

The Effect of Warm-Up Method on Exercise Performance and Rate Pressure Product during Resistance Training

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Abstract

We are designed was to find an efficient warm-up method for resistance training for muscle hypertrophy, and 10 males with at least 3 years of resistance training experience were selected as subjects. The 75% 1RM was measured directly based on the pre-measured bench press 1RM. After that, the main experiment of 75% 1RM bench press according to the three warm-up methods was conducted one week apart, and all experiments were randomized and cross-over. Performance according to the warm-up method (3) was measured by total exercise volume, and physiological changes were determined by myocardial workload. All post-measurement data were analyzed using SPSS.22.0 and analyzed using repeated measures one-way ANOVA and contrast comparisons were made using the deviation method. The results showed that the method of gradually increasing the number of repetitions by performing the same intensity as the intensity of the main exercise in the form of muscle hypertrophy, but at submaximal repetitions, showed the highest performance.

Keywords: Resistance exercise, Warm-up, Bench press, Total work, Rate pressure product

1. Introduction

Warm-ups are recommended to include a combination of stretching, resistance, or aerobic exercises, depending on the specific type of activity to be performed [1]. In recent years, it has been emphasized that warm-ups should include resistance training to prevent musculoskeletal injuries and improve performance [2]. In addition, warm-ups increase blood flow to skeletal muscles and increase muscle temperature to induce positive physiological changes for the main exercise [3].

Improvements in performance after a resistance warm-up are associated with post-activation potentialization (PAP), which is an increase in force production due to muscle contraction during warm-up [4]. This is associated with motor unit mobilization and increased action potentials in the primary muscle and peripheral inhibitory mechanisms involving interneurons [5]. It is also associated with the activation of biochemical functions such as phosphorylation of the myosin light chain and increased Ca²⁺ sensitivity and

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concentration [6] and changes in muscle structure such as increased length of myofibrillar bundles and right upper angle [7].

Looking at studies on warm-up intensity during resistance exercise, one study reported that 80-90% exercise was the most effective warm-up intensity, while bench press after warm-up at 65% 1RM intensity was found to be highly effective. A study [8] was also published. In addition, it was reported that when squatting exercise was performed at three intensities of 56% 1RM, 70% 1RM, and 93% 1RM, vertical jump increased due to a synergistic effect after activation at 70% 1RM and 93% 1RM intensities [9]. The results of studies on warm-up intensity during resistance exercise are inconsistent.

To perform a 10RM weight training exercise, a warm-up of 10 reps at 50% of 10RM for set 1, 10 reps at 75% of 10RM for set 2, followed by 10 reps of 10RM for set 3 was found to be the most effective [10]. When bench pressing was divided into three groups: those who bench pressed without warm-up, those who bench pressed after stretching, and those who bench pressed after resistance warm-up, it was found that bench pressing after resistance warm-up produced the highest strength [11].

Summarizing the above studies, it can be concluded that resistance warm-ups have a positive effect on performance, but there are also different results depending on the application method of resistance warm-ups. Therefore, in this study, we aimed to examine the changes in total workload and myocardial strain during the main exercise by using different loading methods during the warm-up.

2. Experiment materials and methods

2.1 Subject

The subjects of this study were 10 male college students in their 20s enrolled in 'D' University in Cheonan City, Chungcheongnam-do, who had been involved in resistance movements for at least one year. The purpose and procedures of the study were explained to the subjects, and they were encouraged to familiarize themselves with all the contents of the study. All subjects signed an informed consent form after expressing their willingness to participate in the study. The age of the subjects was 26.43 ± 1.40 years, weight was 81.29 ± 5.94 kg, height was 177.14 ± 2.41 cm, and exercise experience was 3.43 ± 1.13 years. Table 1 shows the characteristics of the subjects .

Table 1. Characteristics of subjects

Subjects	Age(yr)	Weight(kg)	Height(cm)	Career(yr)
N=10	26.43 ± 1.40	81.29 ± 5.94 kg	177.14 ± 2.41	3.43 ± 1.13

2.2 Measurement procedure

After selection, bench press 1 repetition maximum (1RM) strength was measured two weeks before the experiment. A total of three warm-up conditions were performed. Subjects were randomized across all trials, with a 1-week washout period between conditions. During the study, subjects were encouraged to avoid excessive exercise outside of their daily activities and to get enough sleep the night before the test. During the study, subjects were advised to avoid excessive exercise outside of their daily activities and to sleep well the night before the test. Blood pressure and heart rate were measured immediately after the main exercise, the 75%1RM bench press, and the number of repetitions was recorded to calculate the total amount of exercise. The measured data were analyzed using repeated measures one-way ANOVA.

2.3 Measuring variables

2.3.1 1-repetition maximum measurement

To determine the individualized bench press weights for this study, bench press 1-repetition maximum was measured one week prior to the experiment by adapting the methodology from NSCA (2015). When measuring the 1RM, the first set was warmed up with a weight that could be lifted for 5-10 repetitions, and then after a 1-minute rest, the weight was increased by 5-10 kg to a weight that was estimated to be lifted for 3-5 repetitions. This was followed by a 2-minute rest period, followed by a 5- to 10-kilogram weight increase to a weight estimated to be lifted for 2 to 3 repetitions, followed by a 2- to 4-minute rest period. The weight was then increased by another 5-10 kg to attempt a 1RM. If successful, the weight was increased further after a 2-4 minute rest period; if unsuccessful, the weight was decreased by 2.5-5 kg after a 2-4 minute rest period and then retried to determine the 1RM.

2.3.2 Bench press perform method

Bench presses were performed lying down in a five-point contact position on a flat bench. The barbell was held in a closed pronation grip at shoulder-width, fist-width apart. The elbow angle was limited to 90°. Figure 1 is an example of a bench press.



Figure 1. Perform bench press

2.3.3 Warm-up Type

Table 2 is show the warm-up exercise was conducted under three conditions, and the execution method

Table 2. Warm-up method

	1set	2set	3set
Type1	30% 1RM 10reps	50% 1RM 10 reps	70% 1RM 10 reps
Type2	75% 1RM 3 reps	75% 1RM 5 reps	75% 1RM 7 reps
Type3	Non warm up		

2.3.4 Total Work(TW)measurement method

The Total Work(TW) of exercise was calculated by multiplying the 75% 1RM load performed in this exercise by the number of repetitions.

2.3.5 Rate Pressure Product

Rate Pressure Product was calculated by measuring heart rate and blood pressure immediately after completing the exercise and multiplying the two records. Heart rate was measured using a wireless heart rate sensor (Polar, Finland), placed on the Xipohid process, and linked with polar beat software (ver. 3.3.3, Polar Electro). Blood pressure was measured using an automatic blood pressure meter (FT500R PLUS, Korea) while sitting.

2.4 Statics analysis

Data processing for this study used the IBM SPSS Statistics (ver 22.0) statistical program to calculate the average and standard deviation of all variables. Differences in TW and RPP according to warm-up method were analyzed using repeated measures one-way analysis of variance, and post hoc comparisons were made using the deviation method.

3. Result

3.1 Difference in total work

Table 3 and Figure 2 is shown the results of one-way analysis of variance on the effect of warm-up method on TW and the difference in mean and standard deviation. There was a statistically significant difference in the TW according to the warm-up method ($p=.000$), and it was highest in type 2, followed by type 1 and type 3.

Table 3. Difference in TW

Type	①T1	②T2	③T3	F	P	Contrast
TW	871.80 ± 76.34	1003.60 ± 59.77	798.00 ± 26.74	68.190	.000	②>①>③

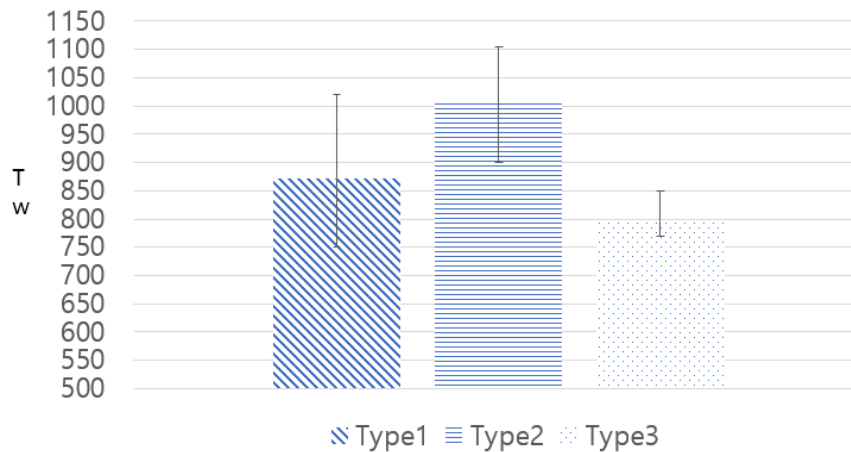


Figure 2. Difference in TW

3.2 Difference in total work

Table 4 and Figure 3 is shown the results of one-way analysis of variance on the effect of warm-up method on RPP and the differences in mean and standard deviation. There was a statistically significant

difference in RPP according to the warm-up method ($p=.000$), and it was highest in type 2, followed by type 1 and type 3.

Table 4. Difference in RPP

Type	① T1	② T2	③ T3	F	P	Contrast
RPP	12262.30 ± 1536.31	12941.80 ± 1885.32	11120.20 ± 1950.06	6.354	.008	②>①>③

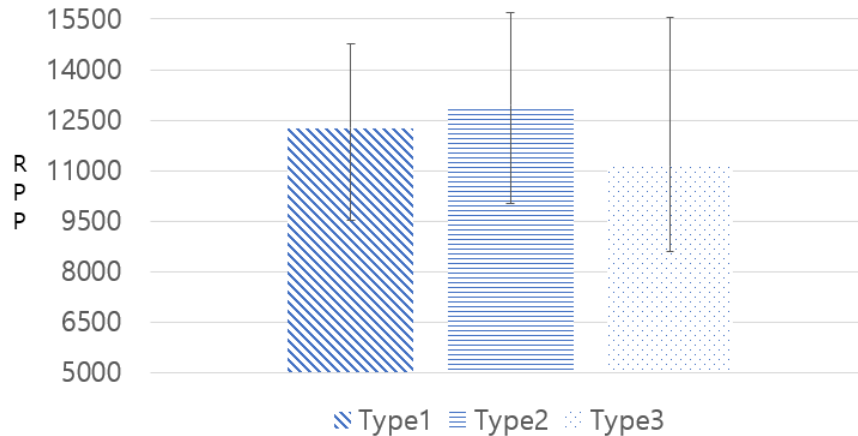


Figure 3. Difference in RPP

4. Discussion

Warm-up is an essential process that must be performed appropriately before various physical activities such as competitions or training. It stimulates the central nervous system physiologically, activating the control of the autonomic nervous system by increasing heart rate and breathing volume, and increasing the internal temperature of the muscles. It increases the flexibility and elasticity of joints and facilitates blood supply to the extremities of the body, supplying nutrients and removing waste products, allowing muscles to exert greater strength [12].

In this study, three warm-up methods were performed to determine the appropriate warm-up method for hypertrophy-intensity resistance exercise, and then 75% 1RM bench press was performed to confirm TW and RPP. We would like to discuss the results obtained through this as follows.

Warm-up exercises with heavy weights performed before the main exercise increase the recruitment of motor units [13], and the Golgi tendon organ and Renshaw act as inhibitory mechanisms of the central and peripheral nervous systems. It is known to reduce cell sensitivity [14]. In addition, it is associated with the activation of acute biochemical functions such as phosphorylation of the Myosin Light Chain, increased sensitivity and concentration of Ca^{+} [15], and changes in muscle structure such as increased length and right superior angle of muscle fiber bundles. It has been reported [16, 17] that it is thought that the amount of exercise of Type 1 and Type 2 in this study increased. In addition, in the case of Type 2 repetitions compared to Type 1, it is thought that relatively small TW appeared because the oxygen-dependent type I fibers caused a temporary local hypoxic state due to the relatively large amount of exercise [18]. Past research reported that as the number of sets of resistance exercise increases, performance decreases due to a decrease in metabolic substrates and an increase in endocrine response due to the accumulated amount of exercise [19].

The higher the exercise load, the lower the maximum number of repetitions. They said it was natural [20]. This study also showed the same results.

Warm-up exercise is known to increase the excitability of the central nervous system and facilitate the control of the autonomic nervous system. It increases the internal temperature and elasticity of muscles, increases heart rate and breathing volume, and supplies more blood flow to active muscles. It is known to improve contractility.

In this study, both type 1 and type 2 heart rate increased compared to resting as the set continued, showing the physiological effect of warm-up exercise. Weight intensity increased linearly and the number of repetitions increased, so it was similar to other warm-up conditions. In comparison, the change in heart rate appears to have been higher.

In addition, in type 2, heart rate appears to have increased due to increased recruitment of fast muscle fibers and accelerated glycolysis due to ATP-PCr depletion immediately after exercise, resulting in increased sympathetic nerves for muscle glycogen decomposition. In addition, increased oxygen demand in muscles and acidification of the body. It is thought that the heart rate increased in the cardiovascular control center of the reticular formation in the back plate of the brain stem due to afferent feedback caused by neural activation of muscles sensitive to metabolic reactions to remove metabolites [21]

5. Conclusion

This study aimed to investigate the appropriate resistance warm-up for resistance training for the purpose of hypertrophy and found the following conclusions.

First, type 2 had the highest TW of the three warm-ups.

Second, type 2 had the highest RPP of the three warm-ups.

In conclusion, highest performance was achieved with resistance warm-up exercises and increasing the number of repetitions per set per week at a high level of skill. It is confirmed that the warm-up exercise is a component of the exercise program and is an important factor that can affect muscle strength expression and exercise performance in this exercise. Intensity warm-up exercises need to be applied differently to the intensity of the exercise, depending on the purpose of the exercise and the information that influences the method of exercise intensity. It's great, and the research complements the effect of linking it to exercise intensity, but I think other factors need to be addressed, such as how to scale up later and how much rest you take.

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