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Free weight vs gym machine: which is better for muscle endurance athletes of archery?

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Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

Abstract

Background and Study Aim: Archery athletes need excellent physical fitness. One indication that significantly influences archery achievement is arm muscle endurance. The study aimed to determine: the effect of free weight training on increasing arm muscle endurance of archery athletes; the effect of gym machine weight training on increasing arm muscle endurance of archery athletes; which is better free weight training or a gym machine, to increase arm muscle endurance of archery athletes.

Material and Methods: This type of research is an experiment with a "Two Groups Pretest-Posttest Design" design. The population is archery athletes, totaling 20 males sex with ages 12-15 years. The exercise was carried out for six weeks. The instrument uses the Holding Bow Digitec Test. The data analysis technique was a t-test.

Results: The results showed: 1) there was a significant effect of free weight training on increasing arm muscle endurance of archery athletes with p-value 0.000 < 0.05; 2) there is a significant effect of gym machine weight training on increasing arm muscle endurance of archery athletes, with p-value 0.002 < 0.05; 3) there is a significant difference between free weight training and gym machine on the arm muscle endurance of archery athletes, with p-value 0.019 < 0.05.

Conclusions: Free weight training and gym machines for 18 meetings can increase the endurance of archery athletes' arm muscles. Free weight training is better than gym machine weight training on the arm muscle endurance of archery athletes. A gym machine is suitable for a school environment with minimal supervision because it does not require another person as a stabilizer.

Keywords: weight training, free weight, gym machine, arm muscle endurance

Introduction

Archery is very popular among young children, teenagers, adults, and seniors, especially in Indonesia. Archery is a sport of targeting, as the goal is to shoot arrows at the target as precisely as possible. The characteristic of archery is releasing hands through a particular trajectory toward the target at a specific distance [1, 2]. Archery is a precision sport that requires consistency and stable movement stability to accurately hit the arrow [3, 4]. Therefore, archery athletes need excellent physical fitness.

The physical conditions of archery include coordination, endurance, flexibility, length of pull, and balance to form good archery techniques [5]. One indication of an athlete's physical condition that significantly influences archery achievement is arm muscle endurance [6, 7]. The importance of arm muscle endurance and archery accuracy is because archery is done over a long time. Good muscle endurance so that the athlete's appearance is not only good at the beginning of the match but is consistent until the end of the race and produces a fast and accurate arrow shot.

Athletes with good arm muscle endurance will help stabilize when shooting, which causes higher archery accuracy and gets perfect points. Archery athletes with good muscle strength and endurance will provide significant benefits for archers to perform optimally [8, 9]. In addition, archery requires the strength of the upper body and core muscles that move the main muscle groups [10]. Therefore, muscle endurance and joint flexibility must be in good condition so that the results obtained are more optimal [11]. Good muscle endurance must be supported by good exercise.

To develop a good archery physical exercise program, it is necessary to have the dominant elements that become the needs of the sport. Knowing the description of the requirements for the physical condition of archery, it is essential to observe and observe the performance of athletes in a competitive atmosphere because the results of the competition are a parameter of success in an exercise. Many training models can be given to training physical conditions in archery, one of which is weight training.

Weight training not only forms muscle hypertrophy but also increases muscle strength [12]. A load on the arm muscles will result in an increase in arm muscle tone, muscle mass, and arm muscle fibers which can increase arm muscle strength.

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Strength training will increase physiological abilities and responses, including neural adaptation, muscle hypertrophy, cell adaptation, muscle endurance, and cardiovascular adaptation. Research conducted by Humphries in Central Queens-land, Australia, found the prevalence of involvement in resistance training was 20.4%, with 15.2% of respondents unable to meet the American College of Sports Medicine (ACSM) guidelines. And 5.2% of respondents were able to meet the ACSM guidelines [13]. Periodization of weight training refers to modifying the number of sets, the number of repetitions, the rest/recovery phase, intensity, volume, and the number of training sessions [14].

Weight training in this study is free weight training and a gym machine. Free weight is an object with a predetermined weight used for physical training and weightlifting competitions. Examples are barbells and dumbbells [15]. This exercise using free weights gives a person more flexibility to do a variety of movements. The flexibility of this movement can make it easy for everyone to train the desired muscles. However, free weights must be used carefully so that there are no movement errors that can result in injury.

The gym machine used during weight training is a tool designed to make it easier for everyone to do weight training. Weight training with a gym machine is more accessible because the tool's shape has been adjusted to the target muscle impact, so someone who will use it only needs to do the movement by lifting, pulling, or pushing according to the handle. There are two most common weight training gym machines, namely the gym machine cam and the gym machine pulley [15].

Carraro found that free weight training increased arousal (psychological state of concern) rather than machine-based training. As the gains fueled by exercise enthusiasm were linked to better cognitive performance [16]. The same thing was found from the results of research by Wilke that resistance exercise performed with free weight was more effective in increasing control acute inhibition than machine training [17]. A study required at least ten sets per week per muscle group to maximize the increase in muscle mass [18]. Each weekly set was associated with an increase in muscle mass of about 0.36%. Weight training not only forms muscle hypertrophy but also increases muscle strength [12].

Based on this explanation, this study aimed to determine the effect of the free weight training method and the gym machine on the arm muscle endurance of archery athletes. This research is expected to contribute to science, especially in archery, and to explain the effects of free weight training and gym machines on the endurance of archery athletes' arm muscles scientifically.

Materials and Methods

Participants

The population is archery athletes in Bantul Regency, totaling 20 males sex with an age range of 12-15 years. The sample was then subjected to a pretest, ranked by the pretest score, then paired with the A-B-B-A pattern. It was found that ten athletes exercised using free weights, and 10 athletes were given exercise using a gym machine. The sampling technique uses ordinal pairing. The division of groups in this way will be more objective for all research subjects. It is based on equal opportunity for all objects to be included in each group.

Research Design

This type of research is experimental. Experimental research is changing one or more variables and studying their effects, namely changes that occur in other variables. The design used is a "Two Groups Pretest-Posttest Design" research design that has a pretest before being given treatment and a posttest after being given treatment, so it can be known more accurately because it can be compared with what was held before being given treatment.

The exercise was carried out for six weeks with 18 treatments. Exercise in the form of a circuit consisting of 8 posts. Free weight exercises include dumbbell presses, one-arm dumbbell presses, lateral raises, incline bench seated bent-overs, rear delt exercises, front raises, side lying lateral raises, and one-dumbbell front raises. The forms of gym machine training are low pulley lateral raises, low pulley front raises, rear delt reverse cable flye, nautilus lateral raises, pec deck rear delt laterals, shoulder press, face pulls, standing late pull down-chili machine. The instrument used is the Holding Bow Digitec Test. This test aims to measure the strength and endurance of the arm muscles for archery. Arm muscle endurance is measured in seconds. The durability validity is 0.895 > r table 0.344, while the reliability is 0.944 > 0.6 [19].

Statistical Analysis

The statistic used is the t-test. There are two t-tests, namely paired sample test and independent sample test with significance (p 0.05), before being analyzed using the t-test, analyzing the prerequisite tests for normality and homogeneity. The statistical analysis technique used the Statistical Package for Social Science (SPSS) version 21 software.

Results

The results of the pretest and posttest arm muscle endurance of archery athletes after being given free weight training and a gym machine are presented in Table 1.

Based on Table 1, it shows that the average arm muscle endurance of archery athletes is 15.3

Table 1. Pretest and posttest of arm muscle endurance.

No	Free Weight			Gym Machine		
	Pretest	Posttest	Difference	Pretest	Posttest	Difference
1	17	19	2	17	19	2
2	17	18	1	16	16	0
3	16	19	3	16	18	2
4	16	18	2	16	16	0
5	15	16	1	15	16	1
6	15	19	4	15	17	2
7	15	18	3	15	17	2
8	14	16	2	14	16	2
9	14	17	3	14	14	0
10	14	17	3	13	15	2
Mean	15.3	17.7	2.4	15.1	16.4	1.3

seconds and increases after being given free weight training by 17.7 seconds, while the pretest in the gym machine weight training group is 15.1 seconds, increasing during the posttest of 16.4 seconds.

Normality Test

Normality test is a way to determine whether the distribution of data in a sample can reasonably be ascribed to a given population with a normal distribution. Calculation of this normality test using Shapiro-Wilk. The results of the normality test are presented in Table 2.

Table 2. Normality test results.

Group		Shapiro-Wilk		
		Statistic	df	Sig.
Free Weight	Pretest	0.878	10	0.124
	Posttest	0.878	10	0.124
Gym Machine	Pretest	0.952	10	0.691
	Posttest	0.955	10	0.732

Based on the statistical analysis of the normality test that has been carried out using the Shapiro-Wilk test in Table 2, the results of the normality test with a value of sig p-value > 0.05, which means the data are normally distributed.

Homogeneity Test

The homogeneity test is useful for testing the similarity of the sample, namely uniform or non-variant samples taken from the population. Homogeneity test using Levene Test. The homogeneity rule if sig. > 0.05, then the test is declared homogeneous. The results of the homogeneity test are presented in Table 3.

Based on the analysis using the Levene Test in Table 3, p-value ⩾ 0.05 was obtained. These results indicate that the data group has homogeneous variants, thus the population has the same variance or homogeneity.

Tabel 3. Homogeneity test results.

Test of Homogeneity of Variances				
Group	**Levene Statistic**	**df1**	**df2**	**Sig.**
Pretest-Posttest Free Weight	0.120	1	18	0.942
Pretest-Posttest Gym Machine	0.206	1	18	0.655

Hypothesis Test Results

The hypotheses in this study were tested using t-test analysis, namely paired sample t-test (df = n-1) for the analysis of hypotheses 1 and 2, while the independent sample test for hypothesis analysis 3 (df = n-2) using the SPSS version 21 software. The results of hypothesis testing are explained in table 4.

Table 4. Test hypothesis 1 and 2.

Paired Samples Test			
Group	**t**	**Sig. (2-tailed)**	**Difference**
Pretest - Posttest Free Weight	7.856	0.000	2.4
Pretest - Posttest Gym Machine	4.333	0.002	1.3

Based on the results of the analysis in Table 4, the free weight training group obtained a t_{count} value of 7.856 and p-value 0.000 ⩽ 0.05, then this result shows that there is a significant difference. Thus the alternative hypothesis (H_1) which reads "There is a significant effect of free weight training on increasing the endurance of archery athletes' arm muscles", is accepted. Arm muscle endurance

increased by 15.69% after being given free weight training for 18 treatments.

Based on the results of the analysis in Table 4, the gym machine weight training group obtained a t_{count} value of 4.333 and p-value 0.002 ⩽ 0.05, then this result shows that there is a significant difference. Thus the alternative hypothesis (H_2) which reads "There is a significant effect of gym machine weight training on increasing the endurance of archery athletes' arm muscles", is accepted. Arm muscle endurance increased by 8.61% after being given a gym machine exercise for 18 treatments.

Table 5. Hypothesis test 3.

Independent Samples Test

Group	t-test for Equality of Means		
	t	Sig. (2-tailed)	Difference
Free Weight - Gym Machine	2.569	0.019	1.1

Based on the analysis results in Table 5, the t-count value of 2.569 and the value of p-value 0.019 ⩽ 0.05, then this result shows that there is a significant difference. Thus the alternative hypothesis (H_3) which reads, "There is a significant difference between free weight training and a gym machine on the arm muscle endurance of archery athletes", is accepted. The difference in arm muscle endurance of archery athletes after being given free weight training and a gym machine is 1.1. This means that free weight training is better than gym machine weight training on the arm muscle endurance of archery athletes.

Discussion

The results showed that free weight training and gym machine increased the arm muscle endurance of archery athletes. The free weight training group was better than the gym machine weight training group in increasing arm muscle endurance. The same thing was found from the results of research by Wilke that resistance training performed with free weights was more effective in increasing acute control inhibition than the use of gym machine exercises [17].

Higher median frequency of the vastus lateralis muscle during free weight single-leg squat than those in the free weight squat (p=0.001) and deadlift (p=0.000) movements in the lifting phase. Also, the median frequency of the vastus lateralis muscle in a single-limb squat with a smith machine was significantly higher than that in the deadlift movement (p=0.021). The median frequency spectrum of the gastrocnemius muscle in the free-weight squat exercise showed a significant increase during the downward phase relative to the free-weight single-leg squat movement (p=0.039). In order to strengthen the vastus lateralis muscle in athletes or individuals with weak vastus lateralis muscle, the free-weight single-leg squat movement is more effective than those in the other movements [20].

Free weight training increased free testosterone concentration, muscle mass, and strength compared to 8 weeks of exercise on a gym machine. Men in the free weight group experienced greater increases in free testosterone from before to after an acute training session than men in the gym machine group and all women ($p < 0.01$); however, there was no difference between groups in the free cortisol response to acute resistance exercise. Free weight training sessions led to a more significant increase in free testosterone in men; however, training with free weights or gym machines resulted in similar muscle mass and strength [21]. Free weight unquestionably provides superior transferability for sports performance activities compared to the gym machine training [22].

The interaction time of group X for strength with significance ($p = 0.054$) with free weight training, the group experienced a greater increase in strength than the gym machine weight training group (13.9%-8.6%). Thigh flexor thickness increased significantly by 3.9% and 5.1% in the gym machine and weight-free groups, respectively ($p < 0.01$), with no difference between groups. There was a significant trend for the free-weight group for maximum strength compared to the machine-load group, whereas there was no difference in the hypertrophy [23]. Free weight resistance training activates more muscle fibers and produces a greater hormonal response when compared to similar movements performed with a gym machine [24]. The percentage increase in pretest and post-test scores on strength, power, and muscle hypertrophy showed that the squat group using free weight was better than the gym machine group [25].

His study comparing strength training using free weights in the form of barbell squats and gym machines in the form of leg presses given to 120 men within eight weeks with two sessions per week showed a significant increase in leg muscle strength. Of the two types of exercise, strength training using free weights in the form of barbell squats is superior to strength training using a gym machine in the form of a leg press. Since the difference between the two training groups was also statistically significant, it can be concluded that training using barbell squats was superior to leg pressure (regarding increased jumping performance) [26]. The results of the squat exercise using free weights are more effective than the squat exercise using the gym machine. This can be seen from the loading characteristics of the two methods; squat exercises using free weights involve free forms, which require a person to use more muscles [27].

Free weights have the following advantages: (a) they are often used for exercises that increase

most of the body's muscles both directly and for support and stabilization, (b) they lend themselves to ballistics or "exploitation" exercises, (c) they can be easily used to simulate real-world lifting movements, (d) involve a range of motion and muscle activation similar to those in many sporting movements particularly for the lower body, and (e) low-cost (25]. Free weight training triggers a greater hormonal response to resistance training than gym machine weight training that uses multijoint lower body movements and similar prime movers [28].

The free weight group also showed significantly greater improvements than the control in peak torque and one-time maximum repetitions for the squat and bench press [29]. Despite the potential benefits of training with machines, training with free weights allows for the recruitment of greater muscle mass. The main difference between training with free weights and gym machines is that training with most gym machines provides a very stable environment. In contrast, training with free weights requires more stabilization and balance, resulting in greater muscle recruitment. Using free weights compared to a more stable gym machine resulted in greater muscle activation (as measured by electromyography) during the upper and lower body [30].

Increased muscle recruitment during free-weight activity has the potential to provide more anabolic stimulation. For example, an acute training session with squat free weight exercises results in the release of more anabolic hormones, such as free testosterone and growth hormone, compared to the more stable leg press exercise [28]. This greater anabolic hormone response has the potential to lead to hypertrophy and greater muscle strength over time [31]. Free weights involve dumbbells, barbells, or other weighted objects used in various training techniques. It is called free weight because the weight is not fixed, which means that the person holding it must stabilize himself. Stabilization is necessary because free weight requires the help of others to control the load [32].

Muscle adaptation due to exercise can be explained by the General Adaptation Syndrome (GAS) principle by Han's Selye, which was developed into the super compensation principle. The super-compensation model explains the adaptation of muscle strength and endurance as a function of time, explaining how adaptation occurs in muscle strength or endurance over a certain period. However, this principle has not explained the molecular mechanisms of adaptation that occur in muscles. The underlying principle of muscle training is the loading principle which states that muscle strength will emerge as a result of systematic and progressive exercise with sufficient frequency, intensity, and duration resulting in adaptation so that the plan of a muscle exercise will consist of load (%1RM), the volume of exercise (sets and reps), rest periods and progressive changes. In addition, we also state the purpose of the exercise (strength, endurance, hypertrophy), the type of exercise performed, and the nature of the contractions that occur (eccentric, concentric, isometric, contraction speed) [33].

Gym machines are ideal for beginners, people with certain injuries, or the elderly. Gym machines are designed to simplify the movement and isolate different muscle groups because muscle stabilization is excluded from the training. For example, the bar follows the same path up and down on a bench press machine (such as the Smith Machine). However, if a person bench presses using free weights, more strength is needed to lift heavy loads horizontally and vertically and keep the body balanced. This can lead to fatigue due to stabilizing muscles [21].

Technological advances, gym machines for strength training have developed significantly and are now more suitable for strength training programs. Free weights utilize the force of gravity to provide resistance, while some gym machines are now capable of using elastic, hydraulic, and pneumatic resistance. The main difference between free weight training and gym machine training is that training with a gym machine provides a very stable environment. In contrast, free weight requires more stabilization and balance. On the other hand, the gym machine is a good way to introduce someone to performing the necessary muscle movements because the gym machine forms the right movement throughout the exercise without worrying about injury due to improper technique [34].

A gym machine is suitable for a school environment with minimal supervision because it does not require another person as a stabilizer. Gym machines can also be useful in injury rehabilitation, for example, when a person needs to strengthen specific leg muscles to recover from a knee injury. Each type of equipment in weight training has its advantages and disadvantages. One should be able to select equipment based on effectiveness, efficiency, and safety while practicing.

Conclusions

The results showed: 1) a significant effect of free weight training on increasing the arm muscle endurance of archery athletes; 2) There is a significant effect of gym machine weight training on increasing arm muscle endurance of archery athletes; 3) There is a significant difference between free weight training and gym machine on the arm muscle endurance of archery athletes, with p-value $0.019 \leqslant 0.05$, and the average difference is 1.1. Free weight training and gym machines for 18 meetings can increase the endurance of archery athletes' arm muscles. Free weight training is better than gym machine weight training on the arm muscle endurance of archery athletes.

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Conflict of interest

We know of no conflicts of interest associated with this publication, and there has been no significant financial support for this work that could have influenced its outcome. As the corresponding author, I confirm that the manuscript has been read and approved for submission by all the named authors.

References

1. Sarro KJ, Viana TDC, De Barros RML. Relationship between bow stability and postural control in recurve archery. *Eur J Sport Sci*. 2021;21(4):515–20. https://doi.org/10.1080/17461391.2020.1754471
2. Ortiz J, Ando M, Miyazaki T. Numerical simulation of wind drift of arrows on the Olympic venue for Tokyo 2020. *Athens J Sport*. 2020;7(1):1–20. https://doi.org/10.30958/ajspo.7-1-1
3. Lo Presti D, Romano C, Massaroni C, D'Abbraccio J, Massari L, Caponero MA, et al. Cardio-respiratory monitoring in archery using a smart textile based on flexible fiber Bragg grating sensors. *Sensors,* 2019;19(16):3581. https://doi.org/10.3390/s19163581
4. Simsek D, Cerrah AO, Ertan H, Soylu AR. A comparison of the ground reaction forces of archers with different levels of expertise during the arrow shooting. *Sci Sports*. 2019;34(2):e137–45. https://doi.org/10.1016/j.scispo.2018.08.008
5. Callaway AJ, Wiedlack J, Heller M. Identification of temporal factors related to shot performance for indoor recurve archery. *J Sports Sci.* 2017;35(12):1142–7. https://doi.org/10.1080/02640414.2016.1211730
6. Lau JS, Ghafar R, Hashim HA, Zulkifli EZ. Anthropometric and physical fitness components comparison between high-and low-performance archers. *Ann Appl Sport Sci*. 2020;8(4):0. https://doi.org/10.29252/aassjournal.897
7. Paz Y. The existence of archery in Early Bronze Age southern Levant warfare: a note. *J Confl Archaeol*. 2018;13(1):3–11. https://doi.org/10.1080/15740773.2018.1533283
8. Arkin I, Budak M. Trunk stabilization, body balance, body perception, and quality of life in professional physically disabled and able-bodied archers. *Sport Sci Health*. 2021;17(4):881–9. https://doi.org/10.1007/s11332-021-00744-9
9. Hamilton BR, Guppy FM, Barrett J, Seal L, Pitsiladis Y. Integrating transwomen athletes into elite competition: the case of elite archery and shooting. *Eur J Sport Sci*. 2021;21(11):1500–9. https://doi.org/10.1080/17461391.2021.1938692
10. Zolkafi M, Juliana N, Azmani S, Hayati A, Monsarip N, Teng N. Influence of Isometric Contraction during Archery Training and Detraining on the Muscles and Hand Grip Strength in Sedentary Youth: A Randomized Controlled Trial: In: *Proceedings of the 8th International Conference on Sport Sciences Research and Technology Support*. Budapest, Hungary: SCITEPRESS - Science and Technology Publications; 2020. P. 119–125. . https://doi.org/10.5220/0010022601190125
11. Spratford W, Campbell R. Postural stability, clicker reaction time and bow draw force predict performance in elite recurve archery. *Eur J Sport Sci*. 2017;17(5):539–45. https://doi.org/10.1080/17461391.2017.1285963
12. Migiano MJ, Vingren JL, Volek JS, Maresh CM, Fragala MS, Ho J-Y, et al. Endocrine response patterns to acute unilateral and bilateral resistance exercise in men. *J Strength Cond Res*. 2010;24(1):128–34. https://doi.org/10.1519/JSC.0b013e3181a92dc5
13. Humphries B, Stanton R, Scanlan A, Duncan MJ. The prevalence and performance of resistance exercise training activities in an Australian population in relation to health authority guidelines. *J Sci Med Sport.* 2018;21(6):616–20. https://doi.org/10.1016/j.jsams.2017.09.018
14. Fleck SJ. Non-linear periodization for general fitness & athletes. *J Hum Kine*t. 2011;29:41. https://doi.org/10.2478/v10078-011-0057-2
15. Baechle TR, Earle RW. *Weight training: steps to success*. Human Kinetics; 2019.
16. Carraro A, Paoli A, Gobbi E. Affective response to acute resistance exercise: a comparison among machines and free weights. *Sport Sci Health.* 2018;14(2):283–8. https://doi.org/10.1007/s11332-018-0427-4
17. Wilke J, Stricker V, Usedly S. Free-weight resistance exercise is more effective in enhancing inhibitory control than machine-based training: A randomized, controlled trial. *Brain Sci*. 2020;10(10):702. https://doi.org/10.3390/brainsci10100702
18. Schoenfeld BJ, Ogborn D, Krieger JW. Dose-response relationship between weekly resistance training volume and increases in muscle mass: A systematic review and meta-analysis. *J Sports Sci*. 2017;35(11):1073–82. https://doi.org/10.1080/02640414.2016.1210197
19. Prasetyo H, Siswantoyo S, Prasetyo Y. Validity and reliability of holding bow digitec test. In: *Conference on Interdisciplinary Approach in Sports in conjunction with the 4th Yogyakarta International Seminar on Health, Physical Education, and Sport Science (COIS-YISHPESS 2021)*. Atlantis Press; 2022. P. 188–92. https://doi.org/10.2991/ahsr.k.220106.036
20. Jafarnezhadgero A, Sadri A, Bahrami Sharif MM, Alipour Sarinasirloo M. Comparison of the EMG frequency spectrum of lower limb muscles during weight training with traditional and novel equipment. *J Adv Sport Technol.* 2020;3(2):19–31.
21. Schwanbeck SR, Cornish SM, Barss T, Chilibeck PD. Effects of training with free weights versus machines

on muscle mass, strength, free testosterone, and free cortisol levels. *J Strength Cond Res.* 2020;34(7):1851–9. https://doi.org/10.1519/JSC.0000000000003349
22. Schwarz NA, Harper SP, Waldhelm A, McKinley-Barnard SK, Holden SL, Kovaleski JE. A comparison of machine versus free-weight squats for the enhancement of lower-body power, speed, and change-of-direction ability during an initial training phase of recreationally-active women. *Sports*. 2019;7(10):215. https://doi.org/10.3390/sports7100215
23. Hadi M, Soegiyanto M, Rahayu S, Setiono H. Effectiveness of free weight exercise and super set machine system on strength and muscle hypertrophy. In: *International Conference on Science and Education and Technology 2018 (ISET 2018)*. Atlantis Press; 2018. P. 191–5. https://doi.org/10.2991/iset-18.2018.40
24. da Silva BVC, Simim MAM, Viegas LCR, Brígido TS, da Silva RÂD, Oranchuk DJ, et al. The acute hypotensive effect of resistance training performed with machines vs free weights in normotensive men. *Mot Rev Educ Física*. 2018;24(2). https://doi.org/10.1590/s1980-6574201800020015
25. Mansur LK, Irianto JP, Mansur M. Effect of squat training using free weights and a gym machine on muscle strength, power, and hypertrophy. *J Keolahragaan*. 2018;6(2):150–61. https://doi.org/10.21831/jk.v6i2.16516
26. Wirth K, Hartmann H, Sander A, Mickel C, Szilvas E, Keiner M. The impact of back squat and leg-press exercises on maximal strength and speed-strength parameters. *J Strength Cond Res*. 2016;30(5):1205–12. https://doi.org/10.1519/JSC.0000000000001228
27. Clayton N, Drake J, Larkin S, Linkul R, Martino M, Nutting M, et al. *Foundations of fitness programming*. Color Springs, CO Natl Strength Cond Assoc. 2015;
28. Shaner AA, Vingren JL, Hatfield DL, Budnar Jr RG, Duplanty AA, Hill DW. The acute hormonal response to free weight and machine weight resistance exercise. *J Strength Cond Res*. 2014;28(4):1032–40. https://doi.org/10.1519/JSC.0000000000000317
29. Shoepe TC, Ramirez DA, Rovetti RJ, Kohler DR, Almstedt HC. The effects of 24 weeks of resistance training with simultaneous elastic and free weight loading on muscular performance of novice lifters. *J Hum Kinet.* 2011;29:93. https://doi.org/10.2478/v10078-011-0043-8
30. Schwanbeck S, Chilibeck PD, Binsted G. A comparison of free weight squat to Smith machine squat using electromyography. *J Strength Cond Res*. 2009;23(9):2588–91. https://doi.org/10.1519/JSC.0b013e3181b1b181.
31. Rønnestad BR, Nygaard H, Raastad T. Physiological elevation of endogenous hormones results in superior strength training adaptation. *Eur J Appl Physiol*. 2011;111(9):2249–59. https://doi.org/10.1007/s00421-011-1860-0
32. Weaver AN, Kerksick CM. Implementing landmine single-leg romanian deadlift into an athlete's training program. *Strength Cond J.* 2017;39(1):85–90. https://doi.org/10.1519/SSC.0000000000000279
33. Wackerhage H. *Molecular exercise physiology: an introduction*. Routledge; 2014. https://doi.org/10.4324/9780203132142.
34. Schwanbeck SR, Cornish SM, Barss T, Chilibeck PD. Effects of Training With Free Weights Versus Machines on Muscle Mass, Strength, Free Testosterone, and Free Cortisol Levels. *Journal of Strength and Conditioning Research*. 2020;34(7): 1851–1859. https://doi.org/10.1519/JSC.0000000000003349

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