International Journal of
Disabilities Sports and Health Sciences

e-ISSN: 2645-9094

RESEARCH ARTICLE

The Effect of Velocity-Based Contraction Strength Training on Performance in Female 400m Athletes

Krit SIRIRUNGRANGCHAI*[1], Natthawee SRIKET[1] and Mantira PHONGAMPAI[1]

[1]Thailand National Sports University Trang Campus, Faculty of Sports and Health Science / Thailand
*Corresponding author: krit.srrc@gmail.com

Abstract

This study aims to compare the differences in strength training at velocity of muscle contraction in 400-meter runners. The sample group consisted of 12 female athletes who participated in the Thailand National Sports competition qualifiers in 2023. The group was divided into two: the first group underwent strength training at a fast muscle contraction rate with 80 bpm, while the second group trained at a normal muscle contraction rate with 40 bpm. The training lasted for 8 weeks, and after a 2-week post-training period, both groups were tested by swapping strength training programs. They were tested for 400-meter speed, strength from finding the 1 RM of Leg curl, Leg extension, and Leg press measured in kilograms, and explosive power from Squat jump, Countermovement jump, and Long jump. The data collected was analyzed to find the average, standard deviation, and one-way ANOVA with a statistical significance level set at .05. From the research's results, it was found that percentage change muscle contraction rates differs significantly between the two strength training formats: one with fast muscle contraction and the other with normal- muscle contraction rate (1.04±0.02 and 1.02±0.02, respectively) at a significance level of .05. Additionally, the strength and explosive power percentage change also significantly differ between the two strength training formats. Therefore, based on this study, it is possible to utilize the fast muscle contraction rate strength training format to enhance the athletic performance of athletes.

Keywords
Athlete, Strength Training, Velocity, Contraction

INTRODUCTION

Athletics encompasses physical activities that align with the natural mechanics of human movement. These activities include running, jumping, and throwing. These fundamental skills, inherent to various sports, rely on the use of our feet. Naturally, each type of athletic discipline demands speed, which significantly impacts competitive outcomes.

Short-distance running races are one of Thailand's successful ongoing sporting events. The 100-, 200-, and 400-meter races, as well as the 4x100- and 4x400-meter relays, comprise these events. Thai athletes have performed exceptionally well in these running events, both at the regional within Southeast Asia and during continental competitions such as the Asian Games (Kaewchuay, 2015). Notably, the Thai men's and women's sprint teams have achieved remarkable success over the past 40 years, competing at a level comparable to sporting like the Republic of China and Japan

The 400-meter sprint is a short-distance event that allows athletes to clearly develop both strength and explosive power (Mulasiwa & Sreesung, 2024). It also demonstrates differences in time duration more effectively than shorter sprints or spins (Iskra et al., 2016). In athletic training, focusing on the lower body is essential for developing strength

Received: 29 March 2024 ; **Revised** ; 15 June 2024 ; **Accepted:** 18 June 2024; **Published:** 25 July 2024

How to cite this article: Sirirungrangchai, K., Sriket, N., and Phongampai, M. (2024 The Effect of Velocity-Based Contraction Strength Training on Performance in Female 400m Athletes. *Int J Disabil Sports Health Sci*;7(4):775-781.https://doi.org/10.33438/ijdshs.1461018

(Okudaira et al., 2019). However, without specifying speed or rhythm during lifts, the athlete's progress may not align with the desired goals. To achieve an explosive power suitable for 400-meter sprinters, it's crucial to tailor the development accordingly.

Based on the concepts, the researcher has an idea to have 12 athletes train a strength training program, with the format being primarily lower body drills, and to set the muscle contraction rate with 40 bpm and 80 bpm. The researcher wants to study the development of strength and speed from running a 400-meter distance by athletes, which the results will help coaches plan to further improve the strength training program for athletes.

MATERIALS AND METHODS

Participant

The dependent variable's effect size on the independent variable determines the sample size. calculated using the following settings and the G*Power program (version 3.1.9.7) T-test is a test family. Test of statistics: Means: Variation from a constant (one example); Power analysis type: Compromise; Effect size: 0.6; β /α ratio : 1; Power of test (1- β err prob): 0.82; Total sample size: 10. Then, ten volunteers (Kantor et al., 1984; Wallace, 1989)were randomly selected from 240 students according to the following criteria

Inclusion Criteria: Female with no issues of pain in the front thigh muscles, knee joints, and ankles. Must have regular track and field training at least 3-5 days per week and participated in the national sports competition, selection round, in the year 2023. Exclusion Criteria: The sample group has an unexpected event that makes it impossible to continue the research from 1 time onwards, and the sample group voluntarily withdraws during data collection.

The population is 40 female athletics between the ages of 18-22 years who participated in the 48th Thailand National Games qualify round. The sample in this research were 12 females. Subject must be training 3-5 days/week. Thailand National Sports University Research Ethics Committee for Research Involving Human Projects, Thailand Approved the study protocol (SCI 042/2023).

The sample group was tested for physical characteristics, including weight, height, and body fat percentage. They were tested for 400-meter speed, strength test form 1RM of Leg curl, Leg extension, and Leg press, explosive power from Squat jump, Countermovement jump, and long jump.

This study divides the participants into groups of 6 people based on their 400-meter running times, aiming for the closest possible average between the two groups. First group trained with a normal muscle contraction 40 bpm., second group trained with a fast muscle contraction 80 bpm. The training duration was 8 weeks. and after a 2-week post-training period, both groups were tested by swapping strength training programs.

Training Protocol

The exercise program involves a sample group performing strength training at 80% of one-repetition maximum (1RM) for the Leg Press, Leg Extension, and Leg Curl exercises. Each exercise consists of 3 sets, with 8 repetitions per set. Additionally, participants will listen to the rhythmic signals from a metronome during each training session. This training program spans 8 weeks.

Measurement of speed

400-meter test (Hanon et al., 2010)

The 400-meter test measures the time it takes to complete 400 meters as quickly as possible. This test measures the ability to run quickly over a distance. procedure: To start, athletes behind the starting timer gate line. On the command ‘ready, start; The subject is to run the 400m route as fast as possible.

Measurement of strength

One repetitions maximum test. (Reynolds et al., 2006)

The one-repetition maximum test finds out how much weight a person can lift in a single rep. It is a common way to find out how strong isotonic muscles are. You can use a one-rep maximum calculator to figure out how much weight you can lift in one rep. To find your one-repetition maximum score.

$1RM = weight \times (1 + (reps / 30))$

Measurement of power

Squat Jump (Samozino et al., 2008)

The vertical jump test is modified to assess explosive leg power with the squat jump. Arm swinging or countermovements are not permitted during this test. Reducing the effect of variations in arm coordination by keeping the arms still isolates the leg muscles. Method: The athlete stands straight below the yardstick. Throughout the test, hands are put on the hips and stay there. While maintaining a straight trunk, the athlete squats down until their knees are bent to a 90-degree angle. The athlete resets the mat, leaps as high as they can, and falls back on it with both feet striking the ground at the same time. The highest rating obtained from a minimum of three tries is noted.

Counter Movement Jump (de Campos Jr et al., 2019)

The Movement Against It When you jump, you can see how powerful your legs are. The athlete stands straight below the yardstick, either with socks on or without, and puts equal weight on both feet. During the test, hands are put on the hips and stay there. When all is set, the athlete squats until their knees are 90 degrees bent. After that, they leap as high as they can and simultaneously land with both feet on the mat. Between trials, there should be a good break. You have to jump with both feet, without taking any steps or shuffling at the start. There can't be a pause at the bottom of the squat.

Standing Long Jump (Zhou et al., 2020)

Standing Long Jump is a test of how strong your legs are when you jump. The athlete stands behind a line on the ground, with their feet spread out a little. The take-off and landing are both done on two feet, and arm swings and knee bends are used to move forward. The person tries to jump as high as they can and land on all fours without falling backwards.

Data Analysis

The statistical analysis was done with SPSS 21.0 software, which stands for Statistical Package for the Social Sciences. The distribution of the data was examined for normalcy using the Kolmogorov-Smirnov test. The independent t-test was used to compare the variable means and standard deviations because the data were normally distributed., The significance level was set at $p<0.05$

RESULTS

The sample group found an age of 20.33±1.37 years, weight 55.67±4.98 kg, height was 1.65±3.74 meters and the percentage of total body fat was 17.55±3.94 (Table 1).

Table 1. Baseline characteristics

	$\bar{x}$±S.D.
Age (year)	20.33±1.37
Weight (Kg.)	55.67±4.98
Height (meter.)	1.65±3.74
Percent of bodyfat	17.55±3.94

Table. 2 Showed the speed distance 400-meter normal contraction pre training, post training, and percentage change, which are 65.83±2.66, 64.83±3.33, and 1.02±0.02 respectively. Fast contraction before training, after training, and percentage change, the values are 68.33±8.84, 65.50±7.90, and 1.04±0.02 respectively. The speed distance of 400 meters Post training compared to Pre training with both strength training patterns differed significantly at the .05 level, and percentage change for both strength training patterns also differed significantly at the .05 level.

Table 2. Speed 400 meter from training both types of strength.

Training Test	Strength training (s)	
	Normal Contraction	Fast Contraction
Pre training	65.83±2.66	68.33±8.84
Post training 8 week	64.83±3.33*	65.50±7.90*
Percentage changes	1.02±0.02	1.04±0.02#

* significant difference same group (*P*<0.05), # significant difference between group (*P*<0.05)

Table. 3 Showed the one repetition maximum of leg press normal contraction pre training, post training, and percentage change, which 249.00±34.11, 258.17±32.17 and 1.04±0.03 respectively. Leg extension normal contraction pre training, post training, and percentage change, which 58.67±12.77, 62.50±12.27 and 1.07±0.04 respectively. Leg curl normal contraction pre training, post training, and percentage change, which 47.50±11.37, 52.67±12.54 and 1.11±0.04 respectively. one repetitions maximum of leg press fast contraction pre training, post training, and percentage change, which 259.67±27.29, 274.83±25.00 and 1.06±0.02 respectively. Leg extension fast contraction pre training, post training, and percentage change, which 58.00±8.22, 60.33±8.24 and 1.04±0.05 respectively. Leg curl fast contraction pre training, post training, and percentage change, which 40.67±6.11, 44.17±6.13 and 1.09±0.03 respectively. found that the maximum strength of the leg press, leg extension, and leg curl exercises post training compared to pre training with both strength training patterns differed significantly at the .05 level.

Table 3. One repetition maximum test from training both types of strength.

Training Test		Strength training (kg)	
		Normal Contraction	Fast Contraction
Leg Press	Pre training	249.00±34.11	259.67±27.29
	Post training 8 week	258.17±32.17*	274.83±25.00*
	Percentage changes	1.04±0.03	1.06±0.02
Leg Extension	Pre training	58.67±12.77	58.00±8.22
	Post training 8 week	62.50±12.27*	60.33±8.24*
	Percentage changes	1.07±0.04	1.04±0.05
Leg curl	Pre training	47.50±11.37	40.67±6.11
	Post training 8 week	51.50±11.81*	44.17±6.13*
	Percentage changes	1.09±0.03	1.09±0.03

* significant difference same group (P<0.05)

Table 4. Explosive power test from training both types of strength.

Training Test		Strength training (cm.)	
		Normal Contraction	Fast Contraction
Squat jump	Pre training	36.50±6.79	37.33±7.10
	Post training 8 week	41.00±4.97*	40.67±7.76*
	Percentage changes	1.15±0.02	1.09±0.06
Counter movement jump	Pre training	40.33±4.74	41.17±8.68
	Post training 8 week	44.83±4.32*	43.83±8.30*
	Percentage changes	1.12±0.15	1.07±0.04
Long jump	Pre training	187.67±16.32	195.67±17.90
	Post training 8 week	194.83±20.14	199.83±18.87*
	Percentage changes	1.04±0.07	1.02±0.01

* significant difference same group (P<0.05)

Table. 4 Showed the explosive power of squat jump normal contraction pre training, post training, and percentage change, which 36.50±6.79, 41.00±4.97 and 1.15±0.02 respectively. Leg extension normal contraction pre training, post training, and percentage change, which 40.33±4.74, 44.83±4.32 and 1.12±0.15 respectively. Leg curl normal contraction pre training, post training, and percentage change, which 47.50±11.37, 52.67±12.54 and 1.11±0.04 respectively. explosive power of squat jumps fast contraction pre training, post training, and percentage change, which 37.33±7.10, 40.67±7.76 and 1.09±0.06 respectively. Leg extension normal contraction pre training, post training, and percentage change, which 41.17±8.68, 43.83±8.30 and 1.07±0.04 respectively. Leg curl normal contraction pre training, post training, percentage change, which 195.67±17.90, 199.83±18.87 and 1.02±0.01 respectively. The explosive power of the squat jump and countermovement jump post training compared to pre training with both strength training patterns differed significantly at the .05 level. However, the explosive strength of the long jump post training compared to pre training with the strength training pattern involving a fast contraction differed significantly at the .05 level.

DISCUSSION

In this research speed test, the researchers used a 400-meter test, which is a distance equivalent to actual competition. The field surface was a standard athletics track, and the test was conducted in lane number 3. Found strength training patterns within an 8-week period had a statistically significant effect on the speed of running 400 meters at the .05 level (Zarzeczny et al., 2011). However, percentage change in the strength training pattern with a high muscle contraction rate and percentage change in the strength training pattern with a normal muscle contraction rate also differed significantly at the .05 level. This is because in short-distance track competitions, athletes must use a fast muscle contraction speed, which corresponds with the training program used. The modulation of training speeds elicits significant neuromuscular adaptations (Sengsai et al., 2019), enhancing both motor unit recruitment efficiency and the neuromuscular system's capacity to execute concentric contractions more effectively (Phogat & Ahlawat., 2015; Yousif et al., 2019).

In the maximum strength test (one repetition maximum) in leg press, leg extension, and leg curl exercises because athletes use the lower body muscles as the primary muscles in competition (Imtanabut et al., 2023), and the defined strength training pattern uses these three exercises in training. It was observed that both strength training patterns within an 8-week period had a statistically significant effect on maximum strength at the .05 level. This corresponds with the development of strength in athletes which requires an 8-week training period, and in developing explosive power (Ameti et al., 2021) it is necessary to have muscle strength at an appropriate level before training to develop explosive power(Ogata et al., 2003).

In this explosive strength test, squat jump, countermovement jump, and long jump exercises because athletes primarily use their lower body muscles in competition (Singh & Singh, 2013) and these exercises involve explosive force in both static and dynamic forms (Phungern & Yimlamai, 2020). Additionally, they involve exerting explosive force vertically under the influence of gravity and horizontally (Markovic et al., 2007). It was observed that both strength training patterns over an 8-week period had a statistically significant effect on the explosive force in the squat jump and countermovement jump at the .05 level.

Conclusion

Strength training with a high rate of muscle contraction can better develop athletes because short-distance runners require speed, strength, and explosive power (Ditroilo & Marini, 2001; Mulasiwa & Sreesung, 2024). This corresponds to movements that use the highest possible frequency of leg movement, akin to training with high muscle contraction (Balsalobre-Fernández et al., 2013). However, athletes must have a good base level of strength before adjusting their training program to a higher rate of muscle contraction, which can reduce the duration of competition (Miguel & Reis, 2004). Therefore, a training program that increases the rate of muscle contraction can be adapted to help athletes reduce their competition times.

Acknowloedment

I appreciate the Thailand National Sports University from the bottom of my heart for giving me the tools I needed to conduct this research. I am truly thankful of all of the staff members who helped me with my study. In addition, I want to

express my gratitude to everyone who helped me carry out this study.

Conflict of interest

The authors declare no conflict of interest.

Ethics

The Thailand National Sports University Research Ethics Committee for Research Involving Human Subjects approved the study protocol (SCI 042/2023). Informed consent was obtained from the parents, and assent was obtained from the children before their inclusion in the study.

Author Contributions

KS, NS, and MP in Study Design; KS in Data Collection; KS and MP in Statistical Analysis Manuscript preparation (KS, NS, and MP); data interpretation (KS); literature search (KS, NS). After reading the published version of the manuscript, all authors have given their approval.

REFERENCES

Alghadir, A. H., Anwer, S., Iqbal, A., & Iqbal, Z. A. (2018). Test-retest reliability, validity, and minimum detectable change of visual analog, numerical rating, and verbal rating scales for measurement of osteoarthritic knee pain. *Journal of pain research*, *11*, 851–856. [Pubmed]

Ameti, V., Iseni, A., Ismaili, H., & Abazi, L. (2021). The impact of Physical Fitness and Body composition on the Success of Sprint running at 400 meters. *Activities in Physical Educatıon And Sport*. [CrossRef]

Balsalobre-Fernández, C., Tejero-González, C. M., del Campo-Vecino, J., & Alonso-Curiel, D. (2013). The effects of a maximal power training cycle on the strength, maximum power, vertical jump height and acceleration of high-level 400-meter hurdlers. *Journal of Human Kinetics*, *36*(1), 119–126. [CrossRef]

de Campos Jr, J. C., Leporace, G., & Souto, A. (2019). Countermovement Jump Test Performance in Different Sports Modalities. *Journal of Exercise Physiology Online*, *22*(5), 172–183. [CrossRef]

Ditroilo, M., & Marini, M. (2001). Analysis of the race distribution for male 400m hurdlers competing at the 2000 Sydney Olympic Games. *New Studies in Athletics*, *16*(3), 15–30. [CrossRef]

Hanon, C., Lepretre, P.-M., Bishop, D., & Thomas, C. (2010). Oxygen uptake and blood metabolic responses to a 400-m run. *European Journal of Applied Physiology*, *109*(2), 233–240. [PubMed]

Imtanabut, W., Kingcha, P., & Sinsurin, K. (2023). Comparison of knee peak toque and H:Q ratio between age above and below 40 years old in Recreational Runner without injuries. *Journal of Sports Science and Health*, *24*(1), 55–66. [CrossRef]

Iskra, J., Pietrzak, M., Szczęsna, M., & Gwiazdoń, P. (2016). The development of results in 100M. and 400M. Sprint race in Athletes aged from 6 to 100. In *Journal of Physical Education & Health* (Vol. 6, Issue 9). [CrossRef]

Kaewchuay, S. (2015). Motivation of Youth for Choosing the Athletics. *Journal of Interdisciplinary Research: Graduate Studies*, *4*(2), 1–6. [CrossRef]

Kantor, M. A., Cullinane, E. M., Herbert, P. N., & Thompson, P. D. (1984). Acute increase in lipoprotein lipase following prolonged exercise. *Metabolism*, *33*(5), 454–457. [PubMed]

Markovic, G., Jukic, I., Milanovic, D., & Metikos, D. (2007). Effects of sprint and plyometric training on muscle function and athletic performance. *The Journal of Strength & Conditioning Research*, *21*(2), 543–549. [CrossRef]

Miguel, P. J., & Reis, V. M. (2004). Speed strength endurance and 400m performance. *New Studies in Athletics*, *19*(4), 39–45. [CrossRef]

Mulasiwa, K., & Sreesung, S. (2024). The effect of accentuated eccentric loading training on leg muscular performance in Youth sprinters. *Journal of Sports Science and Health*, *25*(1), 67–82.

Ogata, M., Manabe, Y., Takamoto, M., & Kigoshi, K. (2003). Relationship between the ability to maintain joint torque and muscular endurance of lower limbs during 400m running. *Japanese Journal of Physical Fitness and Sports Medicine*, *52*(4), 455–463. [CrossRef]

Okudaira, M., Kuki, S., Yoshida, T., Fukuda, D. H., & Tanigawa, S. (2019). Load Characteristics of Sprint Interval Training According to 400 m Running Performance: Competitive Level Comparison. In *148 148 International Journal of Sport and Health Science* (Vol. 17). [CrossRef]

Phungern, A., & Yimlamai, T. (2020). Effect of plyometric and eccentric training on Achilles tendon stiffness in male long-distance runners. In *Journal of Sports Science and Health* (Vol. 22, Issue 2). [CrossRef]

Phogat, W.S., & Ahlawat, R.P. (2015). Relationship of Selected Bio-motor Variables to the Performance of 400 Meter Male Sprinters. *International Journal of Physical Education, Sports and Health*, *46*(5), 46–48. [CrossRef]

Reynolds, J. M., Gordon, T. J., & Robergs, R. A. (2006). Prediction of one repetition maximum strength from multiple repetition maximum testing and anthropometry. *The Journal of Strength & Conditioning Research*, *20*(3), 584–592. [CrossRef]

Samozino, P., Morin, J.-B., Hintzy, F., & Belli, A. (2008). A simple method for measuring force, velocity and power output during squat jump. *Journal of Biomechanics*, *41*(14), 2940–2945. [PubMed]

Sengsai, P., Thanpanich, A., Makaje, N., Theanthong, A., & Phimphaphorn, P. (2019). Effects of resistance training combined with plyometric and specific movement on agility and leg muscle power in male badminton players. *Academic Journal of Thailand National Sports University*, *11*(3), 45–57. [CrossRef]

Singh, D., & Singh, S. (2013). Effects of vertical and horizontal plyometric exercises on running speed. *Human Movement*, *14*(2), 144–147. [PubMed]

Wallace, M. B. (1989). *The acute effects of resistance exercise on parameters of lipoprotein metabolism*. The Florida State University. [CrossRef]

Yousif, H. A., Norasmadi, A. R., Bin Salleh, A. F., Zakaria, A., & Alfarhan, K. A. (2019). Assessment of muscles fatigue during 400-meters running strategies based on the surface EMG signals. *Journal of Biomimetics, Biomaterials and Biomedical Engineering*, *42*, 1–13. [PubMed]

Zarzeczny, R., Kuberski, M., Deska, A., Zarzeczna, D., Rydz, K., Lewandowska, A., Bałchanowski, T., & Bosiacki, J. (2011). Effects of 8-week training on aerobic capacity and swimming performance of boys aged 12 years. *Biomedical Human Kinetics*, *3*(2011), 49–52. [PubMed]

Zhou, H., Yu, P., Thirupathi, A., & Liang, M. (2020). How to improve the standing long jump performance? A mininarrative review. *Applied Bionics and Biomechanics*, *2020*. [PubMed]