Does The Drop Jumps Provide A Post-Activation Potential?

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Received: 07-24-2017
Accepted: 12-28-2017
Published: 01-05-2017
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Abstract

The aim of this study was to investigate the use of drop jumps (DJ) to promote post-activation potential (PAP) and to improve the performance of vertical jump (VJ). For that purpose 15 Volleyball male athletes (19,88±1,54 years old), were conducted randomly: (I) a countermovement jump control (CCMJ); (II) 6 sets of DJ, followed by 4 minutes of passive rest and 3 CMJ (PDJ); (III) 5RM Smith Machine squat (SMS), followed by 4 minutes of passive recovery, and then 3 CMJ (PSMS). All activities had an interval of 72 hours between them. Jump height and power was measured with a jump platform. It was observed a significant increase in jump height (P<0,001) between PSMS and PDJ, in relation to CCMJ. Significant higher values of in jump height (p <0.001) and power (p <0.001) were also observed for PSMS, in relation to PDJ. It can be concluded that both interventions (PDJ and PSMS) promoted a PAP that influenced the height of the CMJ. The uses of DJ in training and pre-competitive situations seem to be an effective way to improve performance.

Keywords: Jump Height; Jump Power; Complex Training; Performance; Vertical Jump

Introduction

Training methods designed to optimize performance have received considerable prominence among coaches and researchers [1-3]. Among these methods there is the Complex Training, a widely used method to enhance the explosive movements, which is characterized by combined training between the traditional strength training (ST) and the plyometric exercises within a single exercise session [4,5], aiming to increase performance in a muscle contraction through the post-activation potential (PAP) [6,7].

The increase in a muscle contraction performance, when it is preceded by a maximal or submaximal muscular activity, is called post-activation potential (PAP) [8]. The physiological mechanisms responsible for this phenomenon are not yet fully understood in the literature. Although, the occurrence of a PAP seem to be dependent of the several variables [9,10], such as: interval between the exercise with additional load [11], the technical gesture to be boosted [12], load [13], number of repetitions and type of muscle contraction used in the exercise with additional load and performance, besides sex and strength training (ST) experience [14].

The type of exercise [15] and the type of muscle contraction used, in the exercise that intends to induce a PAP, has also been studied. It is verified that isometric muscular contractions create a higher PAP than the dynamic contractions [16]. However, both are able to create a PAP [15,16]. Also, in the case of vertical jump, the use of Squatting exercise in the Smith Machine is usual [17]. Unfortunately, the
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Sports facilities where the competitions and trainings are held are not always equipped with infrastructures to carry out exercises such as the squat in the Smith Machine.

The use of plyometric exercises to induce a PAP was observed by Esformes, [15] a sequence of horizontal jumps does not differentiate in the creation of a PAP from the use of the squat exercise in the Smith Machine. One of the premises for the creation of a PPA is that the responsible exercise of creating this potential is performed with a high intensity, about 80% of the 1RM in the case of TF exercises with additional load. Because deep jumps are a form of high intensity plyometric exercise compared to horizontal jumps, comparable to muscle contractions performed through maximal or submaximal exercise [18].

The effect of a traditional ST exercise, performed with maximum and submaximal muscle contractions, in the possible potentiation of vertical jumps, has been one of the most researched themes in this theme [19]. The above mentioned fact may be due to the ability of vertical jump influence, in a relevant way, the final result in the competition of modalities such as Volleyball and Basketball, where this explosive sport gesture is frequently used, in the actions of obtaining points and, also, in the defensive maneuvers [2,20].

However, evidence on the effects of applying plyometric regimens in terms of post-activation-potentiation (PAP) strategies, consisting exclusively of vertically or horizontally oriented plyometric activities in high-level athletes, is still lacking. Thus, the objective of this study was to determine whether the use of multiple sets of drop jumps (DJ) provides a PAP equal or greater than the use of the squat exercise in SMS and, consequently, the effect on the height of the vertical jump (VJ).

Methods

Subjects - 15 Volleyball male athletes state level (19.88 ± 1.54), who performed 5 training sessions per week, lasting 2 hours per session with the characteristics presented in the Table 1, composed the sample of this study. It was established as inclusion criteria: minimum of 2 years of practice in strength training, with an mean frequency of three times a week; have no negative answers in Par-Q test; and no history of injuries in the hip, knee and ankle in the last 6 months. The inclusion criteria were evaluated in an anamnesis for this purpose. The subjects were informed to not perform any training preceding the experimental sessions in at least 72h.

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>Body Mass (kg)</th>
<th>Height (cm)</th>
<th>BMI (kg/m²)</th>
<th>SMS RM (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>19.88</td>
<td>74.49</td>
<td>180</td>
<td>23.05</td>
</tr>
<tr>
<td>±SD</td>
<td>±1.54</td>
<td>±3.17</td>
<td>±0.04</td>
<td>±0.68</td>
</tr>
</tbody>
</table>

Table 1. Subjects characterization.

Procedures - At first, the researchers met with the possible subjects of the sample potential and explained the purpose and procedures of this study. 15 volunteers were selected for nonrandom convenience that met the inclusion criteria. In a second meeting it was realized the anthropometric measurements; the individual test of the DJ height; and the control CMJ (CCMJ) height. In a third session was held the 5RM test for the Smith Machine Squat (SMS) exercise. In the fourth meeting, it was made the re-testing of the DJ and the SVC height. In a fifth session was also made the 5RM re-test of the SMS exercise. In the sixth and final session were carried out randomly the two experimental proposals: (1) SMS followed by the Countermovement Jump (CMJ) and; DJ followed by CMJ. These two interventions had an hour gap in between. All sessions in this study had a 72 hours gap between them.

5RM Test - The 5RM test was performed on the Smith Machine (Technogym brand), following the norms already implemented in other study [21]. The measurement was made in kg. The use of the 5RM load was chosen, due to the same methodology applied in the study of McCann et. al. [22], where they obtained an increase in performance in volleyball athletes.

Determination of the starting height of the Drop Jumps – The best starting height of the drop jump for each athlete was measured. They jumped, at 5-minute intervals, from a bench with different heights (30, 40 and 50 cm). The starting height was the one that the individual reached the highest height in the vertical jump. In the study by Hoffman [23] a standard starting height of 40cm was used, however, due to the biological individuality of the subjects, it was necessary to verify which would be the best starting point for each subject.

Determination of the control countermovement jump (CCMJ) – The jump realized was the Counter Movement Jump (CMJ). Each subject performed 3 CMJs in the jump platform (Cardiomed® Jump Fit), with an interval of 10 minutes between them, aiming to reach the highest height and the highest power, (according to Bosco [24]). Measurements were recorded in centimeters (height) and watts (power).
I was decided to include the use of the arm-swing in all CMJ, as it is important to understand that the arm-swing can improve performance by 10% or more [25]. The depth the athlete will drop to during the short ‘countermovement’ or ‘pre-stretch’ action before they takeoff have no universal agreement on which is depth is most appropriate, higher jumps and peak power outputs appear to increase with larger countermovement depths [26,27]; however, we instruct the subjects to normalize the depth in all jumps. During their time spent in the air, the athletes maintain extension in the hip, knee, and ankle joints to prevent them achieving any additional flight time by bending their legs [3,15]. The athlete not only jumps as high as possible, but also attempts to land in the same position as they took off – as jumping forwards, backwards or sideways can affect the test results.

**Potentiation by squatting on Smith Machine (PSMS)** - To check the ergogenic effect on the potentiation using the squat on the Smith, the subjects performed a set of 5RM of squat on the Smith Machine. After that, rested for 4 minutes in a chair and then, immediately after, performed 3 CMJ in the jump platform. The height and power of the CMJs was measured in order to be comparing with the CCMJ. Potentiation by Drop Jumps (PDJ) - The subjects performed a set of 5 DJ, with the starting height determined, after that rested for 4 minutes sitting in a chair and subsequently performed 3 CMJ in the jump platform, in order to assess the height and the power of the jump. This Jump was performed from a standardized drop height of 40 cm. The athlete stands on the box with the hands placed on the hips, and stayed there throughout the test. The athlete drops down off the box, bending the knees on landing, then immediately going in to a maximal vertical jump. The athlete jumps vertically as high as possible, and back on the mat with both feet landing at the same time. Allow an adequate rest between trials.

**Statistical analyses** - The analysis of all the data was done using the statistical analysis and treatment software “Statistical Package for the Social Sciences, SPSS Science, Chicago, USA” version 20.0. An exploratory analysis of all the data was carried out to characterize the values of the different variables in terms of central tendency and dispersion. Thus, all variables were subjected to a graphical observation in order to detect the existence of outliers and possible incorrect entries of the data. The means and the respective standard deviations of each variable under study and in all the planned analysis contexts were calculated in the descriptive statistical analysis.

In order to perform the inferential statistical analysis, it was necessary to evaluate the normality of the distribution of the collected data. In this way, and taking into account the biological nature of the measures that will be carried out, an analysis of the type of distribution was made through the Shapiro-Wilk test. The homogeneity of variances and covariance was also ensured and tested by the Levene test and sphericity by the Mauchly test. Once the aforementioned procedures were verified, the assumptions of the use of parametric tests were used to compare means of the variables under study in the different study groups and between groups repeated measures ANOVA with a Sidak Post-Hoc. The consistency of the 5RM variables in Squatting exercise in the Smith Machine and the base vertical jump were evaluated through Cronbach’s Alpha and was greater than 90%. The level of significance was maintained at 5%.

**Results**

In this study, a significant difference was observed in the CMJ height and power (F (1,16) = 381,451, p = 0,000, μp² = 0,960 and F (1,16) = 1540,971, p = 0,000, μp² = 0,960, CMJ height and power, respectively), between the three strategies (CCMJ, PSMS and PDJ) (Table 2).

<table>
<thead>
<tr>
<th></th>
<th>CCMJ</th>
<th>PDJ</th>
<th>PSMS</th>
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<tbody>
<tr>
<td>Jump Height (cm)</td>
<td>39.53±8.31</td>
<td>40.71±8.57*</td>
<td>41.88±8.94*†</td>
</tr>
<tr>
<td>Jump Power (Watts)</td>
<td>1343.03±141.23</td>
<td>1343.74±141.15*</td>
<td>1344.45±141.03*†</td>
</tr>
</tbody>
</table>

Table 2. Mean ± Standard Deviation height of the vertical jumps preceded by the jump in depth.

CCMJ - average height of the vertical jumps of control; PDJ - Average height of the CMJ potentied by drop jumps; PSMS - Height of CMJ preceded by the Smith Machine Squat; * P < 0.0001 between CCMJ and PDJ; # - P < 0.0001 between CCMJ and PSMS; † p < 0.001 between PDJ and PSMS.

**Discussion**

This study aimed to verify if DJ could generate a PAP in the CMJ, and thus to use it as a resource to increase the jump performance in volleyball players. It was possible to verify that both PDJ and PSMS were able to increase the CMJ height (p = 0,000) and power (p = 0,000), in relation to CCMJ. Although, the PSMS was able to induce more jump height (p = 0,000) and power (p = 0,000), in relation to PDJ.

Regarding to the potentiation by SMS exercise, the results observed in this study corroborate who those observed in other studies [9,28,29]. In the study by Mitchell & Sale [29] a 5RM set of SMS exercise was performed with 4-minute interval before performing the VJ, it was observed increments in the height of the VJ in about 3%. In our study, the observed increase in height of VJ was 6%. This higher increase in the present study may be related to the subjects’ level of training that participates in both studies. While the study of
Mitchel and Sale [29] subjects were sedentary, contrary, in the current study, the subjects were experienced Volleyball players. As noted by Chiu et al. [30] and Smith and Fry [31] subjects who have a higher level of training are those where one observes a larger PAP.

The physiological mechanisms responsible for this phenomenon are not yet fully understood in the literature. However, some studies consider phosphorylation of myosin light chain, which makes the actin-myosin interaction more sensitive to calcium released by the sarcoplasmic reticulum, one of the main physiological mechanisms responsible for PAP [11,18]. Due to this increased sensitivity, there may be an increase in the number of active cross-bridges and, consequently, the existence of superior muscle torque when compared to non-potentiated muscle contraction [32].

Contrary to the study of Mitchel and Sale [29], in the study Crewther et al. [28] was noted a higher increase in VJ in relation to our study. Crewther used the same interval between the potentiating exercise and what is intended potentiate (4 minutes). However, it was used a load in the SMS exercise to perform with 3RM, while in our study we used 5RM. This may have influenced the differences between the current study and the Crewther [28]. In our literature review, we found that high loads provide greater neural stimulation and allow a higher PAP when applied isotonic muscle contractions [4]. That fact may be the reason why, in our study, the PSMS was more able to create a PAP than PDJ; the SMS is a more intense exercise to the neuromuscular system than the DJ.

Although some studies showed a ergogenic effect of PAP 20 minutes after the end of the potentiating exercise, MacIntosh et al. [17] in its recent review, claim that this data is still incomplete and the effects of potentiation cease 6 minutes after the potentiation event, which prevents the use of PAP as heating methodology. As it can be observed in our results, 4 minutes of interval seems to be sufficient to create a PAP in both exercises applied.

Also, Bevan et al. [9] found significant improvements (p <0.05) in sports performance of rugby athletes with loads higher than those used in our study (3 repetitions of the SMS exercise, with 91% of 1RM). However, we should mention that rugby athletes usually have high levels of muscle strength, which creates a tendency markedly higher from a PAP.

Moreover, McCann et al. [22] used a methodology similar to the present study, found also identical values in VJ. However, the increases of 5.7% observed by McCann, were only observed when the interval time between the exercises of SMS and the VJ was 5 minutes. This fact may be due to the less experienced sample in strength training than the subjects in this study, although they were athletes of different modalities. Also, as suggested Comyns et al. [33] the interval time between exercise and sports potentiating action to be potentiated should be individualized.

Regarding to the increase of 6% in CMJ, observed in our study, obtained when using the exercise of SMS, or even 3% obtained from the DJ, can have much meaning to the sport level. Converging to said earlier, Jones and Lees [5] analyzed the effect of a 5 repetitions set with loads of 85% of 1RM and found increases in the order of 7% at the peak absolute power, 7.1% in the peak relative power and an improvement of 9% in the fatigue index, factors that can influence the performance.

The results observed in our study allow us to state that both a set of 5 DJ, as a set of 5RM SMS exercise, provides a significant increase in height and power of the CMJ in the subjects of this sample. We report that most articles do not mention the increase of muscle power of lower limbs, however, by analogy of Bosco [24] and considering homogeneous samples, if there is an increase in height of the VJ, there is an increase in muscle power fulfilled.

Using the DJ, even with inferior results when compared with stimulation through the SMS (3% vs. 6%), demonstrates advantages such as: less risk of injury; greater ease in performing the exercise (athletes in question, already use this exercise in their training routines). The areas mentioned above, seem to outweigh the difference in performance seen in the use of SMS exercise. Although the increase of 3% from the PDJ may seem insignificant, when we analyze the current situation of the sports around the world where decisions are in milliseconds or centimeters, this increase may have a significant influence on the final result of a competition.

Considering the results of this study and the results of the studies reviewed, it can be said that the use of the DJ as potentiating exercise of VJ, seems to be positive. However, more studies are needed to see if this post activation potential is found with higher recovery times between pairs of exercises. Thus, their use as competitive pre-heating method can be considered. Although its use in the context of sports training is positive, either in terms of management, either in terms of implementation.
Conclusion

It can be concluded that the DJ produces a PAP and consequently an improvement of the height and power of the CMJ. Thus, it seems that DJ can be used as a training strategy for Volleyball players. However, the SMS exercise had a greater ability to leverage the VJ both on the heel height level and within the power of it.

Acknowledgements


Conflict of Interest

The authors declare no conflict of interest.

References


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