Effect of Complex Training on Explosive Strength of Legs Extensors in Junior Basketball Players

Abstract

In ten-week period, junior basketball players divided into two groups, experimental and control, were subjected to various training programs. Experimental group members, in addition to regular technical and tactical basketball training, had additional complex training twice a week, while the subjects in the control group only had a technical-tactical basketball training. The aim of this study was to test the impact of complex training on explosive leg strength in the performance of different jump variants of junior basketball players. Countermovement jump and Squat jump were tested as well as the following variables: maximum jump height (h), maximum force (Fmax) and the time needed for the achievement of the maximum force (tmax) in concentric contraction when performing jumps and explosive strength Index (IES = Fmax / tmax). Comparing the results obtained on the basis of the initial and final measurements, it has been proved that the tested variables have changed under the influence of experimental factors. In both tested jumps the maximum jump height (p=.00) and maximum force (p=.00) were significantly improved, whereas IES improved only in the Countermovement jump (p=.00). the time of the maximum force realization remained unchanged during the ten-week treatment. The research has proven that the complex training has influenced the improvement of explosive leg strength in junior basketball players.

Key words: Vertical Jump / Post-Activation Potentiation / Force / Basketball Player

INTRODUCTION

Complex training was founded by Russian and Bulgarian trainers and includes a combination of large and small ballast during a training. This form of exchange of the maximum and explosive muscle contractions of the same muscular groups is in science and sport practice known as „complex training”. Coaches believe that the simultaneous mastering of the large exterior loads (a weight) and small loads (body weight) will produce a better neuro-muscular adaptations. Guided by the above, came the idea for testing the effect of complex training on explosive strength of legs extensors.
This type of training is used to improve neuromuscular adaptation and the maximum force and the speed of force manifestation. In this way a combination of concentric, eccentric-concentric exercises affects a rapid generation of muscular force (Adams et al., 1992; Burger et al., 2000; Fatouros et al., 2000; Jensen et al., 2003). Recently science has confirmed trainers’ assumptions and in research laboratories came to the conclusion that the exchange of the large and small loads can have significant training effects (Blakey, 1987; Ebben et al., 1998; Duthie et al., 2002; Ebben et al., 2002). Using large training loads as initial weight can lead to the improvement of the explosive movements. By doing large load exercises we allow the next action to be temporarily improved due to increased excitation of the central nervous system (Jensen et al., 1999; Ebben et al., 2000; Fatours et al., 2000). Excitation of the central nervous system is the result of the acute physiological adaptation, which lasts 8 to 10 minutes and is called post-activation potentiation PAP (Sale, 2002). The essence of the PAP is in the effect of the large loads that cause a high degree of nerve stimulation, resulting in inclusion of a larger number of motor units and increased discharge frequency of nerve impulses.

There are two basic ways of implementation of complex training:
- Combining large and small loads between a series of exercises and
- Combining large and small loads within the series, so called superseries.

In this paper we used the second way, which is a grouping of two or more exercises that are performed in a large series (superseries), while exchanging large and small loads with a maximum speed of execution, known as the ‘Russian complex’.

The aim of this study was to determine how complex training affects the maximum height of the jump and the value of the force, and the time of her achievements in concentric contraction during the performance of different variants of the jump.

METHOD

Subjects sample

Subjects were the 20 junior basketball players (age 16-17), members of BC „Zvijezda”, Banja Luka and BC „Alfoni”, Banja Luka. Subjects were of normal health status, divided into two groups: experimental group (Exp.) and control group (Con.). At the time of testing, all subjects were healthy and without injuries of the lower extremities. The groups were homogenized after the initial measurements based on Z-value of each criterion variable, as a precondition for the implementation of the experiment with parallel groups.

Variable sample

Two jumps were tested:
1. Countermovement jump - two foot standing jump.
2. Squat jump – two foot squat jump.

Within each jump following variables were tested:
- Max jump height (h),
- Maximum force in concentric contraction ($F_{max}$),
- Time to achieve the maximum force in concentric contraction ($t_{max}$) and
- Explosive strength index ($IES = F_{max} / t_{max}$).

After warming up, each subject performed two different vertical jump on the force plate: squat jump in which the candidate takes the position of half squat, retains that position for two seconds, and performs the maximum bounce and countermovement jump in which the candidate takes the position of the half-squat and goes into maximum jump immediately afterwards. Both vertical jumps were repeated three times, with the highest jumps selected for further analysis. Interval between jumps lasted about one minute.

Research procedure

In the period of ten weeks the experimental group, in addition to the regular basketball training, was subjected to the additional complex training method, twice a week, while the control group only had technical-tactical basketball training.

Training consisted of 3 to 5 exercises for leg extremities. Each exercises consisted of load which was 50% -80% of maximum. After load and 2-minute break, there was another specific exercise without effort. Previous research recommend similar training program while thinking that the two-minute break should be applied between load and a specific
exercise in order to use PAP effect better (Young et al., 1998). Load was performed in 4 series with 6-8 repeats, and specific exercises with 10 repetitions. Break between the series amounted to 4 minutes.

Subjects were tested in laboratory conditions, with the help of Tanita BC-418MA and GLOBE ERGO TESYS SYSTEM 1000, following standard procedure on the force plates (Force Plate - mega twin plates), collected data was subjected to statistical data processing by applying of statistical operating system SPSS 14.0. For all the variables standard central (arithmetic average) and dispersive parameters (standard deviation) were calculated. Differences between control and experimental groups will be determined by the T-test for independent samples. The level of statistical significance set at p<0.05.

RESULTS AND DISCUSSION

The basic descriptive parameters of the analyzed variables for experimental and control groups are shown in Table 1 and 2. There were no statistically significant differences in the variables tested in the initial measurement (p> 0.05), which is not the case with the final measurement. The experimental treatment led to changes in maximum jump height, maximum force achieved in concentric contraction, as well as the IES-A. In tables 1 and 2 we note that the subjects in terms of morphological characteristics were not significantly different the initial and final measurement. Logical final results rise from the fact that the subjects of both groups had exercises of sub maximum and maximum intensity, with short periods of stress, insufficient to engage the aerobic mechanisms through which it is possible to engage energy sources and reduce the body mass.

Table 1. Values of arithmetic mean and the standard deviations of variables tested in subjects in experimental and control groups at initial measurement.

<table>
<thead>
<tr>
<th>Tests</th>
<th>Two foot standing jump (Countermovement)</th>
<th>Two foot squat jump (Squat)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Arithmetic mean</td>
<td>Standard deviation</td>
</tr>
<tr>
<td>Body height</td>
<td>186</td>
<td>186.4</td>
</tr>
<tr>
<td>Body mass</td>
<td>75</td>
<td>75.8</td>
</tr>
<tr>
<td>Height jump</td>
<td>32.7</td>
<td>33</td>
</tr>
<tr>
<td>Fmax</td>
<td>1683.16</td>
<td>1671.50</td>
</tr>
<tr>
<td>tmax</td>
<td>.19</td>
<td>.19</td>
</tr>
<tr>
<td>IES</td>
<td>9023.33</td>
<td>9189.84</td>
</tr>
</tbody>
</table>
Table 2. Values of arithmetic mean and the standard deviations of variables tested in subjects in experimental and control groups at final measurement

<table>
<thead>
<tr>
<th>Tests</th>
<th>Two foot standing jump (Countermovement)</th>
<th>Two foot squat jump (Squat)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Arithmetic mean</td>
<td>Standard deviation</td>
</tr>
<tr>
<td>Body height</td>
<td>186.4</td>
<td>186.8</td>
</tr>
<tr>
<td>Body mass</td>
<td>75.3</td>
<td>76.15</td>
</tr>
<tr>
<td>Height jump</td>
<td>37.4</td>
<td>33.4</td>
</tr>
<tr>
<td>Fmax</td>
<td>1931.27</td>
<td>1695.29</td>
</tr>
<tr>
<td>tmax</td>
<td>.18</td>
<td>.19</td>
</tr>
<tr>
<td>IES</td>
<td>10533.33</td>
<td>9156.29</td>
</tr>
</tbody>
</table>

The relation of force parameters during Countermovement jump

Comparing the average values obtained from the initial and final measurements it has been determined that with the experimental group there was a statistically significant increase of maximum jump height (p = .00), maximum force (p = .00), and IES-A (p = .00). Time for achievement of the maximum force under the influence of the experimental treatment was not statistically significantly improved (p = .36). At the same time, in the control group, there has been no significant changes in any parameter observed countermovement jump.

Figure 1. The significance of differences of arithmetic mean in maximal jump height (cm) for experimental and control groups in the initial and final measurement in the Countermovement jump.

As expected, under the influence of experimental factors, there was a statistically significant improvement of maximum height of the jump in the experimental group, while in the control no improvements in jump height were noted (Figure 1).

The consequence of increasing the value of maximum force and better intramuscular and intermuscular coordination enabled greater values of vertical jump. Adams et al., (1992) had similar results. Statistically significant improvement of the maximum force value and IES-A (Figure 2 and 4), is the result of a partial muscular fiber hypertrophy, a larger number of activated motor units, fast frequency discharge, or change the frequency of activation of motor units, as well as more coordinated activation of motor units.

There are two factors affecting the degree of manifestation and speed of maximum force: peripheral and central. The most important peripheral factor to achieve maximum muscle force is the size of a muscle that is directly associated with the size of the cross section. On the other hand CNS is the most important factor for the development of muscle force, not only by the amount of muscle involved but also the degree to which the individual muscle fibers are activated - intramuscular coordination of muscles. Activating a larger number of motor units, increased discharge frequency and synchronization of muscle units, allows the creation of maximum muscle force. Training contents applied in this program included the entire movement, not just individual muscle force or movement in an isolated joint, which improves in-
termuscular and intramuscular coordination of muscles. Fatouros et al., (2000) came to similar result.

**Figure 2.** The significance in differences of arithmetic mean of the maximum force (N) in experimental and control groups in the initial and final measurement of Countermovement jump

![Graph showing differences in maximum force between experimental and control groups](image)

**Figure 3.** The significance in differences of time achievement of maximum force (s) in experimental and control groups at the initial and final measurement of the Countermovement jump

![Graph showing differences in time achievement of maximum force](image)

When observing Figure 3 we note that there has been no statistically significant improvements in time needed to achieve maximum power. The cause of this lies in the frequency of discharge, or change of the frequency of activation of motor units. Speed of nerve impulse discharge depends on many factors, and both CNS and the number of fast fibers in the muscle play a key role. It turned out that the period of implementation of training programs is insufficient to affect the time needed to achieve maximum force.

**Figure 4.** The significance in differences between the IES-A (N / s) average in experimental and control groups in the initial and final measurement in the test for Countermovement jump

![Graph showing differences in IES-A (N / s) average](image)

Comparing the values of maximum force obtained on the basis of the results of initial and final measurements, the changes under the influence of experimental factors have been determined. Training facilities have improved the value of maximum force leading to improvement of maximum jump height. As a result of the implementation of the experimental factors the explosive strength index has been improved (Figure 4). As we have already said, it directly depends on the value of maximum force and the time of her achievements (Zatsiorsky, 2009). Since that time did not significantly change, this improvement could be explained by higher value of maximal force. Each dynamic movement will be more effective if we are able to act with a higher power in the shortest possible period of time. If we manage to do in case of jumps, the result is greater jump height. Even in the countermovement jump test due to increasing values of force the IES improved, which caused greater explosive force when performing the jump. Exploring the impact of PAP on explosive movement Sale 2002 got similar results in 2001.

The relation of force parameters during Squat jump

As in the previous test, in the squat jump test too, due to the implementation of the experimental factors the maximum height of the jump in the experimental group (p = .00) has been significantly improved, whereas in the control group there were no improvements (p = .09) (Figure 5). Factors that have led to improvements in jump height are increased value of maximum force (Fmax) in concentric concenc-
tion during the performance of the jump as well as better intramuscular and intermuscular coordination. Duthie et al., 2002), while testing complex training came to similar results, which confirmed its influence on the maximum height of the jump and the duration of contact with the surface when performing a jump.

**Figure 5.** The significance in differences of arithmetic mean of maximum jump height (cm) of experimental and control groups at initial and final measurement of the test in *Squat jump*.

In the same test statistically significant increase in maximum force was recorded (Figure 6.). However, it is interesting that the increase occurred in both groups tested. While within the experimental group it was expected, in the control group, this change was surprising. It is difficult to attribute this progress in the control group to any logical or physiological adaptive process. Since this is the only statistically significant change of the all six variables tested in this jump, we can not take it into serious consideration. If we consider the value of maximum force, we see that the changes are relatively small. As a possible cause of the changes we can name the motivation factor in the control group subjects at the final measurement. Janeiro and Santos came to the similar results (2008) on a sample of 25 young players. As for the time parameters of force (Figure 7) no significant changes have not been noticed in tested groups. Although it was expected, the change in the IES-A (because of the increased value of Fmax), hasn’t occurred. It is obvious that increasing the value of maximum force was not enough to change IES.

**Figure 7.** The significance in differences of time achievement of maximum force (s) in experimental and control groups in the initial and final measurement of final *Squat jump* test.

As in the previous test by applying a complex training the value of force has been improved which also led to improvements in the maximum height jump performance of squat jump. So, once again, the effectiveness of complex training on explosive strength of legs extensors has been proved.
**CONCLUSION**

In the period of ten weeks the influence of complex training on explosive strength of legs extensors has been tested. Comparing the results from the initial and final measurements the following results were obtained and used to come to following conclusions:

- Complex training affected the improvement of maximum jump height, maximum force and IES in concentric contraction during the performance of different variants of the jump. Thus is confirmed the influence of physiological mechanisms of post activating potentiation on dynamic tasks such as countermovement jump. The conclusion is that the performance of dynamic motion with load produces acute improvement of the manifestation of the explosive power. Applied program did not significantly affect the time of maximum force realization. Since it is known that in time of maximum force realization can be influenced by training, probably the period of implementation of this training program was short to significantly affect the time of maximum force realization.

- In the control group no significant changes after experimental treatment have been notices, except in the maximum force variable in the squat jump test. Such results were quite expected since the subjects in the control group were not subjected to additional training forces. The exception in the maximum force can be considered accidental because of all the six variables tested in the squat jump test, only one has shown significant improvement.

**REFERENCES**


