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Research Article

Comparative Analysis on Blood Fatigue Variables after Isokinetic and Isotonic Exercise Training in Elite Athletes

Seong-Wook Seo, PT, MS · Kyoung Kim, PT, PhD[1†] · Sang-Cheol Im, PT, PhD

Department of Rehabilitation Sciences, Graduate School, Daegu University
[1]Department of Physical Therapy, College of Rehabilitation Sciences, Daegu University

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| Abstract |

PURPOSE: This study examined the changes in the blood fatigue variables caused by isokinetic and isotonic exercise training.

METHODS: Ten healthy adult males with at least one year of athletic experience participated. The participants performed the isokinetic circuit exercise program first, followed by an isotonic circuit exercise program. A two-hour break was allowed between the isokinetic circuit exercise program and the isotonic circuit exercise program. The circuit exercise program consisted of four items (Squat, Deadlift, Shoulder press, and Bench press). The blood samples were analyzed for the LDH, CPK, and Cortisol levels.

RESULTS: The LDH level in the isokinetic group was significantly different from the isotonic group. In particular, the change in LDH level in the isokinetic group was 33.30% lower than that of the isotonic group. The serum CPK level of the isokinetic group showed a 10.03% lower decrease than the isotonic group, but the difference was not significant. The Cortisol level was relatively unchanged in the isotonic group, but it decreased in the isokinetic group. On the other hand, the Cortisol level did not show a significant difference between the two groups.

CONCLUSION: The isokinetic group showed alleviation of the three indices, unlike the isotonic group. Further studies associated with the changes in blood fatigue variables through various exercise programs and exercise intensity will be needed.

Key Words: Blood fatigue variables, Circuit training, Isokinetic exercise training, Isotonic exercise training

Ⅰ. Introduction

Physical imbalances are generated by excessive energy intake and insufficient physical activity that ultimately leads to serious health problems, such as heart disease, diabetes, cancer, stroke, chronic lung and kidney diseases, and Alzheimer's disease [1]. Various chronic diseases can be alleviated by engaging in an ongoing healthy lifestyle, including regular exercise and appropriate physical activities [2]. Accordingly, the interest in weight-training sports, including weightlifting, bodybuilding, powerlifting, strongman competition, and CrossFit, has increased annually [3]. On the other hand, overtraining or overuse due to overflowing information and incorrect skill acquisition

†Corresponding Author : Kyoung Kim
kykim257@hanmail.net, https://orcid.org/0000-0003-4169-6852

can cause injury [4]. Malina reported that weight training relates to a large variety of dynamic resistance training based on progressive overload and improves muscular strength and endurance [5]. Resistance training plays a substantial role in improving the athletic performance by elevating muscular strength, hypertrophy, power and speed, local muscular endurance, balance, motor performance, and coordination [6]. In addition, resistance training helps maintain body composition (height and body weight) and bone mineral content and reduces sports injuries. Herein, resistance training (two or three times per week) results in meaningful improvement in muscular strength during childhood and early adolescence. Among these weight training studies, studies on two types of active resistance training for isokinetic and isotonic exercise training have been widely studied [5,7].

Power is the amount of work (force x distance) divided by time; it is influenced by both speed and strength. The power or peak can be measured using isotonic or isokinetic modes with a dynamometer [8]. Isokinetic exercise training, which is a form of dynamic exercise, predetermines and holds the constant velocity of the muscle (lengthening and shortening) and the angular limb velocity by a rate-limiting device known as isokinetic special dynamometer like Cybex, Biodex, and Kin-COM [9,10]. The resistance is equivalent in the case of the muscular forces imposed throughout the range of movement and provides the optimal load to the muscles. Hence, resistance has generally been used to measure the muscular forces in dynamic conditions [11]. Moreover, isokinetic exercise training has been successful in rehabilitating osteoarthritis, anterior cruciate ligament reconstruction, muscle weakness, jumping capacity in athletes, and Parkinson's disease [12]. Munhoz da Silveira Campos et al. recently reported that aerobic plus resistance training associated with a long-term weight loss program and isokinetic parameters could reduce body fat and improve muscle strength [13]. Isotonic exercise training has been used in clinical settings and sports fields to prevent the loss of muscle strength or sarcopenia, including the accelerated loss of muscle mass and function [14] and has been incorporated into early rehabilitation programs [12]. Accordingly, isotonic exercise training is an exercise that changes the length and speed of muscles while folding and unfolding the joints. Thus, isotonic exercise is a useful exercise to increase the size of the muscles [8]. Ultimately, exercise training is an exercise program that induces dynamic muscle contraction to improve strength and endurance. During rehabilitation exercise, the type of tissue damage or disease, the stage of tissue healing, the state of the joint, and the goal of the exercise program will determine which type of exercise to proceed with [15].

Circuit training combines several exercises targeting different muscles with only a short rest between 12-15 repetitions [16,17]. Circuit training can increase lower and upper body strength. Above all, it can be applied safely in metabolically challenged people who suffer from disorders, such as hypertension, chronic heart failure, obesity, borderline coronary heart disease, and non-insulin-dependent diabetes mellitus (NIDDM) [18].

Physical exercise affects the homeostasis of the internal environment of the body. Fatigue is a physical exercise-induced inability to achieve the desired work output. Physical fatigue, including excessive physical loading, mental strain/pressure, inadequate rest, is accompanied by a decline in functional performance. Thus, repeated fatigue causes constant damage to the muscular apparatus that can lead to changes in serum constituent enzymes, such as lactate dehydrogenase (LDH) and creatine phosphokinase (CPK) [19]. These enzymes have been studied by many researchers before and after exercise and can be used to confirm muscle diseases [20,21]. Moreover, physical fatigue, which means a stress situation, can lead to the hypersecretion of serum Cortisol after physical exercise training [22]. These blood fatigue variables (LDH, CPK, and Cortisol) are considered the limiting factors of exercise capacity.

Despite the many studies on different types of muscle contraction, few studies have examined the effects of isokinetic and isotonic exercise on the blood fatigue parameters. This study compared the changes in blood fatigue parameters after performing isokinetic and isotonic exercise training, which is being introduced to rehabilitation exercise therapy after an injury. These results are intended to provide basic data for setting the exercise design and direction when performing a rehabilitation exercise program. This study hypothesized that there would be differences in the blood fatigue parameters according to the isokinetic and isotonic exercise training methods.

Ⅱ. Methods

1. Participants

Among the 12 male adults living in Daegu with more than one year of exercise experience, 10 people who do not correspond to the following exclusion criteria were selected. The inclusion criteria were not tested on isokinetic dynamometers or participated in exercise-related studies. The exclusion criteria were a history of respiratory and cardiovascular disease, musculoskeletal disease, or injury, including ankle in the past six months, and a history of neuromuscular disease in the past six months [8]. All participants signed a consent form after receiving detailed explanations on the purpose and method of this study, which was approved by the Daegu University Institutional Review Board (1040621-201907-HRBR-041-02), before commencing the study. G-power 3.1.9.4 was used to determine the sample size. The effect size of the static balance variable of a previous study that examined the effects of the circuit exercise program was used [16]. Ten subjects were selected according to a calculated effect size of 1.20, a significance level of .05, and a power of 80% [23].

2. Experimental procedure

A xim machine (Ronfic, Busan, Korea) was used to set the exercise intensity of the circuit training exercise. Xim machine enables isokinetic and isotonic exercise, and is an instrument that can measure the precise muscle strength and speed of muscle contraction. In addition, it is equipped with a function to check and save real-time exercise information on a computer. The one-repetition maximum (1RM) of four circuit training exercise programs (Squat, deadlift, Shoulder press, and Bench press) was measured. The participants exercised at the same intensity and frequency of 70% RM during the isokinetic and isotonic circuit training exercises. Before applying for this training program, a preliminary training program was practiced to familiarize the subjects with the circuit training methods and prevent injuries. The pre-training program was repeated 10 times at an intensity of 40–50% of 1RM. This training program was applied 11 times at a 70% intensity of 1RM using the xim machine computer measurement method (Table 1). After a two-hour break, the participants performed isokinetic circuit training first, followed by isotonic circuit training.

3. Measurement methods

The participants fasted for 12 hours after dinner the day before the experiment. Blood sampling was performed 30 minutes before and immediately after exercise in isokinetic and isotonic circuit training. The exercise program of this study was conducted at the hospital's health promotion center, and a professional nurse working in this hospital collected the blood samples. The participants collected 10 ml of blood from the antecubital vein. The collected blood was centrifuged at 3,000 rpm for 10 minutes using a centrifuge (HA-1000-3, Hanil Industrial, Korea) to obtain a serum sample. After centrifugation, the supernatant was separated and analyzed by EONE Life Science Institute (Incheon, Korea). The serum LDH was measured using a SICDIA LDH reagent kit (Eiken Chemical, Tokyo, Japan) according to the manufacturer's protocols with a Hitachi 7600-110 (Hitachi, Tokyo, Japan).

Table 1. Circuit Training Program

Exercise Program			
Warm um Exercise (10min)			Stretching
Circuit training	Procedure 1	Squat	After holding the barbell behind the shoulders, stand with the legs shoulder-width apart and toes pointing 15°. Sit using only the lower body without bending the upper body. Sit deeply so that the knee angle is 90°, and return to the original position.
	Procedure 2	Deadlift	From a sitting position with the legs shoulder-width apart, fix the waist like a bow, and get up as if a barbell rubs against the legs.
	Procedure 3	Shoulder press	Standing or sitting, grab a barbell that is twice shoulder-width apart and feet shoulder-width apart. Raise the barbell above the chest. Lift the barbell over the head from the chest. While feeling resistance in the shoulders, lower the bar until it is level with the ears.
	Procedure 4	Bench press	Lie on a bench and place the hips and shoulder blades on the backrest, arching the back approximately 10 cm. Hold the bar twice shoulder-width apart and position the eyes perpendicular to the barbell. Lift the bar and place it so that the center of the chest and the bar are perpendicular, then bend the elbow slightly to fix it. Push up on the barbell as you feel it tightening the armpits.
Cooldown Exercise (5min)			Stretching

The serum CPK activity was assayed using a commercial kit (L-Type CK; Wako Pure Chemical Industries, Osaka, Japan) with Hitachi 7600-110 (Hitachi, Tokyo, Japan). The serum cortisol level was determined by the electrochemiluminescence immunoassay (ECLIA) and measured using a Cortisol assay (Roche Diagnostics, Germany) on a Roche Cobas analyzer. The LDH is an enzyme that catalyzes the reaction when synthesizing ATP. The LDH concentration increases when the lactic acid produced by the muscles is released into the blood. CPK regulates the ATP levels during muscle contraction and is used as an energy source. Cortisol is responsible for storing the energy required by the body and making it easier to use energy sources when needed.

4. Statistical analysis

This study used SPSS version 25.0 software (SPSS Inc., Chicago, IL, USA) to analyze the data. The data are presented as the mean ± standard deviation. The normality of the data was tested using a Shapiro-Wilk test. An independent t-test was used to compare the results of the two groups, and a paired t-test was used to compare the effects between the pre-and post-exercise after invention. $P < .05$ was considered to indicate a significant difference.

Table 2. Participants Characteristics (n = 10)

Variable	Mean ± SD
Gender (M/F)	10/0
Age (years)	30.50 ± 4.35
Height (cm)	178.10 ± 4.20
Weight (kg)	79.31 ± 11.17
Muscle (kg)	38.16 ± 6.00
BMI (kg/m2)	15.20 ± 6.32

Ⅲ. Results

1. General Characteristics of the participants

Table 2 lists the general characteristics of the study participants.

2. Change in serum LDH

The LDH activity (IU/L) in the isokinetic group showed a significant difference between the pre-exercise and

Table 3. Change of LDH Level (IU/L)

Group	LDH Level			t	p
	Pre	Post	Post-Pre		
Isokinetic exercise	342.31 ± 78.70	439.37 ± 87.25	97.03 ± 54.61	-5.027	.003**
Isotonic exercise	365.68 ± 119.03	511.05 ± 138.44	145.42 ± 165.67	-2.324	.059
t	-.454		-.739		
P	.658		.483		

Mean ± SD, $^{**}p < .01$

Table 4. Change of CPK Level (IU/L)

Group	CPK level			t	p
	Pre	Post	Post-Pre		
Isokinetic exercise	298.90 ± 194.37	330.32 ± 208.25	31.41 ± 18.16	-5.499	< .001***
Isotonic exercise	324.06 ± 210.41	358.92 ± 223.44	34.93 ± 18.24	-6.052	< .001***
t	-.277		-.431		
p	.785		.671		

Mean ± SD, $^{***}p < .001$

post-exercise (342.31 ± 78.70 and 439.37 ± 87.25, respectively). By contrast, the LDH activity in the isotonic group did not show a significant difference between pre-exercise and post-exercise (365.68 ± 119.03 and 511.05 ± 138.44, respectively). The decrease in the LDH activity was 33.30% lower in the isokinetic group than in the isotonic group, but the difference was not significant (Table 3).

3. Change in serum CPK

The CPK activity (IU/L) in the isokinetic group was 298.90 ± 194.37 and 330.32 ± 208.25 in the pre-exercise and post-exercise groups, respectively. By contrast, the CPK activity in the isotonic group was 324.06 ± 210.41 and 358.92 ± 223.44 pre-exercise and post-exercise, respectively. The change in the CPK activity was 10.03% lower in the isokinetic group, but the difference was not significant (Table 4).

4. Change of serum Cortisol

The Cortisol level (μg/dL) in the isokinetic group was 11.05 ± 2.22 and 10.26 ± 2.20 pre-exercise and post-exercise, respectively. By contrast, the Cortisol level in the isotonic group was 8.80 ± 2.33 and 8.87 ± 2.61 pre-exercise and post-exercise, respectively. The Cortisol level in the isokinetic group decreased after exercise, but the Cortisol level in the isotonic group increased after exercise (Table 5). There was no significance between the two groups.

Ⅳ. Discussion

Despite the many studies on different types of muscle contractions, few studies have examined the effects of isokinetic and isotonic exercise on the blood fatigue parameters. Furthermore, studies on the effectiveness of isokinetic and isotonic exercise training report conflicting results [24]. Therefore, the present study compared and analyzed the effects of isokinetic versus isotonic exercise training in terms of blood fatigue variables, including LDH, CPK, and Cortisol. The circuit exercise program used in this experiment consisted of four items (Squat, Dead Lift,

Table 5. Change of Cortisol Level (μg/dL)

Group	Cortisol level			t	p
	Pre	Post	Post-Pre		
Isokinetic exercise	11.05 ± 2.22	10.26 ± 2.20	-.85 ± 1.13	2.042	.075
Isotonic exercise	8.80 ± 2.33	8.87 ± 2.61	.11 ± 1.30	-.243	.813
t	1.960		-1.825		
p	.072		.086		

Mean ± SD

Shoulder Press, and Bench Press). The squat is considered a fundamental movement in athletic training and is used as an effective exercise commonly applied during patellofemoral or cruciate ligament rehabilitation [25]. Dead Lift exercise with barbells, dumbbells, and kettlebells activates all the muscles of the lower body, such as the legs, hips, back, and core muscles [26]. Shoulder Press has several benefits, including the development of strength and size of triceps muscles, trapezius muscle, and core muscles [27]. Moreover, the main three muscles like the pectoralis major, the anterior deltoid muscles, and the triceps brachii, develop when the bench press does [26].

Before and after isokinetic and isotonic exercise training, the blood fatigue variables, such as LDH, CPK, and Cortisol, were evaluated through the collected serum. Lactate dehydrogenase (LDH) is normally present at low concentrations. On the other hand, during high-intensity exercise, intracellular LDH is released from the cell due to muscle damage, increasing the LDH level. This increase in LDH level was evaluated as an indirect marker of muscle damage, and as an indicator of the exercise capacity and fatigue patterns based on energy metabolism [28]. Creatinine phosphokinase (CPK) was observed in most forms of strenuous exercise, approximately 20 times the normal range (usually 10 times the normal range when exercise-induced rhabdomyolysis) [29,30]. Buonocore D et al. (2020) suggested that physical exercise training leads to increased LDH and CPK. According to the above result, LDH and CPK in the two groups increased after exercise [31]. The significance in the LDH level between post- and pre-exercise was observed only in the isokinetic group ($p < .01$). The change in LDH level in the isokinetic group was 33.30% lower than that of the isotonic group. In addition, the serum CPK level of the isokinetic group showed a 10.03% lower decrease than the isotonic group, but the differences were not significant. The rest time between the exercise sets and recovery time after exercise can be affected by the exercise intensity, muscle activation (number and size of muscles mobilized), and microtrauma caused by stimulation (amount of muscle protein destroyed during exercise) [32]. In this experiment, isokinetic and isotonic exercise did not induce high fatigue. In addition, although the initial value of the isokinetic group was slightly higher than that of the isotonic group, it is not expected to affect the interpretation of the results because there was no significance when the independent t-test was performed. These results suggest that isokinetic exercise training is more beneficial for fatigue and recovery after exercise. A previous study reported that the isotonic exercise protocol caused a significant functional defect because of the decreased muscle strength after exercise more than the isotonic exercise protocol [33].

Cortisol, which plays a substantial role in regulating energy metabolism and homeostasis on the skeletal muscle, is regulated at the tissue and systemic level to maintain glucocorticoid homeostasis [34]. The cortisol level caused by exercise is highest when the overall stress of the training period increases [35]. The change in Cortisol between post-and pre-exercise was -.85 ± 1.13 (at isokinetic group) and .11 ± 1.30 (at isotonic group). The Cortisol level in the isokinetic group decreased after exercise, but the Cortisol level in the isotonic group increased after exercise. This result is consistent with previous studies reporting that intense resistance exercise increased the amount of cortisol and testosterone, but resistance exercise with low muscle use had little effect [36]. These blood fatigue parameters reflect muscle damage and are useful indicators for determining the condition of muscle tissue [37]. Overall, these results suggest that isokinetic circuit training exercise has partial advantages over isotonic circuit training exercise in muscle fatigue.

This study had some limitations. The sample size was relatively small, so generalization is limited. In addition, the participants were recruited only from men from Daegu area. In future experiments, more scientific results can be obtained by expanding the range of participants related to residence and gender. In addition, another limitation of this experiment is that it did not consider the factors that could affect the blood fatigue variables when they had underlying diseases as the participants were normal elite athletes.

Ⅴ. Conclusion

The increase in the blood fatigue variable LDH was significantly smaller in isokinetic circuit training exercise than in the isotonic circuit training exercise. Thus, the isokinetic group reduced the blood fatigue variables more effectively than the isotonic group. Both isokinetic exercise and isotonic exercise have advantages and disadvantages. On the other hand, isokinetic exercise was evaluated to be more effective than isotonic exercise only when blood fatigue parameters were compared in this experiment. Nevertheless, more study is needed because there are various factors affecting the body.

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