity of the bands is different for people with different heights and body types.

Taking into account these percentages that were lifted by each group, future studies must realize if a maximum effort is given because more often than not, maximum effort yields maximum results. Max effort allows for the overload principle to really take its place. For future studies, I am recommending the OMNI RPE Scale (Lagalley, 2006) be placed into the program design to gage effort on a daily basis. It is a scale, much like that of the Borg Scale which
measures how the subject is feeling. Using this scale could help prescribe higher intensities on a
day-to-day basis to give a max effort instead of just going through the motions. Of course this
will be based on the goals of the workout, but the goal of the overall program is to stress the total
body by training all the systems (phosphocreatine, anaerobic, and aerobic).

Flaws in the way the resistance band apparatus fit the participants was a setback of the
study. Obviously, you can make adjustments to the apparatus, but there is no universal way to
adjust the apparatus on an individual basis. This would believe one to think that the resistance
level and distribution of the resistance was different on each individual. Furthermore, for
example, the level of resistance throughout the range-of-motion on a back squat was not
consistent. Standing straight up and taking the bar of the rack is near optimal resistance. Moving
to the lowering phase of the exercise, the resistance decreases, and as you power up, the
resistance becomes more exuberant throughout the body. This was very similar to using chains
on a barbell. Future studies should incorporate some type of adjustment protocol to ensure proper
fit and resistance for each participant, but more importantly maintain the integrity of the study by
ensuring safety.

Taking into further accounts such as neuromuscular development, technique, and
individual assessment is also essential. Using the criteria sheet set forth in Appedix G for the
back squat assessment was crucial for development, however, the overall technique was average
at best. Even though the athletes were recreationally active and had previous experience in
resistance training protocols, making the study longer is essential to building the structure base
of the athlete neuromuscularly so we can see that overload principle take ahold. An eight-week
study was not sufficient to see results because the subjects had not been coached correct
technique on a daily basis and had not been motivated to improve their technique to see results.
This was the first study to incorporate the use of the resistance training apparatus that had both plyometric and strength training exercises in a workout. The data demonstrate that there were no significant differences between or within groups over time. There is no evidence that suggests using a resistance band apparatus is better than not using one to train on this population. Without change to this pilot study design, the apparatus will not be of any significant value to traditional weight training. If these effects are present in future studies, then adding resistance training apparatus’ to plyometric and strength training programs will not provide any additional benefits to power or agility performance over time.
REFERENCES


APPENDICES
APPENDIX A

INFORMED CONSENT FORM
DESCRIPTION: You are invited to participate in a research study that investigates the influence of a resistance training apparatus on performance measurements including vertical jump, parallel squat, pro-agility, and 40-yard sprint. From the information collected and studied in this project we hope to learn more about this resistance training apparatus and if it can be an efficient method of training.

PROCEDURES: With your permission, we would like to collect information about you, including performance measurements such as vertical jump, parallel squat, pro-agility, and 40-yard sprint. You will undergo these performance measures at two time points – prior to the start of the study and at week ten. You are required to refrain from strenuous physical activity or training for one day prior to each testing session. The purpose of this study is to compare a traditional dynamic training program with a dynamic program incorporating the resistance training apparatus on measures of performance. You will maintain your current training and nutritional routine with only minimal alterations. Furthermore, you will meet for 45 minutes, two times per week to perform the dynamic workout routine either with or without the resistance training apparatus. You will perform plyometric and resistance training exercises such as: squats, squat jumps, lunges, depth jumps, etc.

RISKS: The possible risks associated with this study include muscle soreness or muscle strains associated with dynamic training and performance testing, which is normal when performing any kind of exercise. Each testing session and training session will be monitored and you will be shown the correct way to
perform each activity to reduce the risk of any serious injury.

**BENEFITS:** The possible benefits of this study to you are enhanced knowledge of your performance in standard athletic tests and effective training program techniques to optimize performance.

This information was explained to me by one, or both, of the following:

Michael Rebold
Joshua Bauman

I understand that they will answer any questions I may have concerning this investigation of the procedures at any time by calling the phone numbers listed below. I also understand that my participation in this study is entirely voluntary, that I must be 18 years of age or older, and that I may decline to enter this study or may withdraw from it at any time without jeopardy. I understand that the investigator may terminate my participation in the study at any time.

Contact information about the study:

Michael Rebold (440) 227-1413 mjr59@zips.uakron.edu
Joshua Bauman (716) 866-4553 jjb87@zips.uakron.edu
Dr. Otterstetter (330) 972-7738 ro5@uakron.edu

I understand I am not receiving any compensation for participating in this study, other than the individual data from the testing procedures.

____________________________________
Signature of Research Subject/Date
APPENDIX B

PHYSICAL ACTIVITY READINESS QUESTIONNAIRE (PAR-Q)
Regular physical activity is fun and healthy, and increasingly more people are starting to become more active every day. Being more active is very safe for most people. However, some people should check with their physician before they start becoming more physically active. Please complete this form as accurately and completely as possible.

PAR-Q FORM Please mark YES or No to the following: YES NO
Has your doctor ever said that you have a heart condition and recommended only medically supervised physical activity? ______
Do you frequently have pains in your chest when you perform physical activity? ______
Have you had chest pain when you were not doing physical activity? ______
Have you had a stroke? ______
Do you lose your balance due to dizziness or do you ever lose consciousness? ______
Do you have a bone, joint or any other health problem that causes you pain or limitations that must be addressed when developing an exercise program (i.e. diabetes, osteoporosis, high blood pressure, high cholesterol, arthritis, anorexia, bulimia, anemia, epilepsy, respiratory ailments, back problems, etc.)? ______
Are you pregnant now or have given birth within the last 6 months? ______
Do you have asthma or exercise induced asthma? ______
Do you have low blood sugar levels (hypoglycemia)? ______
Do you have diabetes? ______
Have you had a recent surgery? ______
If you have marked YES to any of the above, please elaborate below:
____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________

Do you take any medications, either prescription or non-prescription, on a regular basis? Yes/No
What is the medication for?
How does this medication affect your ability to exercise or achieve your fitness goals?
____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________

Please note: If your health changes such that you could then answer YES to any of the above questions, tell your trainer/coach. Ask whether you should change your physical activity plan.
I have read, understood, and completed the questionnaire. Any questions I had were answered to my full satisfaction.
Print Name: _________________________________ Signature: _______________________________________
Date: ________________________________
APPENDIX C

GODIN LEISURE TIME PHYSICAL ACTIVITY QUESTIONNAIRE
Godin Leisure Time Physical Activity Questionnaire

Considering a 7-Day Period (a week), how many times on the average do you do the following kinds of exercise for more than 15 minutes during your free time? (write on each line the approximate number)

Times Per Week

1. Strenuous Exercise
   a. (Heart beats rapidly)
   b. Examples: running, jogging, hockey, football, soccer, squash, basketball, cross country skiing, judo, roller skating, vigorous swimming, vigorous long distance bicycling

2. Moderate Exercise
   a. (Not Exhausting)
   b. Examples: fast walking, baseball, tennis, easy bicycling, volleyball, badminton, easy swimming, alpine skiing, popular and folk dancing

3. Mild Exercise
   a. (Minimal Effort)
   b. Examples: yoga, archery, fishing from river band, bowling, horseshoes, golf, snowmobiling, easy walking

4. Considering a 7-Day period, during your leisure-time, how often do you engage in any regular activity long enough to work up a sweat (heart beats rapidly)?
   a. Often
   b. Sometimes
   c. Never/Rarely
APPENDIX D

PRE- AND POST-TESTING RECORDING SHEET
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**Day 2**

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Name: ____________________  EST Squat Max: ______________  Group: _______   Apparatus ________
APPENDIX F

WORKOUT LOG FOR EXERCISE GROUP
Name: ______________  EST Squat Max: __________  Group: Non-Apparatus  

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APPENDIX G
BACK SQUAT EVALUATION
## Parallel Squat

### Preparatory Phase
1. From rack with barbell upper chest height.
2. Position barbell on back of shoulders.
3. Grasp bar two sides with hands.
4. Dismount bar from rack.
5. Take one step backward so that feet are shoulder width apart and body is located between safety bars.

### Execution Phase
6. Bend knees forward allowing hips to dip.
7. Keep back straight.
8. Knees pointed same direction as feet.
9. Feet flat on ground.
10. Descend until knees/hips are fully bent to a 90 degree angle.
11. Head/eyes up.

### Follow Through
12. Extend knees and hips until legs are straight.
13. Return and repeat.

---

**Observer's Name:** _________________________________
**Performer:** _______________________ **Date:** ___________
**Skill to be diagnosed:** ______________________________
APPENDIX H

HUMAN SUBJECTS APPROVAL FORM
NOTICE OF APPROVAL

May 20, 2010

Michael Rebold
10427 Abbey Road
North Royalton, Ohio 44133

From: Sharon McWhorter, IRB Administrator

Re: IRB Number 20100503 “The Influence of a Resistance Training Apparatus on Vertical Jump and Parallel Squat Performance”

Thank you for submitting an IRB Application for Review of Research Involving Human Subjects for the referenced project. Your protocol represents minimal risk to subjects and has been approved under Expedited Category #4.

Approval Date: May 20, 2010
Expiration Date: May 6, 2011
Continuation Application Due: May 20, 2011

In addition, the following is/are approved:

☐ Waiver of documentation of consent
☐ Waiver or alteration of consent
☐ Research involving children
☐ Research involving prisoners

Please adhere to the following IRB policies:

- IRB approval is given for not more than 12 months. If your project will be active for longer than a year, it is your responsibility to submit a continuation application prior to the expiration date. We request submission two weeks prior to expiration to ensure sufficient time for review.
- A copy of the approved consent form must be submitted with any continuation application.
- If you plan to make any changes to the approved protocol you must submit a continuation application for change and it must be approved by the IRB before being implemented.
- Any adverse reactions/incidents must be reported immediately to the IRB.
- If this research is being conducted for a master’s thesis or doctoral dissertation, you must file a copy of this letter with the thesis or dissertation.
- When your project terminates you must submit a Final Report Form in order to close your IRB file.

Additional information and all IRB forms can be accessed on the IRB website at:
http://www.uakron.edu/research/orssp/compliance/IRBHome.php

Cc: Ronald Otterstetter - Advisor
Cc: Stephanie Woods - IRB Chair

☐ Approved consent form/s enclosed

Office of Research Services and Sponsored Programs
Akron, OH 44325-2107
330-972-7666 • 330-972-8281 Fax
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