Passive Repetitive Isokinetic Training Compared with Resistance Training: Effects on Performance and Hormones in Untrained Men

被動反覆衝擊式等速訓練與傳統訓練比較：對未受過訓練之男性其運動表現及安靜期荷爾蒙之影響

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Abstract

The purpose of this study was to investigate the effects of 10 weeks Passive Repetitive Isokinetic Training (PRI) training on hormone concentrations and physical performance. Nineteen untrained men were randomized to intervention with either PRI training (*n*= 10) or traditional resistance training (n = 9). PRI group performed five sets with ten repetitions with corresponding 70-75% repetition maximum (RM) loads on the PRI platform and 2-min rest periods, whereas TR group performed the same protocol with squat exercise. Strength and power performance testing were measured before and after 10-week training. Resting hormones were measured at pre-training (week-0), week-6, and post training (week-10). The results of our study were that after 10 weeks of PRI training, vertical jump, running vertical jump, 30-m sprint time and maximal strength by squat-test were significantly higher with respect to pre-training ($p < 0.05$). In TR group, maximal strength by squatting test was significantly increased compared with pre-training ($p < 0.05$), while no significantly changes were observed for the other power tests. There were no significantly changes in GH, IGF-1, testosterone, cortisol, and T/C ratio during the 10-week training period in both groups. The data indicated that PRI and traditional resistances training have similar hormonal states. The PRI training significantly increased power and strength performance.

Key words: resistance training, growth hormone, testosterone, cortisol.

摘　要

被動反覆衝擊式訓練(Passive Repetitive Isokinetic Training；PRI)主要是依據伸展縮短循環（Stretch-Shortening-Cycle）特性所發展出的一種訓練肌力和爆發力的器材，然而PRI訓練對訓練效果及人體體內荷爾蒙的影響，尚無相關的實驗數值來證實。因此，本研究目的在探討PRI訓練前後安靜期血液中荷爾蒙之變化及肌力與爆發力等運動表現的影響。研究中共有19名受試者，隨機分為PRI訓練組(**n**=10)及傳統蹲舉訓練組(TR；n=9)，進行每週三次共10週之訓練，並於訓練前、訓練第6週及訓練後分別進行安靜時的血液採集，分析安靜時血液中生長激素(Growth hormone；GH)、類胰島素生長因子(Insulin-like growth factor)、睪固酮(Testosterone)及皮質醇(Cortisol)的濃度，並於訓練前後進行肌力及爆發力測試，結果發現：PRI組其肌力及爆發力表現在訓練後顯著的提升，而TR組僅增加最大肌力，兩組間以變化百分比進行比較：PRI在肌力及爆發力的變化百分比皆顯著高於TR組。血液荷爾蒙的結果：第6週和第10週時之安靜生長激素、類胰島素生長因子、睪固酮及皮質醇的濃度，組內訓練前後相比並無顯著性的改變；PRI組與TR組兩組間安靜期的荷爾蒙濃度反應亦無差異。由本研究得知：為期10週之PRI訓練能有效的提升肌力以及爆發力之運動表現，然而安靜期的荷爾蒙於訓練前、中、後並無顯著的變化。

關鍵字: 肌力、生長激素、睪固酮、皮質醇

Introduction

Resistance and power training is known to be an effective method of improving the functional capacity of the neuromuscular system. Several modes of resistance training equipment are now available (e.g., free weights, machines with stacked plates, and machines with pneumatic resistance), and they all serve as an effective stimulus to the neuromuscular and endocrine system. Power training, like plyometric training, develops more techniques, stretch and reflex capacity in a muscle. With regular exposure to this training stimulus, muscle fiber should be able to store more elastic energy and transfer more quickly and powerfully from the eccentric to the concentric phase. Passive Repetitive Isokinetic (PRI) training machine is a new machine, which based on the theory of high speed contraction, explosive-plyometric power training, and stretch shortening cycle (SSC). SSC training is a form of physical conditional characterized by an intense eccentric contraction of a muscle followed immediately by a rapid concentric contraction. This action produces a forceful and explosive movement. Explosive-reactive power training event involves powerful muscular contractions in response to a rapid stretching of the involved musculature. Several researches in Taiwan have demonstrated that the PRI training significantly improved strength and power in elite athletes (Chang, 2004; Liu, et al., 2001; Liu, 2005; Wen, 2000; Wen, et al., 2002).

It is well known that skeletal muscle is regulated in part by the circulating hormonal environment (Kraemer, et al., 1999), and it has been suggested that muscle adaptations may be related to changes in the anabolic and catabolic hormone profile (Haddad & Adams, 2002). However, the effect of PRI training on hormonal concentration was still unclear. The purpose of this study was to investigate the effects of 10 weeks PRI training on resting hormone concentrations and physical performance (power and strength).

Methods

Subjects

Nineteen non-athletes male were recruited for this experiment, which was approved by the Human Research Ethics Committee. All subjects were asked to maintain their usual food intake. No medication or food supplements were taken by the subjects, which would have been expected to affect physical performance. The purpose and possible discomfort of the study were fully explained to each subject. And they should signed informed consent forms.

Experimental Design

To test the effects of PRI training on relevant dependent variables, a typical research testing design including before and after an intervention period was used. In our study, subjects were divided into two training groups, a PRI training group (PRI, N = 10), or traditional resistance training control group (TR, N = 9). All participants were instructed not to alter their normal physical activities during participation in this study.

Testing procedures

Prior to initial testing each subject was familiarized with testing protocol and completed a full practice testing session. After this familiarization testing session, each subject was tested on two separate occasions: prior to the commencement of training and at the completion in the 10-wk training period. The tests included: (1) Jump and Reach tests. (2) Time for a 30-m sprint according to the procedures of field. (3) Maximal strength by squatting test. Jump and reach performance was measured using a Vertec (Questtek Corp., Northridge, CA). Reach height was established by having the subject stand flat-footed and reach up to displace the marker on the Vertec. The subject then performed two types of jumps:(a) The standing vertical jump and reach (VJR) for which he dipped to a self-selected depth and then jumped and reached with his preferred hand to displace the marker on the Vertec; (b) Running jump and reach (RJR): a running three-step approach followed by a takeoff from one leg to reach and displace the marker on the Vertec. Three trials were permitted for all jumps with the highest jump being used in subsequent statistical analysis. Maximal strengths were assessed by squat-exercise. In the squat-test, the shoulder was in contact with a bar and the starting knee angle was 110°. On command, the subject performed a concentric squatting (as fast as possible) starting from the flexed position to reach the full extension of 180° against the resistance determined by the weight plates added to both ends of the bar. Prior to all testing, the subjects performed a sub-maximal trial to familiarize themselves with that test. Subjects completed a standard warm up which consisted of 5 min running on the spot, with an intensity corresponding to a heart rate of 130-150 beats per minute. After completing the running the subjects performed stretching exercise for a further 3 min.

Training Protocol

Subjects randomized to exercise training group underwent a 10-wk regimen. The subjects were all familiarized with the exercises before start and all training sessions were individual supervised on PRI and traditional resistance machine (squat training method). They were trained three times a week from 15:00 to 17:00 on Monday, Wednesday, and Friday for 10 weeks. The training of this study was performed at a resistance that was initially 70% of one repetition maximum (1RM) on the PRI or traditional resistance training machine (squat training). The reaction forces of both legs on PRI machine were shown on the display for a visual feedback and subjects were requested to exceed in 70% of the maximum resistance force. PRI group performed five sets with ten repetitions with corresponding 70-75% repetition maximum (RM) loads on the PRI platform and 2-min rest periods, whereas TR group performed the same protocol with squat exercise. Training intensity used in this study was determined during the training sessions every week (on Monday) for the 10-wk training period using 1RM approach.

Blood Collection and Analyses

This study examined whether growth hormone (GH), insulin-like growth factor (IGF-1), testosterone, and cortisol concentrations at rest situation in response to 10 weeks of exercise-training. Resting blood samples drawn at pre-training, week-6, and post-training. Blood was drawn at the same time of day (on Monday) from each subject (between 7:30 a.m. and 8:30 a.m.) to minimize diurnal hormonal variations. At the time of blood draw, subjects had abstained from food for 8 hours. Whole blood samples were allowed to clot at room temperature for 30 min, after which it was centrifuged for 10 min at 1500 × g, 4°C, with resulting serum stored at -80°C until assayed. Enzyme-linked immunosorbent assays (ELISA) were performed in duplicate for all hormones (Diagnostic Systems Laboratories, Webster, TX, USA). GH serum concentrations were determined by ELISA kit. Intra-assay CV was 3.3-4.3%, and interassay CV was 6.3-6.5%. IGF-I was determined by DSL-10-2800 Active kit. Intra-assay CV was 6.3-8.6%, and interassay CV was 3.3-6.8%. Testosterone was determined by DSL-10-4000 Active kit. Intra-assay CV was 4.8-6.8%, and interassay CV was 2.8-4.9%. Cortisol was determined by DSL-10-2000 Active kit. Intra-assay CV was 2.4-10.3%, and interassay CV was 6.1-12.0%.

Statistical Analysis

Values are reported as means ± standard deviations error mean (SE). Differences of performance between pre- and post-training were tested by paired t-test observations and results between the experimental groups were analyzed by independent t-tests. Differences of hormone concentrations within each time point were analyzed utilizing repeated-measures ANOVA. The level of significant difference was established at $P< 0.05$.

Results

The characteristics of subjects were shown in Table 1. Both groups were similar in age, height, and weight. Performance results were shown in Table 2. After 10 weeks of PRI training, vertical jump, running vertical jump, 30-m sprint time and maximal strength by squat-test were significantly higher with respect to baseline (P< 0.05). Maximal strength by squat-test in TR group was significantly increased compared with pre-training (P< 0.05). The percent changes of power and strength performance in PRI training group was significantly higher than in TR group (P< 0.05, Figure 1 & 2).

Resting hormones of two groups were shown in Table 3. Resting concentrations of hormones remained constant throughout the 10-wk period training. There were no significantly changed in GH, IGF-1, and testosterone, cortisol, and T/C ratio during the 10-week training period in groups. And there were also no significantly differences in GH, IGF-1, testosterone, cortisol, and T/C ratio between PRI and TR groups.

Discussion

The purpose of this study was to investigate the effects of 10 weeks PRI training on resting hormone concentrations and physical performance. The major finding was that PRI training significantly increased power and strength performance. Traditional squat-training only significantly increased the strength performance. The percent change of power and strength performance in PRI training group was significantly higher than in TR group. The difference between PRI training and traditional squat training is the passive- and active-contraction. Traditional squat-training could perform by descending, stopping for several seconds before ascending, and squats could be performed from a pin at a set height in a power rack.

The experimental design of our study was similar to Ahlborg et al. (2006) and Kvorning et al. (2006) studies which were to compare changes in performance and hormones between whole-body vibration training and resistance training. PRI training machine based on the theory of explosive-reactive power training, and stretch shortening cycle. In PRI machine, the trainee's shoulders are restricted from an upward vertical motion by a horizontal and stationary cushioned bar. This cushioned bar is used by the muscle groups of lower limbs to apply a downward force against the moving platform. Hence, this allows the muscles of the trainee to accomplish isokinetic contraction, as well as concentric and eccentric contraction passively with maximum muscle strength. The interesting finding in our study strongly supported in research by Hakkinen (1985) who found that explosive-type resistance training resulted in significantly greater increases in rate of force development. And Kraemer et al. (1999) reported that maximal power training involving ballistic movements was found to be more effective than traditional resistance training for increasing power performance. Holcomb et al. (1996) compared the effects of 10 wk of three training modalities included (1) explosive-weight training at the load that maximized mechanical power output, (2) traditional weight training, and (3) plyometric training. The experimental group which trained with the load that maximized mechanical power achieved the best overall results in enhancing dynamic athletic performance recording statistically significant (P< 0.05) improvements on most test items and producing statistically superior results to the two other training modalities on the jumping and isokinetic tests.

Endocrine responses and adaptations to resistance training entail four general classifications: (1) acute changes during and post-resistance exercise; (2) chronic changes in resting concentrations; (3) chronic changes in the acute response to a resistance exercise stimulus; (4) changes receptor content. Resistance exercise has been shown to elicit a significant acute hormonal response (Hakkinen & Pakarinen, 1993; Ratamess, et al., 2005; Rubin, et al., 2005). It appears that this acute response is more critical to tissue growth and remodeling than chronic changes in resting hormonal concentrations, as many studies have not shown significant chronic changes during resistance training despite increases in muscle strength and hypertrophy. (Bermon, et al., 1999; McCall, et al., 1999; Hakkinen, et al., 2000). The chronic hormone adaptation for exercise training has also been studied in older individuals (Hakkinen, et al., 1988). These data indicate that older men do respond with an enhanced hormonal profile in the early phase of a resistance training program, but the response is different from that of younger men (Kraemer, et al., 1999). It appeared that resting hormone concentrations may reflect differences at various stages depending on the volume and intensity of the training stimulus. As well as genetic predisposition, sex, fitness level and the potential for adaptation all play significant roles in the hormonal response to resistance exercise.

In our study, we focused on chronic changes in resting concentrations. And the results showed that resting hormone concentrations did not change during training period either in both groups. Hakkinen, et al. (2000) reported the effects of 6 months of heavy resistance training combined with explosive-exercises on basal concentrations and performance. The strength gains were accompanied by large increases in the maximal voluntary activation of the trained muscles, but the mean serum concentrations of hormones did not change during the training period. Ahtiainen, et al. (2003) also reported that improvements in muscle strength occurred without any accompanying basal hormonal changes. They suggested that it may have been due more to factors such as neural recruitment and skeleton adaptation rather than changes in the resting hormonal environment.

Various studies have demonstrated the important role played by the nervous system in strength gains during the early phase (initial 6-8 wk) of resistance training in untrained individuals (Chilibeck, et al., 1998). Early gains in strength may be due to adaptations within the nervous system such as increased motor neuron activation and motor unit synchronization (Griffin & Cafarelli, 2005). Previous studies have also shown that PRI training increased the power and strength performance (Wen, 2000; Wen, et al., 2002; Lee, et al., 2004). Liu (2005) confirmed that neural-muscular adaptation occurred after 10-weeks PRI training. According to those studies, we speculated that the muscle performance improvements from the PRI training method may display neural recruitment or muscle adaptation rather than changes in the resting hormonal concentrations. Although this study has increased our knowledge of the effects of 10-week PRI training on performance and resting hormones for young man, there remain a number of avenues for further research. What are the specific effects of different load PRI training and the velocity-specific changes occurring in terms of neural activation and motor unit recruitment patterns, as well as histochemical changes such as calcium activity and myosin heavy chain isoform profile?

In summary, this study has investigated resting situation in hormonal concentrations and performance after 10 weeks of PRI training and traditional resistance training. The data indicated that PRI and traditional resistance training may have similar hormonal state. However, the PRI training significantly increased power and strength performance. Traditional squat-training only increased the strength performance.

Table 1. Characteristics of Subjects.

Group	n	Age	Height (cm)	Weight (kg)	Body fat (%)
PRI	10	20.6 ± 0.4	175.4 ± 1.8	70.3 ± 2.0	15.5 ± 1.0
TR	9	20.5 ± 0.5	174.5 ± 1.8	69.7 ± 2.1	13.1 ± 1.2

Values are reported as means ± standard deviations error mean (SE)

Table 2. Results for the Standing Vertical Jump and Reach (VJR), Running Jump and Reach (RJR), 30-m Sprint Time, and Maximal Strength of Squat Tests for the Pre-training and Post-training Testing Occasions (Means ± SE).

Groups	Testing Occasions	
	Pre-training	Post-training
Vertical jump (cm)		
PRI	61.4 ± 0.9	66.1 ± 1.3*
TR	65.5 ± 2.6	65.8 ± 2.7
Running vertical jump (cm)		
PRI	65.3 ± 0.9	70.0 ± 1.8*
TR	71.9 ± 2.4	72.2 ± 2.5
30-m sprint time (s)		
PRI	4.6 ± 0.06	4.4 ± 0.07*
TR	4.6 ± 0.05	4.5 ± 0.05
Maximal strength of squat-test		
PRI	162.2 ± 6.8	295.6 ± 10.7*
TR	180.0 ± 8.4	302.0 ± 15.7*

*Denotes statistical significance from the pre-training ($p < 0.05$).

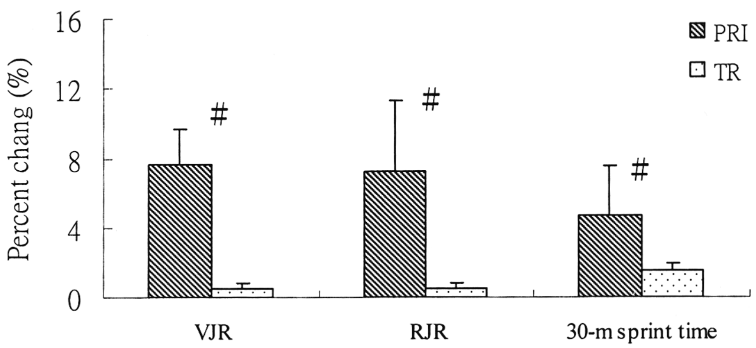

Figure 1. Percent Change (Pre- vs Post-training) in Standing Vertical Jump and Reach (VJR), Running Jump and Reach (RJR), and 30-m Sprint Time Tests.
#Denotes statistical significance between the groups ($p < 0.05$).

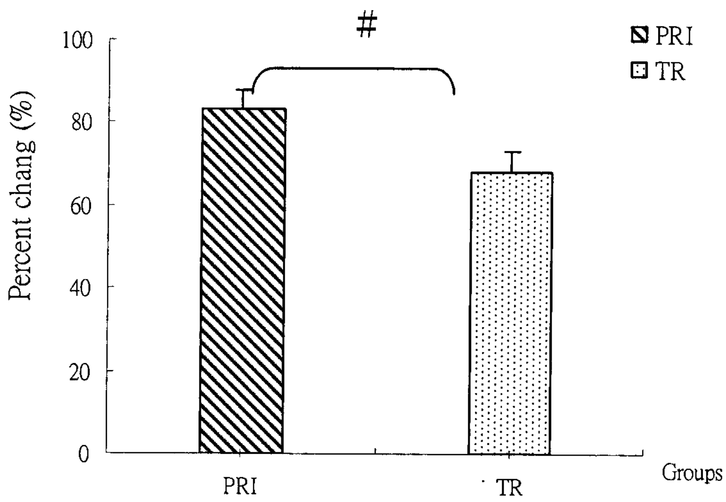

Figure 2. Percent Change (Pre- vs. Post-training) in the Squat-test, Starting Knee Angle was 110° to Reach the Full Extension of 180° against the Resistance Determined by the Weight Plates Added to both Ends of the Bar.
#Denotes statistical significance between the groups ($p< 0.05$).

Table 3. Resting Serum Growth Hormone(GH), Insulin-like Growth Factor (IGF-I), Insulin-like Growth Factor Binding Protein-3 (IGFBP-3), Testosterone, and Cortisol Concentrations for the Pre-training, Week-6 of Training, and Post-training (Mean ± SE).

Groups	Testing Occasions		
	Pre-training	Week-6	Post-training
GH (ng/mL)			
PRI	0.46 ± 0.04	0.48 ± 0.04	0.47 ± 0.03
TR	0.48 ± 0.03	0.52 ± 0.03	0.50 ± 0.03
IGF-1 (ng/mL)			
PRI	285.1 ± 17.7	268.8 ± 18.2	278.6 ± 11.9
TR	269.6 ± 12.4	233.5 ± 17.3	289.8 ± 22.8
IGFBP-3 (ng/mL)			
PRI	4332.2 ± 129.6	4346.9 ± 124.5	4009.2 ± 144.5
TR	4408.6 ± 153.7	4673.8 ± 93.1	4316.8 ± 76.7
Testosterone (ng/mL)			
PRI	5.6 ± 0.6	5.7 ± 0.5	5.1 ± 0.3
TR	4.7 ± 0.4	4.7 ± 0.3	4.3 ± 0.3
Cortisol (ng/dL)			
PRI	17.2 ± 0.9	17.0 ± 0.8	17.0 ± 1.5
TR	16.6 ± 0.9	15.1 ± 0.8	14.5 ± 0.9

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