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The Influence of Pneumatic Exercise and Traditional Barbell Exercise on Post-activation Potentiation Effect

Qiannan Liu[1, a]

[1]Department of Physical Education, College of Sport Sciences, Dong-A University, Busan,604-714, South Korea

[a]2178317@donga.ac.kr

Abstract

Objective: This study used the post-activation potentiation (PAP) as the breakthrough point, by comparing the effects of two exercises on PAP effect, to find a more effective training method to induce PAP. Methods: Ten male undergraduate volunteers were selected. PAP induction included pneumatic half squat exercise and traditional barbell half squat exercise with 60% 1RM, repeated 3 times, 5 groups, and the interval between groups was 2 minutes; pneumatic half squat exercise and traditional barbell half squat exercise with 90% 1RM, repeat 3 times, 5 groups, and interval 2 minutes between groups. After PAP induction, the squat jump test (CMJ) was performed every 2 minutes from the 4th minute (i.e., the 4th, 6th, 8th, 10th and 12th minutes). The peak power of the CMJ is obtained. Statistical analysis includes paired sample t-test and repeated-measures ANOVA. Conclusion: Both pneumatic exercise and traditional barbell exercise can produce PAP effect. At 60% 1RM and 90% 1RM intensity, PAP of pneumatic exercise was better than that of traditional barbell exercise, especially at the 4th-10th minute after PAP. Whether using pneumatic trainer or the barbell for PAP induction, the greater the intensity, the better the PAP effect.

Keywords

Post-activation potentiation effect, Explosive force, Pneumatic training.

1. Introduction

Explosive force is a crucial athletic quality, the most typical manifestation of the speed force. It refers to the ability of the muscle to contract rapidly and produce super explosive force when it begins to be constantly affected by external tension [1]. Post-activation Potentiation (PAP) refers to the physiological phenomenon of acute increase of muscle explosive force or exertion speed caused by one extreme or sub-extreme exercise. PAP is affected by training factors such as load mode, intensity, training volume, recovery time, following exercise type and so on [2].

Pneumatic training is variable aerodynamic resistance training, which needs to be trained by an aerodynamic variable resistance trainer (KEISER equipment). The equipment uses air pressure instead of an inertial resistance body (such as barbell), and the resistance of the human body is relatively constant during the whole action, which can minimize the inertial effect of the instrument. Researchers found that the combination of pneumatic trainer and traditional barbell training is superior to traditional barbell training in developing athletes' endurance explosive force and peak power [3]. However, there is a lack of relevant research on the influence of pneumatic training on PAP effect, and the comparative research on the influence of pneumatic training and traditional barbell training on PAP is blank. It is necessary to study this and explore some theoretical and practical basis for explosive training or pre-competition warm-up.

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The purpose of this study is to find a more effective training method to induce the post-activation effect by comparing the effects of two exercises on PAP. Specifically, this study will explore the optimal load and time of PAP produced by pneumatic exercise, and compare the impact of PAP produced by two instruments, which will be realized as the comparison of peak power.

2. Materials and Methods

2.1. Experimental Approach to the Problem

This study implemented a repeated measures and self-control study design. Subjects were given 4 kinds of PAP induction exercises, including (1) pneumatic half-squat exercises with 60% 1RM, repeated 3 times, 5 groups, and intermittent 2 minutes between groups. (2) Traditional barbell half-squat exercises with 60% 1RM, repeat 3 times, 5 groups, and intermission between groups is 2 minutes; (3) Pneumatic half-squat exercises with 90% 1RM, repeated 3 times, 5 groups, with an interval of 2 minutes between groups; (4) Traditional barbell half-squat exercises with 90% 1RM, repeat 3 times, 5 groups, and interval 2 minutes between groups. Only do one induction exercise at a time, and the Counter Movement Jump (CMJ) was performed every 2 minutes from the 4th minute after induction (i.e., the 4th minute, the 6th minute, the 8th minute, the 10th minute, and the 12th minute).

Use KEISER equipment (including KEISER special rod and air pump) for half-squat exercise, and use Kistler Quatter Jump (Switzerland 9290CD) to obtain Peak Power (pp) for comparative analysis.

2.2. Subjects

The subjects were 12 male undergraduate volunteers. All subjects met the following inclusion criteria: (1) aged between 18 and 30 years old, with training experience, able to perform half squat exercises proficiently, and volunteered to participate in this study. (2) During the whole experiment, no high-intensity resistance exercise, no drinking, and no caffeine intake within 3 hours before the test. (3) There is no history of lower limb injury and no contraindication symptoms such as cardiovascular diseases in recent 3 months.

2.3. Statistical Analyses

The results were expressed by mean ± standard deviation. SPSS 24.0 was used for statistical processing of experimental data. Paired sample t-test was used to analyse and compare the effects of different instruments on peak power after PAP induction and different loads on peak power after PAP induction.

3. Result

3.1. The results of peak power after induction of 60% 1RM intensity PAP with both devices

The results of paired samples t-test showed that the PAP effect of using pneumatic trainer was better than that of traditional barbell at 60% 1RM strength. At the 4th minute (p=0. 042) and 10th minute (p=0. 033) after PAP induction, the peak power of the traditional barbell group was significantly different from that of the pneumatic trainer group.At the 6th minute after PAP induction (p=0. 001), there was a significant difference between the peak power of the traditional barbell group and that of the pneumatic trainer group. There was no significant difference between the two groups before PAP induction and at the 8th minute (p=0. 067) and 12th minute (p=0. 058) after PAP induction,see Fig. 1.

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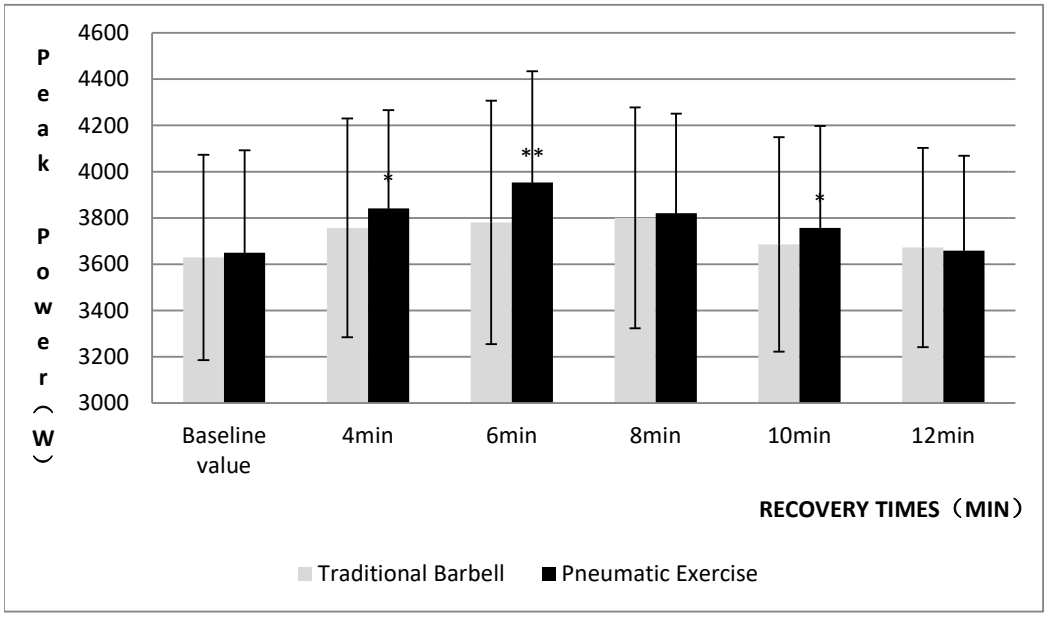

Figure 1. Comparative histogram of peak power after PAP induction with 60% 1RM intensity between two instruments

Baseline value: Peak power of squat jump before PAP induction.

* Indicates that there is a significant difference between the traditional barbell group and the pneumatic group ($P < 0.05$), and * * indicates that there is a very significant difference between the traditional barbell group and the pneumatic group ($P < 0.01$).

3.2. Results of peak power after 90% 1RM PAP induction with two instruments

The results of paired sample t-test showed that there were significant differences between the peak power of the traditional barbell group and that of the pneumatic trainer group at the 4th minute (p=0. 033), 6th minute (p=0. 02), 8th minute (p=0. 024) and 10th minute (p=0. 01) after induction at 90% 1RM intensity.There was no significant difference between the two groups before PAP induction and 12 minutes after PAP induction (p=0. 09),see Fig. 2.

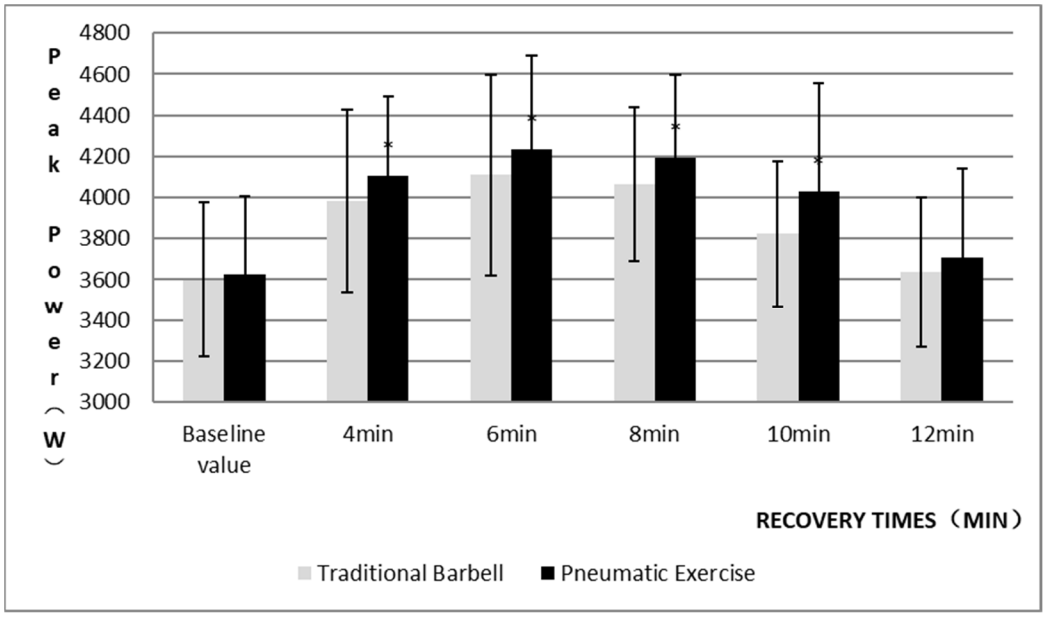

Figure 2. Comparative histogram of peak power after PAP induction with 90% 1RM intensity between two instruments

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3.3. The peak power results at different recovery times after PAP induction using an air resistance trainer at two load intensities

The results of paired sample t-test showed that there were significant differences in peak power generated at the 4th minute (p=0. 02), 6th minute (p=0. 023), 8th minute (p=0. 18), and 10th minute (p=0. 033) after being induced by 60% 1RM and 90% 1RM load intensity (Figure 7).

There was no significant difference in the peak power produced at the 12th minute (p=0. 82) after being induced by 60% 1RM and 90% 1RM load intensity, respectively,see Fig. 3.

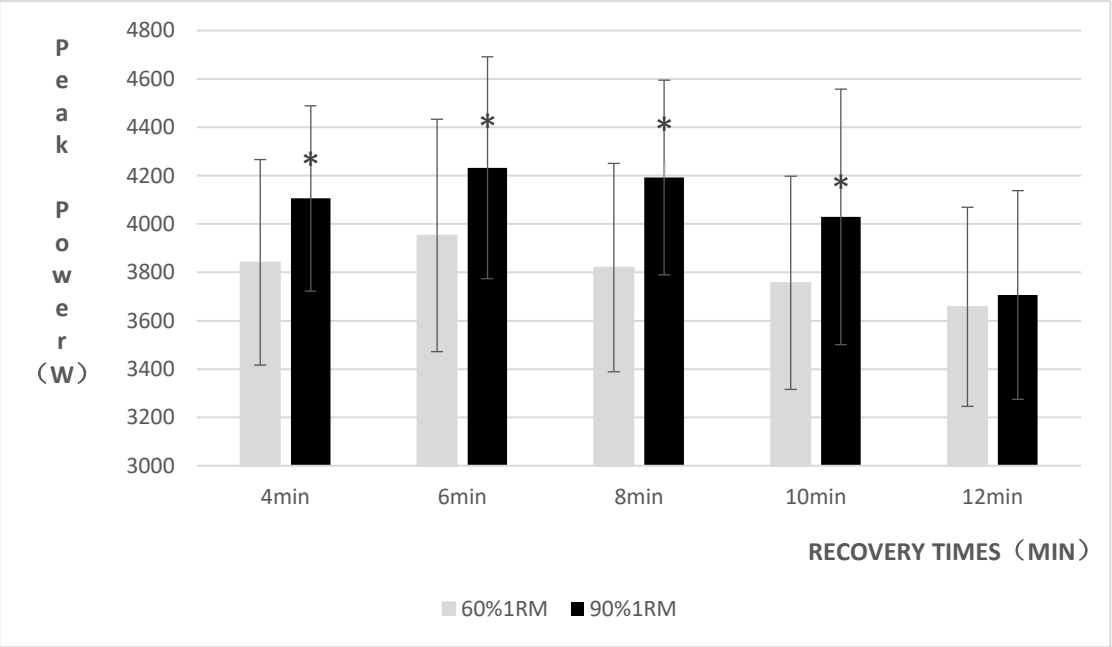

Figure 3. Histogram of peak power at different recovery times after PAP induction under two load intensities using the pneumatic trainer.

4. Discussion

Apanukul S and other researchers found that when the pneumatic trainer is combined with the traditional barbell for training, it is superior to the traditional barbell training in developing athletes' explosive force and peak power [3]. Some studies have found that compared with traditional barbell training, pneumatic training has more advantages in developing fast strength and explosive force with a small load [4]. The results of this study (Fig. 1 and Fig. 2) are reasonable. When the traditional barbell weight-bearing training exerts force quickly, the inertia force increases with the speed increase, and the resistance will gradually decrease. However, the resistance of pneumatic training equipment to the human body is relatively constant in the whole process of movement completion, so inertia can't help the centripetal contraction stage, you need your own strength to complete the movement in the whole process, so the pneumatic training equipment will have better stimulation effect than the traditional barbell weight-bearing equipment. Because of the particularity of the bar of the pneumatic trainer, its balance is not as good as that of the barbell bar. Simply put, when using the pneumatic trainer to practice, it is necessary to mobilize more deep stable muscle groups to control the balance of the bar, which makes more muscle groups participate in the practice.

Fukutani and other researchers found that with the growth of stimulus intensity, the vertical jump height and peak power gradually increased [5]. According to exercise physiology, in the process of muscle contraction, the recruitment of exercise units is orderly, that is, in low-intensity exercise, small motor neurons are the first to be recruited. Large motor neurons are

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recruited only when the exercise intensity increases, so different load intensities have an impact on the explosive force. The results of this study (Figure 3) agree with the views of other researchers. The analysis reason is that the greater the intensity, the greater the phosphorylation of muscle myosin regulating light chain, or the more high-order motor units are recruited, so the more significant the post-activation enhancement effect is. However, at the 12th minute after PAP activation, the load intensity has no significant impact on the peak power generated by PAP. The reason may be that when the load intensity is 60% 1RM and 90% 1RM, the post-activation enhancement effect disappears after 12 minutes of PAP activation, which is basically consistent with previous studies [6].

5. Conclusion

Under 60% 1RM and 90% 1RM intensity, the post-activation enhancement effect of pneumatic exercise was better than that of traditional barbell exercise, especially in the 4 ~ 10 minutes after PAP activation.

When using the pneumatic trainer for PAP induction, the greater the intensity, the better the post-activation potentiation effect.

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