The effect of plyometric training on performance levels of the shot put technique and its related motor abilities

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Authors’ Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

Abstract

Purpose: The aim of this research is to evaluate the effects of plyometric training on the shot put technique. It was oriented to improve the basics for the development of power related-indicators such as power (explosive force), acceleration speed, and strength endurance.

Material: The study sample included 220 male students, aged 16 years ± 6 months from Fehmi Lladrovci High School, Glogoc municipality, Republic of Kosovo from the 2019/2020 academic year. The experimental group (110 male students) applied a 12-week program (see the training program paragraph). The control group (110 male students) continued only with their regular physical education lessons (2 times a week).

To determine the differences between pre- and post-test values of the control and experimental groups ANOVA calculations were made. The development percentage in time (between pre-test and post-test) were calculated using the formula: \( \Delta\% = (x_{\text{post-test}} - x_{\text{pre-test}}) / x_{\text{pre-test}} \times 100 \).

Results: Results of the study show that pre- and post-test average values (tests within subjects) of the shot put technique (\( p<0.05 \)) were statistically different according to measurement over time (interaction; \( p<0.05 \)), and in tests between the subjects (\( p<0.05 \)). The shot put technique (\( \Delta\%: 50.88 \)) test of the experimental group (plyo-training) had higher developmental percentages compared to (\( \Delta\%: 1.69 \)) the control group (\( p<0.05 \)). When analyzing the developmental percentage, it was observed that the performance of the shot put technique of the experimental group compared the control group 49.2% more developed.

Furthermore, the impact of the plyometric training program in motor abilities related to the shot put technique also observed similar improvements in the impact of the shot put technique.

Conclusions: In conclusion, the impact of the plyometric training program on motor abilities related to the shot put technique also observed similar results as the training program’s impact on the shot put technique. The applied plyometric training program benefits were not just in the shot put technique but also improved all motor abilities related to the shot put technique such as power, strength endurance, speed and acceleration. Therefore, the development of the shot put technique occurred by an increase in motor abilities related to the shot put technique as a result of the plyometric training program.

Keywords: shot-put technique, plyometric training, power (explosive force), acceleration speed, strength endurance.
groups of athletes, beginners and elite throwers, spend a great deal of their preparation using conventional power training or various forms of energy training to increase muscular power and throwing performance. For beginner and intermediate-trained throwers, resistance training causes a significant increase in shot put performance [7].

Although, shot put is a dynamic event demanding high power production, one of the parameters that determines the power production of a muscle group (whole-body), is muscular strength. However, the relationship between strength and shot put performance has not been thoroughly examined [8]. In light of this information, we think that the shot put technique and its related factors should be examined in more detail. The aim of this research is to evaluate the effects of plyometric training on the shot put technique. It was oriented to improve the basics for the development of power related-indicators such as power (explosive force), acceleration speed, and strength endurance.

Material and Methods

Participants

The study sample included 220 male students, aged 16 years ± 6 months from Fehmi Lladrovci High School, Glogoc municipality, Republic of Kosovo from the 2019/2020 academic year. The experimental group (110 male students) applied a 12-week program (see the training program paragraph). The control group (110 male students) continued only with their regular physical education lessons (2 times a week).

The study was conducted in a manner that respected the principles established by the Declaration of Helsinki and it was approved by the Ethics Committee of the University.

In the study, data collection tools were as folows. Countermovement jump (CMJ), Standing broad jump (SBJ), Tipple standing jump (TSJ), Standing medicine ball throw (SMBTH), 10 Meters run (10mRUN), 20 Meters run (20mRUN), Plate tapping (PLT), Foot-tapping against the wall (FTW) were performed according to the standard procedure used in the euro-fit test battery [12]. The sit-ups in 30 sec (SUP30s) test measured by bending the elbows from the straight position, then approaching the ground and straightening the elbows again; correctly done and completed sit-ups were counted and recorded [13]. Push-ups in 30 sec (PU30s) have validity and reliability [14] to measure the muscular strength endurance of the chest and back arm muscles [14, 15]. General body balance was used by the Flamingo Balance (FLB). A metal beam 50 cm long, 4 cm high, and 3 cm wide were used in this test. During this test, the subject tries to maintain his posture like a flamingo for a long time by standing on the metal beam. For 1 minute, any intervention (that does not fall) made to maintain balance in the beam is considered as a point. The dips (D) test was performed in parallel for men placed in the gym. The subject is placed with support in the hands at the beginning of the parallel bars, with straight legs hanging down. The task of the test holder is to perform parallel lifts. The maximum number of parallel rises is estimated. At the moment of ascent, the arms must be completely straight, respectively gathered during the phase of falling on the support. At the same time, the legs are straight. [16].

Training Program

The plyometric training program was prepared according to the National Strength and Conditioning Association (NSCA). The volume of the training varied between 85-120 contacts per session, intensity varied between low to high load and was applied 3-4 times per week (fig. 1). Bounding drills normally covered distances greater than 98 feet (30 m) or work time approximately

Figure 1. Plyometric training program loads
20–25 sec, and box jumps were repeated 10–15 times. Recovery for depth jumps consisted of 5 to 10 seconds of rest between repetitions and 2 to 3 minutes between sets. The time between sets was determined by a proper work-to-rest ratio (i.e., 1:5 to 1:10) and was specific to the volume and type of drill being performed (tabl. 1).

For safety considerations, athletes who were more than 100 kg were not requested to lift 1 RM squat minimum of 1.5 times his or her body weight, and to stand on one leg for 30 seconds without falling, and were not included in the plyometric training (tabl. 1).

When the training intensity in the lower extremities was low, moderate and low-severity exercises were applied in the trunk and upper body (fig. 2). The same rule applied when working with other parts of the body.

**Statistical Analysis.**

IBM SPSS Statistics 24 software was used for data analysis. To determine the differences between pre and post-test values of the control and experimental groups, ANOVA calculations were made. The development percentage in time (between pre-test and post-test) were calculated by using the formula “%Δ = (x post-test – x pre-test) / pre-test *100” where the confidence interval was chosen as 95% and values below p <0.05 were considered statistically significant.

**Results**

According to the results of Table 2, it was observed that pre- and post-test averages (tests within subjects) of the shot put technique (p<0.05) tests values were statistically different according to measurement in time (interaction; p<0.05). Similar results were observed in the tests between subjects (p<0.05). When analyzing the differences between the groups, it was observed that the shot put technique (Δ%: 50.88) test of the experimental group (plyo-training) had higher development percentages compared to the shot put technique (%Δ: 1.69) tests of the control group (p=.00).

According to the results of Table 3, it was observed that pre- and post-test averages (tests within subjects) of the countermovement jump (p<0.05), standing broad jump (p<0.05), triple standing jump (p<0.05) and standing medicine ball throw (p<0.05) test values were statistically different according to measurement over time.

**Table 1. Exercises included on the plyometric training program**

<table>
<thead>
<tr>
<th>Exercises</th>
<th>Lower body exercises</th>
<th>Upper body exercises</th>
<th>Trunk exercises</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jump in place</td>
<td>Throw (power drop)</td>
<td>Plyometric push-ups</td>
<td>Medicine ball throw</td>
</tr>
<tr>
<td>Standing jumps</td>
<td>Plyometric push-ups</td>
<td>Bench Press with Medicine Ball</td>
<td>45° sit-up</td>
</tr>
<tr>
<td>Multi hops and jumps (lateral barrier hop)</td>
<td>Plyometric push-ups</td>
<td>Depth Push-Ups (from Box)</td>
<td>V – sit ups (one rapid repetition)</td>
</tr>
<tr>
<td>Bounds (leaping movement upward)</td>
<td>Depth Push-Ups (gymnasti parallels)</td>
<td>Alternating Med Ball Plyometric Push Up</td>
<td>Frog sit ups (one rapid repetition)</td>
</tr>
<tr>
<td>Bounds (power skip)</td>
<td>Push-ups (gymnasti parallels)</td>
<td>Theraband internal rotation (start position).</td>
<td>Sit-up with medicine ball</td>
</tr>
<tr>
<td>Box drills</td>
<td>Theraband internal rotation (finish position).</td>
<td>Theraband external rotation (finish position).</td>
<td>Med ball throw (sitt position)</td>
</tr>
<tr>
<td>Depth jumps</td>
<td>Theraband internal rotation (finish position).</td>
<td>Theraband external rotation (finish position).</td>
<td></td>
</tr>
</tbody>
</table>

**Note:** Depth jumps exercises were not applied between first to sixth week and in the last week.

**Figure 2. Weekly training intensity**

![Weekly training intensity](image-url)
(interaction: CMJ, SBJ, TSJ, SMBTH; p<0.05). Similar results were observed in the tests between subjects (CMJ, SBJ, SMBTH; p<0.05, TSJ; p>0.05). When analyzing the differences between the groups it was observed that the countermovement jump (Δ%: 28.90), standing broad jump (Δ%: 26.19), triple standing jump (Δ%: 11.46) and standing medicine ball throw (Δ%: 16.07) results of the experimental group (plyo-training) had higher development percentages compared to the countermovement jump (%Δ: 0.00), standing broad jump (%Δ: 3.02), triple standing jump (%Δ: 1.22) and standing medicine ball throw (%Δ: 1.38) results of the control group (CMJ: p=.00, SBJ: p=.00, TSJ: p=.06, SMBTH: p=.00).

According to the results of Table 4, it was observed that pre- and post-test averages (tests within subjects) of the 10 meters run (p<0.05) and 20 meters run (p<0.05) values were statistically different according to measurement over time (interaction: 10mRUN; p<0.05, 20mRUN; p<0.05). The results observed in the tests between subjects were not statistically different (p>0.05). When analyzing the differences between the groups, it was observed that the 10 meters run test (Δ%: -12.67) and 20 meters run test (Δ%: -10.90) of the experimental group (plyo-training) had higher development percentages compared to the 10 meters run (Δ%: -3.05) and 20 meters run (Δ%: -2.31) tests of the control group (10mRUN: p=.01, 20mRUN: p=.14).

According to the results of Table 4, it was observed that

### Table 2. Impact of plyometric training in the shot put technique performance level

<table>
<thead>
<tr>
<th>V</th>
<th>Groups</th>
<th>N</th>
<th>Pre-test</th>
<th>Post-test</th>
<th>Total</th>
<th>%Δ</th>
<th>η2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>X̄±SD</td>
<td>X̄±SD</td>
<td>X̄±SD</td>
<td>F</td>
<td>p</td>
</tr>
<tr>
<td>SHP</td>
<td>Plio-training</td>
<td>110</td>
<td>5.7±1.14</td>
<td>8.6±1.33</td>
<td>7.2±1.5</td>
<td>55.19</td>
<td>.00* 50.88</td>
</tr>
<tr>
<td></td>
<td>Control Group</td>
<td>110</td>
<td>5.9±1.26</td>
<td>6.0±1.22</td>
<td>5.95±0.05</td>
<td>1.69</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>220</td>
<td>5.8±1.20</td>
<td>7.3±1.81</td>
<td>6.55±0.75</td>
<td>F =1032.139; p =.00*</td>
<td></td>
</tr>
</tbody>
</table>

**NOTE:** V – variable; *p<0.05. SHP: Shot put technique. X̄±SD: Mean and standard deviation. »: Tests of between-subjects’ effects. ›: Testing effects within subjects (Greenhouse-Geisser). ‹: Interaction (Time*Groups). Δ%: development %. η2: partial eta squared, V: Variables

### Table 3. Impact of plyometric training with respect to power ability (explosive force) factors

<table>
<thead>
<tr>
<th>V</th>
<th>Groups</th>
<th>N</th>
<th>Pre-test</th>
<th>Post-test</th>
<th>Total</th>
<th>%Δ</th>
<th>η2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>X̄±SD</td>
<td>X̄±SD</td>
<td>X̄±SD</td>
<td>F</td>
<td>p</td>
</tr>
<tr>
<td>CMJ</td>
<td>Plio-training</td>
<td>110</td>
<td>27.79±4.82</td>
<td>35.82±4.28</td>
<td>31.80±4.02</td>
<td>27.770</td>
<td>.00* 28.90 .11</td>
</tr>
<tr>
<td></td>
<td>Control Group</td>
<td>110</td>
<td>28.44±5.27</td>
<td>28.44±4.90</td>
<td>28.44±0.00</td>
<td>3.02</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>220</td>
<td>28.12±5.05</td>
<td>32.13±5.89</td>
<td>30.12±2.01</td>
<td>F =996.720; p =.00*</td>
<td></td>
</tr>
</tbody>
</table>

**NOTE:** V – variable; *p<0.05. CMJ: Countermovement jump, SBJ: Standing broad jump, TSJ: Triple standing jump, SMBTH: Standing medicine ball throw. X̄±SD: Mean and standard deviation. »: Tests of between-subjects’ effects. ›: Tests of within subjects’ effects (Greenhouse-Geisser). ‹: Interaction (Time*Groups). Δ%: development %. η2: partial eta squared.
plate tapping (p<0.05), foot-tapping against the wall (p<0.05), sit ups in 30 sec (p<0.05) and push-ups in 30 sec (p<0.05) test values were statistically different according to measurement over time (interaction: PLT, FTAW, SUP30s, SMBTH; p<0.05). Similar results were observed in the SUP30s (p<0.05) and PU30s (p<0.05) between subjects. However, the results showed that in the PLT and FTAW results between subjects did not have any statistical difference (p>0.05). When analyzing the differences between the groups, it was observed that the plate tapping (Δ%: -12.43), foot-tapping against the wall (Δ%: -9.32), sit ups in 30 sec (Δ%: 40.00) and push-ups in 30 sec (Δ%: 45.83) test values of the experimental group (plyo-training) had higher development percentages compared to the plate tapping (Δ%: -2.18), foot-tapping against the wall (Δ%: -2.25), sit ups in 30 sec (Δ%: 2.01) and push-ups in 30 sec (Δ%: 2.87) tests of the control group (PLT: p=.23, FTAW: p=.45, SUP30s: p=.00, PU30s: p=.00).

According to the results of Table 6, it was observed that pre- and post-test averages values (tests within subjects) of the dips (p<0.05) and flamingo balance (p<0.05) were statistically different according to measurement over time (interaction: D, FB: p=.00). Similar results were observed in the D test between subjects (p<0.05). However, the results indicated that there was no statistical difference (p>0.05) in the FB test between the subjects.

When analyzing the differences between the groups, it was observed that the dips (Δ%: 70.51) and flamingo balance (Δ%: -50.00) test of the experimental group (plyo-training) had higher development percentages compared to the dips (Δ%: 5.95) and flamingo balance (Δ%: -15.38) tests of the control group (D: p=.01, FB: p=.45).

Table 4. Impact of plyometric training in acceleration ability factors

<table>
<thead>
<tr>
<th>V</th>
<th>Groups</th>
<th>N</th>
<th>Pre-test</th>
<th>Post-test</th>
<th>Total</th>
<th>%Δ</th>
<th>η²</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>X±SD</td>
<td>X±SD</td>
<td>X±SD</td>
<td>F</td>
<td>p</td>
</tr>
<tr>
<td>10mRUN</td>
<td>Plio-training</td>
<td>110</td>
<td>2.408±.35</td>
<td>2.103±.23</td>
<td>2.256±.15</td>
<td>6.481</td>
<td>.01*</td>
</tr>
<tr>
<td></td>
<td>Control Group</td>
<td>110</td>
<td>2.390±.33</td>
<td>2.317±.30</td>
<td>2.354±.04</td>
<td>.234</td>
<td>&lt;.05</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>220</td>
<td>2.399±.34</td>
<td>2.210±.29</td>
<td>2.305±.09</td>
<td>.023</td>
<td>&lt;.05</td>
</tr>
</tbody>
</table>

Table 5. Impact of plyometric training in the speed of the upper and lower extremities and endurance in force factors

<table>
<thead>
<tr>
<th>V</th>
<th>Groups</th>
<th>N</th>
<th>Pre-test</th>
<th>Post-test</th>
<th>Total</th>
<th>%Δ</th>
<th>η²</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>X±SD</td>
<td>X±SD</td>
<td>X±SD</td>
<td>F</td>
<td>p</td>
</tr>
<tr>
<td>PLT</td>
<td>Plio-training</td>
<td>110</td>
<td>10.86±1.66</td>
<td>09.51±1.32</td>
<td>10.18±0.68</td>
<td>1.404</td>
<td>.23</td>
</tr>
<tr>
<td></td>
<td>Control Group</td>
<td>110</td>
<td>10.55±1.65</td>
<td>10.32±1.63</td>
<td>10.43±0.12</td>
<td>.23</td>
<td>&lt;.05</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>220</td>
<td>10.71±1.66</td>
<td>09.82±1.53</td>
<td>10.31±0.45</td>
<td>.01</td>
<td>&lt;.05</td>
</tr>
</tbody>
</table>

NOTE: V – variable; *p<0.05. 10mRUN: 10 Meters run, 20mRUN: 20 Meters run. X±SD: Mean and standard deviation. »: Tests of between-subjects’ effects. ›: Tests of within subjects’ effects (Greenhouse-Geisser). ‹: Interaction (Time*Groups). Δ%: development %. η2: partial eta squared.
Table 6. Impact of plyometric training of the speed of the upper and lower extremities and endurance in force factors

<table>
<thead>
<tr>
<th>V Groups</th>
<th>N</th>
<th>Pre-test</th>
<th>Post-test</th>
<th>Total</th>
<th>F</th>
<th>p</th>
<th>%Δ</th>
<th>η²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plio-training</td>
<td>110</td>
<td>7.8±5.16</td>
<td>13.3±5.69</td>
<td>10.6±2.8</td>
<td>6.60</td>
<td>.01</td>
<td>70.51</td>
<td></td>
</tr>
<tr>
<td>Control Group</td>
<td>110</td>
<td>8.4±5.79</td>
<td>8.9±5.52</td>
<td>8.65±0.25</td>
<td>.57</td>
<td>.45</td>
<td>-50.00</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>220</td>
<td>8.1±5.47</td>
<td>11.1±6.00</td>
<td>9.6±1.5</td>
<td>.45</td>
<td>.45</td>
<td>-15.38</td>
<td></td>
</tr>
</tbody>
</table>

NOTE: V – variable; *p<0.05. PLT: D: Dips, FB: Flamingo balance test. X̄±SD: Mean and standard deviation. ‹: Tests of between-subjects’ effects. ›: Tests of within subjects’ effects (Greenhouse-Geisser). Δ%: development %. η²: partial eta squared.

Discussion

In the study it was observed that pre- and post-test averages (within and between subjects) of the shot put technique (p<0.05) were statistically different according to measurement over time (interaction; p<0.05). When analyzing the development percentage, it was observed that the performance of shot put technique (Δ%: 50.8) of the experimental group compared to the shot put technique (Δ%: 1.6) results of the control group had developed by 49.2%.

If we refer to the research of Mustapha et al. [17], they also found significant statistical differences in the pre-test and post-test in the experimental sample for muscular strength and digital achievement in the shot put technique. According to the researchers, this result was due to the proposed training program based on scientific foundations of the application of physical exercises of quality that are related to the game, especially the use of the plyometric exercises (08 weeks & 02 times in one week). Furthermore, T-test values for the experimental sample was also (2.57 and 3.04) larger than the tabulated T-test, which means there was also the existence of a significant difference between the pre-test and post-test calculated average in favor of the post-test group [17].

Similar results in the shot put technique were also observed in analyzing the impact of the plyometric training program in the motor abilities related to the shot put technique. Applied plyometric training program benefits were not just in the shot put technique, but also improved all motor abilities related to the technique such a power, strength endurance, speed, and acceleration. Thus, the development of the shot put technique occurred by the increase in motor abilities related to the shot put technique as a result of the plyometric training program.

Referring to the literature, ten weeks of strength and power training induced significant increases in the shot put throw, standing long jump work production, and sprinting performance. These changes were accompanied by adaptations in muscle thickness and fascicle length. The current data suggest that examination of muscle thickness and performance in explosive field tests may partly predict the training-induced increase in actual track and field throwing performance [18].

When the same analyses were applied in the explosive force factors, it was observed that the differences within subjects and between subjects of the countermovement jump (p<0.05), standing broad jump (p<0.05), triple standing jump (p<0.05) and standing medicine ball throw (p<0.05) test values were statistically different (p<0.05). When analyzing the development percentage, it was observed that the countermovement jump (Δ%: 28.9), standing broad jump (Δ%: 26.1), triple standing jump (Δ%: 11.4) and standing medicine ball throw (Δ%: 16.0) test results of the experimental group (plyo-training); compared to the countermovement jump (Δ%: 0.00), standing broad jump (Δ%: 3.0), triple standing jump (Δ%: 1.2) and standing medicine ball throw (Δ%:1.3), have shown higher development percentages (CMJ: 28.9%, SBJ: 23.1%, TSJ: 10.2%, SBMTH: 14.7%).

Based on the literature, we can see that there were statistically significant differences in post-test between the control and experimental sample in favor of the experimental group. This indicates that plyometric exercises were more effective in improving performance in the shot put through the use of medicine balls and iron balls with different weights. This actually confirms the effectiveness of using plyometric exercises leads to an improvement in physical abilities and performance in sports activities [19, 20]. If we see the literature, we can verify that a combined plyometric and squat training program significantly increased vertical jump results compared to training with squats or plyometric alone [21].

With regards to acceleration abilities, it was observed that within subjects the 10 meters run (p<0.05) and 20 meters run (p<0.05) test values were statistically different according to measurement over time. The results observed in the tests between subjects were not statistically different (p>0.05).

When analyzing the development percentage, it was observed that the 10 meters run test (Δ%: -12.6) and 20 meters run (Δ%: -10.9) test of the experimental group (plyo-training) have shown higher development percentages compared to the 10 meters run (Δ%: -3.0) and 20 meters run (Δ%: -2.3) tests of the control group (10m
run: 9%, 20m run: 8.6%). When analyzing the development percentage, it was observed that the dips (Δ%: 70.5) and flamingo balance (Δ%: -50.0) test of the experimental group (plyo-training) had higher development percentages compared to the dips (Δ%: 5.9) and flamingo balance (Δ%: -15.3) tests of the control group (D: 64.6%, FB: 34.7%).

The research showed that when the effects of psychomotor training on balance was taken into consideration, a statistically significant difference was found between pre-test (x̅ 4.59) and post-test (x̅ 1.98) in the training group (experimental group) (p<0.01). No statistically significant difference was found between the balance pre-test (x̅ 4.54) and post-test (x̅ 3.69) in the non-training group (control group) (p<0.05) [26].

### Conclusion

In conclusion, the impact of the plyometric training program on motor abilities related to the shot put technique also observed similar results as the training program’s impact on the shot put technique. The applied plyometric training program benefits were not just in the shot put technique but also improved all motor abilities related to the shot put technique such as power, strength endurance, speed and acceleration. Therefore, the development of the shot put technique occurred by an increase in motor abilities related to the shot put technique as a result of the plyometric training program.

### Conflict of interests

No potential conflict of interest was reported by the authors.

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