available online at http://journal.uny.ac.id/index.php/jolahraga

Jurnal Keolahragaan, 10 (1), 2022, 1-8

The impact of overhead dumbbell squat towards swimming speed of Tirta Palm Swimming Club members

Winaspita Aulia Putri[1], Adelia Handoko[1]*, Ulfa Elfiah[2]

[1]Department of Physiology, Medical Faculty University of Jember. Kalimantan St No. 37 Tegal Boto Campuss Jember, 68121, Indonesia.
[2]Department of Anatomy, Medical Faculty University of Jember. Kalimantan St No. 37 Tegal Boto Campuss Jember, 68121, Indonesia.
*Corresponding Author. E-mail: adelia.fk@unej.ac.id

Received: December 29, 2021; Accepted: March 15, 2022 Published: April 25, 2022

Abstract: Swimming athletes compete by how fast they can swim at a certain distance. One of the most important things that affect the swimming speed was the muscle strength of the arms and legs. The swimming speed can be increased by doing the physical exercise that can affect the arms and legs muscle which was called overhead dumbbell squat (ODS) exercise. The purpose of this study was to find out if there was an effect of ODS towards increased breaststroke swimming speed of Tirta Palm swimming club members. This study was an experimental study with one group pretest-posttest design that was implemented for a month about 16-20 years old that met the qualifications of inclusion did the ODS exercise thrice a week for 4 weeks. The duration of each exercise was 10 repetitions, 6 sets, and breaks for a minute in each set. The result showed that the average pretest swimming speed was 67,84 seconds and the post-test was 59,07 seconds. The analysis result of paired sample t-test showed a value p<0,001, so there was a significant difference between pretest and posttest. It could be concluded that overhead dumbbell squat exercises could enhance the swimming speed of Tirta Palm swimming club members.

Keywords: Overhead dumbbell squat, swimming speed, repetition, muscle strength, hypertrophy.

How to Cite: Putri W.A., Handoko A., & Elfiah, U. (2022). The impact of overhead dumbbell squat towards swimming speed of Tirta Palm Swimming Club members. *Jurnal Keolahragaan, 10(1), 1-8*. doi: https://doi.org/10.21831/jk.v10i1.37031

INTRODUCTION

Sport was useful as a means of recreation, health, and achievement. Recently, one of the sports that people are starting to like was swimming. Swimming has now widely competed at both international and national levels. In the international swimming sports championships, Indonesia has not been able to achieve optimal results, for example at the 2018 Asian Games, Indonesia did not manage to get a medal in the swimming sports championship (Wikipedia, 2020). At the 2019 Southeast Asian Games swimming championship, Indonesia only won 1 gold medal and this result was very far from Singapore which could get 23 gold medals (Wikipedia, 2020). One of the contributing factors was the duration of training carried out by Indonesian athletes before the competition, which was only 3 months, while minimal preparation for training before an international competition was 1 year, at least. The combination of exercise duration and type of exercises was an important component in strengthening the muscles of an athlete (Indrajaya, 2019). The quality of preparation before the race will determine the final result. Physical exercise modifications and innovations are needed to help improve athlete performance in training time as effectively and efficiently as possible (McArdle, Katch, & Katch, 2010).

Swimming was a sport that prioritizes body coordination, especially the hands and feet to make movements in the water. Swimming movements are influenced by arm movements, leg movements, respiratory strength, and movement coordination (Lekso, 2013). The effectiveness of good arm and leg movements can increase the speed of swimming time. The style of swimming that was very popular with the public was breaststroke because of the ease of movement and was the basic style in every swimming training (Mulyono, 2013). Breaststroke was one of the swimming styles that are competed at national and international levels. Arm and leg movements are more dominant in the breaststroke that

uses the m muscles. brachioradialis, m. brachialis, m. bicep brachii, m. latissimus dorsi, m. pectoralis major, m. trapezius, m. biceps femoris, m. gluteus maximus, and m. rectus femoris. In the breaststroke swimming style, the strength of the arm and leg muscles greatly affects swimming speed. Coordination of arm and leg movements can produce great propulsion in the breaststroke swimming style (Setiawan, Aswin, & Prakosa, 2005). Previous research has stated that arm muscle strength can contribute 49% to the ability to swim in the breaststroke, while leg muscle strength contributes 81% to the ability to swim in the breaststroke (Penara, Razali, & Putra, 2015). Physical exercise can increase the strength of these muscles, one of which wasby doing squats. Previous research has shown that squats using free weights such as dumbbells, barbells, or other heavyweights can significantly increase muscle strength compared to using a gym machine (Mansur, Irianto, & Mansur, 2018). Other studies have also found that barbell squats training can significantly increase leg muscle strength and speed, (Nasrulloh et al., 2021). The squat exercise using a free weight that can be done was the Overhead Dumbbell Squat (ODS).

ODS was a weight training that combines squats with overhead dumbbells, as in previous studies which stated that squats using free weights such as dumbbells, barbells, or other heavyweights can increase muscle strength significantly compared to using a gym machine. The muscles involved in the squat movement include m. quadriceps, m. gluteus medius, and m. gluteus maximus (Mansur, Irianto, & Mansur, 2018). While the muscles involved in the overhead dumbbell movement are m. triceps brachii, m. deltoid, m. pectoralis major, and m. serratus anterior. These exercises can develop the entire pectoralis muscle and also work on the triceps, teres major, latissimus dorsi, serratus anterior, rhomboideus, and pectoralis minor muscles, (Nasrulloh et al. 2018). Every weight training program has the terms repetitions, sets, and rest periods (straight-set pattern). This pattern aims to build maximum muscle strength and increase muscle mass (Pambudi & Hidayah, 2014). Therefore, an exercise program was very important for athletes to achieve success. Athletes' success was generally the result of a proper training program and over the long term. This long-term training program serves to improve mental and physical conditions when competing in a championship (Falaahudin & Sugiyanto, 2013).

The increase in muscle mass was also known as hypertrophy. Hypertrophy occurs due to changes in muscle, including an increase in the number of myofibrils proportional to the degree of hypertrophy, an increase in mitochondrial enzymes up to 120 percent, an increase in components of the phosphagen metabolic system by about 60-80 percent, an increase in glycogen reserves by about 50 percent, and an increase in triglyceride reserves. as much as 75-100 percent (Hall, 2016). Weight training can lead to hypertrophy. Nasrulloh et al., (2020) found that weight training with the tricet method performed 3 times a week for 8 weeks, with an exercise intensity of 70% - 80% (1RM), 3 sets, and 8-12 repetitions could significantly increase muscle hypertrophy with a value ($p < 0.05$). Weight training carried out for 6 weeks with a frequency of exercise 4 times a week was able to increase the size of the upper arm circumference by 5.47%, the size of the upper arm circumference was measured using a measuring tape (Jais, 2011). Another study also concluded that the squat exercise combined with free weight which was carried out for approximately 1 month on 32 male samples could increase the size of muscle fibers by 4.97% as measured using a measuring tape (Mansur, Irianto, and Mansur, 2018). Based on this, this study aims to examine the effect of ODS on increasing swimming speed for members of the Tirta Palm Swimming Club.

METHOD

This research was an experimental type of research with one-group pretest-posttest design research held on from June 2020 to July 2020 at the Palm Bondowoso Hotel swimming pool. This research has received ethical approval from the Research Ethics Commission of the Faculty of Medicine, University of Jember. The subjects came from members of the Tirta Palm Swimming Club in Bondowoso Regency as many as 16 men. The sampling method used was purposive sampling that met the inclusion criteria, namely men aged 16 to 20 years, had a Body Mass Index (BMI) in the normal category, did not do physical exercise that could affect muscles outside the study, mastered the breaststroke swimming technique, in good health, not injured or in the stage of recovering from physical injury, willing to be a research subject by filling out informed consent and parental consent. The exclusion criteria were the research subjects did not follow the complete research procedure.

The research subjects 16 personal did ODS exercise for 4 weeks with a frequency of exercise 3 times a week on Mondays, Wednesdays, and Fridays so that the total number of exercises was 12 times. The duration of each exercise is 10 repetitions, 6 sets, and a 1-minute rest between each set then followed

by regular swimming exercises. Routine exercises performed by athletes during the study were jogging on the side of the court for 10 minutes, swimming breaststroke 4 times (50 meters), and cooling down. Research during the pandemic was carried out while maintaining health protocols by using disposable surgical masks or 3-ply cloth masks, making shifts for arrival hours, checking temperatures, maintaining distance, providing hand sanitizers, and regulating entry and exit flows.

The loading (dumbbell weight) in the initial phase was carried out in stages, the dumbbell weight starting from 1 kg, so that each research subject lifted 2 kg for 3 meetings. At the 4th to 12th meeting, the load was added by 1 kg to 2 kg, so that each research subject lifted a load of 4 kg. Before the exercise begins, it begins with a warm-up and ends with a cool-down. Supervision in each exercise is supervised directly (direct observation) by researchers and trainers. The research instruments used during the study were digital scales, stature meters, stopwatches, whistles, stationery, dumbbells weighing 2 kg, and a first aid kit. The assessment in this study was to measure the time it took the research subjects to cover a swimming track distance of 50 meters in seconds taken on the first day before the ODS exercise (pretest) and after 12 times the ODS exercise (posttest). Data analysis in this study used bivariate analysis which aims to determine whether there is an increase in swimming speed in research subjects. First, the data normality test was carried out using the Saphiro Wilk test (n<50), if the data were normally distributed, it was continued with a comparative test using the Paired T-Test.

RESULTS AND DISCUSSION

After doing ODS training for 4 weeks, the data obtained can be seen in Table 1. The results of average time needed to swim a distance of 50 meters during the pretest were 67.84 seconds, while the posttest was 58.07 seconds. There was a decrease in the amount of time needed to cover the track after 12 ODS exercises.

Table 1. Research Data

No	Subject Number	BMI		Swimming speed (second)	
		Pretest	***Posttest***	***Pretest***	***Posttest***
1	S1	20,98	20,16	58.6	41.1
2	S2	20,81	20,34	57.4	52.26
3	S3	20,47	20.90	67.5	61.17
4	S4	24,44	23,39	89.4	79.82
5	S5	19,11	19,92	69.2	66.35
6	S6	20,46	19,74	54.2	53.02
7	S7	21,84	21,31	51.7	48.03
8	S8	26,73	25,87	85.7	79.45
9	S9	21,33	20,94	59.34	47.41
10	S10	26,07	24,65	60.3	55.03
11	S11	21,95	21,28	75.41	63.52
12	S12	19,31	19,25	61.03	57.26
13	S13	22,01	21,64	69.57	64.12
14	S14	21,21	21,77	78.82	62.3
15	S15	24,16	23,34	84.6	56.37
16	S16	24,13	23,18	62.72	58.03
Mean		22,18	21,73	67,84	59,07

The data that has been obtained were tested for normality. The normality test used the Saphiro Data are normally distributed if the significance value was greater than 0.05. The significance value before treatment (pretest) was 0.225, while after treatment (post-test) 0.482. Both of these data show the results of significance > 0.05. It shows the data was normally distributed. The results of the normality test can be seen in Table 2.

Table 2. Normality Test Results

Description		Shapiro-Wilk		
	Group	Statistic	df	Sig.
Swimming - speed	Before	.928	16	.225
	After	.950	16	.482

Normally distributed data continued to be analyzed using the Paired T-Test. The results of the analysis using the Paired T-Test obtained a significance value of p<0.001, which means there was a significant difference between the data before (pretest) and after (posttest) ODS exercise. The results of the Paired T-Test test can be seen in Table 3.

Table 3. Paired T-Test Results

Description	Mean	T	df	Sig.
Before - After	8.76563	4.977	15	.000

This study uses ODS exercises that are included in weight training which combines squats and overhead dumbbells. ODS is a physical exercise consisting of squats and overhead dumbbells. Squats are a type of exercise that aims to increase strength, especially in the leg muscles (Rachman, 2013). Squat exercises involve large muscle groups in humans, especially muscles in the lower limbs including the quadriceps, gluteus medius, and gluteus maximus. (Mansur, 2018). ODS movement can increase muscle contraction, especially in the arms and legs. Muscle contractions that occur are movements that are executed by a group of voluntary muscles because the mechanism of contraction can be controlled consciously (Sherwood, 2014). Skeletal muscle contraction was initiated by an action potential that travels along with the motor nerve fiber until it reaches the end of the motor nerve fiber in the muscle fiber. The action potential triggers the release of small amounts of acetylcholine. The release of acetylcholine causes the opening of "acetylcholine gated" cation channels in the plasma membrane of muscle cells, resulting in a displacement of the action potential. An action potential in the T tubule triggers the release of Ca2+ ions from the sarcoplasmic reticulum. The Ca2+ ion will bind to one of the protein subunits on the actin filament, namely troponin, causing the tropomyosin to change position opening the active site of the actin filament for attachment of the myosin head. Simultaneously with the opening of the active site of the actin filament, the myosin heads on the myosin filaments bind to ATP. The ATPase in the myosin head hydrolyzes ATP to ADP and phosphate ions so that the position of the myosin head was cocked towards the active site of the actin filament and the myosin head was attached to the actin filament. There was strong pedaling which ends with the release of ADP and phosphate ions from the myosin head so that the myosin head is separated from the active site of actin. ATP was needed for both contraction and relaxation (Silverthorn, 2016).

Increased muscle contractions performed in repetition can lead to muscle hypertrophy (Pambudi & Hidayah, 2014). Muscle hypertrophy occurs due to changes that occur in the muscle, including an increase in the number of myofibrils (myofibrillogenesis) which was proportional to the degree of muscle hypertrophy which results in enlarged muscle size or the addition of sarcomeres (sarcomerogenesis). Resistance training shows significant changes in the muscles, especially in terms of adaptation. Resistance training-induced hypertrophy was caused by the addition of sarcomere (sarcomerogenesis) or an increase in the number of myofibrils in muscle fibers (myofibrillogenesis) (Haun , et al., 2019). . In hypertrophy there was also an increase in mitochondrial enzymes up to 120% which causes an increase in the amount of ATP produced, an increase in the components of the phosphagen metabolism system needed by muscles to carry out the physical activity with high intensity and in a short time, and an increase in glycogen reserves of about 50% needed as fuel when ATP requirements increase during physical activity. The phosphagen system was the system that muscles use for power bursts for a few seconds, the glycogen-lactic acid system was important for energy-intensive races, and the aerobic system was needed for long-term sports activities. (Hall, 2016). The energy that can be produced in this system is even greater than the energy that can be produced by ATP, which was 10,300 calories in every release of 1 high-energy phosphate bond. This metabolic system can produce

energy in a short time and can prepare the energy for 8-10 seconds. However, because this system was only able to last a short time, the body cannot rely completely on this metabolic system (Hall, 2016).

Changes that occur in the muscles due to hypertrophy can lead to an increase in muscle strength which can help to increase the athlete's swimming speed. The results of the study are in accordance with research conducted by Mansur (2018) proves that squats that are carried out for approximately 1 month using free weight can increase leg muscle strength by 8.89% as indicated by the average results of pretest and posttest muscle strength measurements using a back and leg dynamometer, which was 53.5000 to 58.2500. In addition, other studies have concluded that weight training carried out 12 times a month in the adolescent age group can increase biceps muscle mass which before exercise was 25.7 while after exercise there was an increase to 27.0 (Soethama, Silakarma, & Wiryanthini, 2016). In addition to muscle hypertrophy, muscle strength can also be influenced by the type of muscle tissue whereas someone who genetically has a lot of fast glycolytic fibers was a good candidate for sports that rely on strength and speed because they can generate ATP in a short time and fast (Sherwood, 2014).

In every physical exercise program, there are always terms of repetitions, sets, and rest periods. Reps are one complete movement in each exercise, for example in ODS, 1 rep was when the athlete stands with both feet parallel to the shoulders and then lifts two dumbbells with each hand and performs a squat movement, and then stands back up. 1 set is a group of repetitions of reps. The rest period was the time it takes the athlete to relax and not work on the same muscles between sets. The ODS exercise in this study was carried out in a straight-set pattern. This technique can increase muscle mass and muscle strength. These results are reinforced by previous studies which concluded that there was an effect of weight training with a straight-set pattern of 8-12 repetitions, 3 sets, with 1-2 minutes of rest, and adding weight every 10-20 days on hypertrophy and biceps muscle strength in UNNES Semarang college students (Pambudi & Hidayah, 2014).

Swimming was a sport that performed in water by moving the body, especially the feet and hands so that the body floats on the surface of the water (Budiningsih, 2010). The benefits of swimming include training for breathing, relieving stress, burning calories, and building muscle. The principles in swimming are (1) the principle of resistance and encouragement, where the speed of moving forward in swimming is the result of the strength to resist the resistance of the water and the force to push forward caused by the movement of the arms and legs, (2) the principle of the regularity of encouragement or continuity of movement. , doing regular arm and leg movements are more effective for pushing movements (Setiawan & Setiowati, 2014).

Breaststroke swimming or commonly known as the frog style was the basic movement in any swimming training. The characteristics of breaststroke swimming include: the slowest swimming speed, the greatest resistance, and the body position are not horizontal. The movement of the breaststroke swimming begins with both arms, body, and both legs straight on the surface of the water; the arm moves in a semicircle outward, backward, and inward; elbows bent 90^0 while taking a breath, continue to straighten both arms forward together by entering the head into the surface of the water; pull the legs closer to the hips with the thighs slightly apart when bending the knees; the body was slightly lower than the surface of the water so that the heels remain under the surface of the water; push the leg out to continue with a strong stamp and end until it was straight and tight again (Solihin, 2013). In breaststroke swimming, the strength of the arm and leg muscles greatly affects speed because the coordination of arm and leg movements can produce a large thrust in breaststroke swimming. This statement was following the results of research conducted by (Rachman, 2013) that the arm muscle strength contributed 99.7% while the leg muscle strength contributed 39.4% to the speed of the breaststroke swimming. The strength of the leg muscles was needed to kick when starting the breaststroke swimming, where a strong kick can affect the distance of the glide at the beginning of the swimming movement so that less energy was used to perform the breaststroke movement.

The increase in swimming speed in this study can also be caused by a decrease in the average BMI of research subjects. BMI was one of the assessments used to measure the relationship between a person's weight and height to determine their health status and the risks that they may have. The decrease in BMI was due to weight training causing an increase in the use of fat as energy during exercise, causing weight loss (Purwanto & Nasrulloh, 2019). Weight loss can cause the research subjects to become lighter so that the movement in the water was also faster. In this study, the average BMI of research subjects decreased from 22.18 to 21.73 which was included in the normal BMI category. These results are following previous studies which concluded that weight training carried out for 12 times exercise in 1

month can affect the decrease in BMI from 23.91 to 23.05 due to a decrease in the size of the arm, stomach, and thigh fat as measured by the skinfold tool (Razy, 2019).

Glucose, fatty acids, and amino acids are food materials that are oxidized in the mitochondria to produce energy in the aerobic system. These foodstuffs will bind with oxygen to release useful energy to convert AMP and ADP into ATP. Muscle power in the aerobic system was not limited as long as the food was available. During the early stages of physical activity, muscles use most of the fat as energy in the form of fatty acids and acetoacetic acid, while the protein in the form of amino acids was used only in small amounts. In the first few seconds to minutes, most of the energy comes from a high-carbohydrate diet, but when fatigue occurs, about 60 to 85 percent of the energy comes from fat (Hall, 2016). . Research by Sholikhah (2021)In rats, it was found that moderate-intensity swimming exercise reduced body weight and total cholesterol levels in hyperlipidemic rat models. Previous studies revealed that exercise-induced changes in blood lipid levels are also associated with exercise duration, volume, and intensity. Muscella (2020) explained in his research that exercise intensity and total energy consumption are the main factors that influence changes in lipid profiles. Further research by Kannan (2014) found that for the same amount of exercise, blood lipid changes were more significant at higher intensity exercise. Thus, many studies suggest moderate-intensity exercise compared to high and low-intensity to induce changes in blood lipid levels in general, including total cholesterol levels.

ODS was carried out with a frequency of exercise 3 times a week on Mondays, Wednesdays, and Fridays for 4 weeks so that the total exercise is 12 times. This exercise interval corresponds to the recovery time of muscle glycogen. Recovery of muscle glycogen from fatigue takes a few days. Recovery time was the time needed to restore the body's condition before the match to get maximum results or achievements (Parwata, 2015). Any form of physical activity will cause fatigue in athletes and it takes time for recovery. A heavy training load on athletes will cause great fatigue so that it takes longer recovery time, and the results of the exercise do not have a significant effect on the body. If an athlete does exercise with a light load, this will cause mild fatigue in an athlete with a short recovery time but minimal performance. Moderate or submaximal exercise in an athlete will require a longer recovery time than a light training load but the effect was much more significant than a heavy or light load so that an athlete's physical performance can improve. The physical performance of athletes can affect their recovery time, especially the ability of cardiovascular and muscular endurance. On a high-carbohydrate diet, recovery time occurs in approximately 2 days. Whereas in someone who does not eat and someone on a diet high in fat and protein, recovery was slow and even up to 5 days. It can be concluded that it was important for every athlete to have a high-carbohydrate diet before taking part in a race and not to engage in any strenuous physical activity for 48 hours before a race (Hall, 2016)

The limitation in this study was that the measurement of muscle strength and hypertrophy was carried out indirectly, namely only by measuring the swimming travel time of the pretest and posttest so it was not known for certain changes in the size of muscle hypertrophy in learning. subjects. In addition, this study did not examine the effect of overhead dumbbell squats on Range of Movement (ROM) so researchers do not know for sure whether ODS can affect joint flexibility which can affect movement while swimming. The study was conducted during the COVID-19 outbreak so that there was a limited time during meetings resulting in researchers not being able to fully record the nutrients consumed by research subjects during the study and this study was only conducted on 16 male swimming athletes, so the results of the study were not representative of all swimming athletes.

CONCLUSION

In sum, the overhead dumbbell squat exercise could increase swimming speed for members of the Tirta Palm Swimming Club as indicated by a decrease in the travel time of the 50-meter swimming distance with the breaststroke.

REFERENCES

Budiningsih, A. (2010). *Berenang Gaya Bebas.* Kudus: Pura Barutama.

Falaahudin, A., & Sugiyanto. (2013). Evaluasi Program Pembinaan Renang Di Klub Tirta Serayu,TCS, Bumi Pala, Dezender, Spectrum Di Provinsi Jawa Tengah. *Jurnal Keolahragaan, 1*(1).

Hall, J. E. (2016). *Textbook of Medical Physiology 13th ed.* Mississippi: Elsevier.

Haun , C. T., Vann, C. G., Roberts, B. M., Vigotsky, A. D., Schoenfeld, B. J., & Roberts, M. D. (2019). A Critical Evaluation of the Biological Construct Skeletal Muscle Hypertrophy: Size Matters but So Does the Measurement. *Frotiers in Physiology Perspective, 10*(247), 1 - 23.

Indrajaya, N. (2019). *Atlet Renang Andalan Indonesia Sebut Kualitas Persiapan Jadi Jurang Pembeda dengan Singapura.* . Retrieved from https://sportfeat.bolasport.com/read/441960753/atlet-renang-andalan-indonesia-sebut-kualitas-persiapan-jadi-jurang-pembeda-dengan-singapura?p

Jais, M. (2011). Pengaruh latihan beban terhadap hipertrofi otot lengan atas pada anggota pusat kebugaran Golden Fitness Padang. Skripsi. *Lampung: Fakultas Ilmu Keolahragaan.*

Lekso, M. F. (2013). Pengaruh metode latihan dan power tungkai terhadap kecepatan renang gaya dada 50 meter atlet kelompok umur IV perkumpulan renang spectrum semarang. *Journal of Physical Education and Sports, 2*(1), 213 - 2019.

Mansur, L. K. (2018). Pengaruh latihan squat menggunakan free weight dan gym machine terhadap kekuatan, power, dan hypertrophy otot. *Jurnal Keolahragaan, 6*(2), 150-161.

McArdle, W. D., Katch, F., & Katch, V. (2010). *Exercise Physiology: Nutrition, Energy, and Human Performance.* Lippincott Williams & Wilkins.

Mulyono, R. W. (2013). Pengaruh Leg Press terhadap Peningkatan Tinggi Lompatan (Vertical Jump) pada Pemain Badminton. *Skripsi. Program Studi S1 Fisioterapi Fakultas Ilmu Kesehatan Universitas Muhammadiyah Surakarta.*

Kannan, U., Vasudevan, K., Balasubramaniam, K., Yerrabelli, D., Shanmugavel, K., & John, N. A. (2014). Effect of exercise intensity on lipid profile in sedentary obese adults. *Journal of Clinical and Diagnostic Research*, *8*(7), 8–10. https://doi.org/10.7860/JCDR/2014/8519.4611

Mansur, L. K., Irianto, J. P., & Mansur, M. (2018). Pengaruh latihan squat menggunakan free weight dan gym machine terhadap kekuatan, power, dan hypertrophy otot. *Jurnal Keolahragaan*, *6*(2), 150–161. https://doi.org/10.21831/jk.v6i2.16516

Muscella, A., Stefàno, E., Lunetti, P., Capobianco, L., & Marsigliante, S. (2020). The regulation of fat metabolism during aerobic exercise. *Biomolecules*, *10*(12), 1–29. https://doi.org/10.3390/biom10121699

Nasrulloh, A., Deviana, P., Yuniana, R., & Pratama, K. W. (2021). The Effect of Squat Training and Leg Length in Increasing the Leg Power of Volleyball Extracurricular Participants. *Teorìâ Ta Metodika Fìzičnogo Vihovannâ*, *21*(3), 244–252. https://doi.org/10.17309/TMFV.2021.3.08

Nasrulloh, A., Prasetyo, Y., Nugroho, S., Yuniana, R., Pratama, K. W., Mustapha, A., Idrus, S. Z. S. (2020). Tricet Method to Increase the Hypertrophy Muscle. *Journal of Physics: Conference Series*, *1529*(3), 032006. https://doi.org/10.1088/1742-6596/1529/3/032006

Nasrulloh, A., Prasetyo Y,. Apriyanto, K. D. (2018). *Dasar-Dasar Latihan Beban*. UNY Press: Yogyakarta.

Purwanto, P., & Nasrulloh, A. (2019). Efektivitas Latihan Beban Dengan Metode Circuit Weight Training Dengan Super Set Terhadap Penurunan Berat Badan Dan Prosentase Lemak. *MEDIKORA*. https://doi.org/10.21831/medikora.v16i1.23484

Rachman, J. A. (2013). *Sumbangan Kekuatan Otot Tungkai Dan Daya Ledak Otot Lengan Terhadap Kecepatan Renang Gaya Dada 50 Meter*.

Sholikhah, A. M., & Ridwan, M. (2021). Swimming training on moderate intensity significantly reduces total cholesterol and bodyweight on hypercholesterolemic rat model. *Jurnal Keolahragaan*, *9*(1), 51–58. https://doi.org/10.21831/jk.v9i1.33362

Pambudi, N., & Hidayah, T. (2014). Pengaruh latihan pola straight-set dan drop-set terhadap hipertropi dan kekuatan otot bisep pada member Fik Fitness Center UNNES Semarang. *Journal of Sport Sciences and Fitness., 3*(2), 6 - 10.

Parwata, I. M. (2015). Kelelahan dan Recovery dalam Olahraga. *Jurnal Pendidikan Kesehatan Rekreasi. 1(1): 2-13., 1*(1), 2 - 13.

Penara, S., Razali, & Putra, S. (2015). Hubungan kekuatan otot lengan dan power otot tungkai terhadap kemampuan renang gaya dada pada mahasiswa penjaskesrek FKIP Unsyiah angkatan 2011. *Jurnal Ilmial Mahasiswa Pendidikan Jasmani, Kesehatan dan Rekreasi, 1*(1).

Purwanto, P., & Nasrulloh, A. (2017). Efektivitas latihan beban dengan metode circuit weight training dengan super set terhadap penurunan berat badan dan prosentase lemak. *MENDIKORA, 16*(1), 76 - 90.

Rachman, J. A. (2013). *Sumbangan Kekuatan Otot Tungkai dam Daya Ledak Otot Lengan terhadap Kecepatan Renang Gaya Dada 50 Meter.* Semarang: Skripsi. Pendidikan Kepelatihan Olahraga Fakultas Ilmu Keolahragaan Universitas Negeri Semarang.

Razy, H. A. (2019). *Efek Latihan Beban terhadap IMT dan Penurunan Lemak Tubuh pada Member Fitnes di Stadium Fitnes dan Futsal Center Ungaran Tahun 2017.* Semarang, Semarang: Skripsi. Jurusan Ilmu Keolahragaan Fakultas Ilmu Keolahragaan Universitas Negeri Semarang.

Setiawan, T. T., Aswin, S., & Prakosa, D. (2005). Kontribusi kekuatan otot dan fleksibilitas sendi terhadap waktu tempuh renang 50 m gaya crawl. *Jurnal Sains Kesehatan, 18*(3), 371-381.

Setiawan, D. A., dan A. Setiowati. 2014. Hubungan indeks massa tubuh (IMT) terhadap kekuatan otot pada lansia di Panti Wredha Rindang Asih III Kecamatan Boja. *Journal of Sport Sciences and Fitness, 3*(3), 30 - 35.

Sherwood, L. (2014). *Fisiologi Manusia dari Sel ke Sistem Edisi 8.* Jakarta: EGC.

Sholikhah, A., & Ridwan, M. (2021). Swimming training on moderate intensity significantly reduces total cholesterol and bodyweight on hypercholesterolemic rat model. *Jurnal Keolahragaan, 9*(1), 51 – 58.

Silverthorn, D. U. (2016). *Human Physiology: An Integrated Approach, 7th Edition.* University of Texas, Austin: Pearson.

Soethama, G. R., Silakarma, D., & Wiryanthini, I. (2016). Pengaruh latihan beban terhadap peningkatan massa otot pectoralis mayor dan biceps pada remaja dan dewasa. 2(1):52-57. *Majalah Ilmiah Fisioterapi Indonesia., 2*(1), 52-57.

Solihin, A. O. (2013). Peran alat bantu rubber resistant terhadap kecepatan renang gaya dada 25 meter mahasiswa PJKR angkatan 2009 di STKIP Pasundan Cimahi. *Jurnal Kepelatihan Olahraga., 5*(1), 1-11.

Wikipedia. (2020). Retrieved from Swimming at the 2018 Asian Games. https://en.wikipedia.org/wiki/Swimming_at_the_2018_Asian_Games.