EFFECT OF WATER EXERCISES, PLYOMETRIC EXERCISES AND A COMBINATION OF BOTH ON SELECTED PHYSICAL VARIABLES, PHYSIOLOGICAL VARIABLES AND PERFORMANCE OF TRIPLE JUMPERS

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DECLARATION

I hereby declare that the work presented in the thesis entitled **"Effect of Water exercises, Plyometric exercises and a combination of both on selected Physical variables, Physiological variables and Performance of Triple Jumpers"** is based on the original work done by me under the guidance of **Dr. Sakeer Hussain V.P.,** Director, Department of Physical Education, University of Calicut and has not been included in any other thesis submitted previously for the award of any degree. The contents of the thesis are undergone plagiarism check using iThenticate software at C.H.M.K. Library, University of Calicut, and the similarity index found within the permissible limit. I also declare that the thesis is free from AI generated contents.

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CERTIFICATE

This is to certify that the thesis entitled **"Effect of Water exercises, Plyometric exercises and a combination of both on selected Physical variables, Physiological variables and Performance of Triple Jumpers"** submitted to the University of Calicut, in fulfillment of the requirements for the award of the degree of Doctor of Philosophy in Physical Education is recorded of original research work done by **Rajesh P.K.**, during the period of 2016 – 2023 of his study in the Department of Physical Education, University of Calicut, Thenjipalam, under my supervision and guidance and the thesis has not been previously submitted elsewhere for the award of any Degree/Diploma/Associate ship/Fellowship or any other similar title and it represents entirely an independent work on the part of the candidate.

The examiners have not recommended any modifications or suggestions and therefore the original thesis is resubmitted as such. Soft copy attached is the same as that of the resubmitted copy.

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CHAPTER I

INTRODUCTION

1.1 Introduction

Sports is a blessing in this busy lifestyle and helps in protecting the health of mankind. People who get involved in sports activities, forget their day today sorrow, subconsciously develop leadership qualities and they get the boldness to face any depressing situations. When a person excels in his field of sports, it is not only his health which improves, but also his wealth and popularity. The satisfaction gained by a sportsperson cannot be gained even by the richest person in the world.

A sportsperson leads a good life and never feels life is a burden. The people taking part in sports will be active and enthusiastic in their work. Sports is not just for entertainment. It is for healing many diseases and also to protect a person from disease and to bring people out of traumatic experiences, it rehabilitates people.

Sports unites people belonging to any caste, creed or religion. When a team from one country plays against another, they forget all differences and this develops a friendly atmosphere and a good understanding between countries. Sports plays a good role in world peace. When one country's team wins in a match, the people take it as their victory and this is done only through the help of sports. Sports provide healthy and socially acceptable opportunities for the people and nations to compete against each other thereby touching heights of excellence of human endeavour and attainment. **(Hardayal Singh, 1991)**

All the above said benefits and influences of sports needs active, agile and powerful sportsperson to take part in the sports. To exhibit the high degree of talent in the sports the sportsperson needs a lot of training. Such trainings focus on their physical, physiological, psychological and sociological characteristics. This training is denoted as sports training.

The term "training" is widely used in various contexts to refer to an organized and systematic instructional process aimed at enhancing an individual's physical, psychological, and intellectual performance capacity. In the field of sports, this term is frequently used by players, coaches, and scientists. Training is a critical aspect of sports that enables athletes to develop their skills, improve their physical fitness, and enhance their overall performance.

1.2 Science of sports training

Research in exercise training has uncovered a set of general principles of conditioning that must be followed to develop an effective exercise program. The principle of specificity states that the body's adaptation or change in physical fitness is specific to the type of training undertaken. In simple terms, if the fitness goal is to increase flexibility, then flexibility training must be employed, and if one wishes to develop strength, resistance or strengthening exercises must be used. This principle is straightforward; however, it is often overlooked. Some fraudulent exercise products or systems promise overall physical fitness from a single training technique, which is usually a red flag. One should be wary of such claims and consider whether the recommended exercise training is the type that will produce the desired specific changes.

The principle of overload is a crucial aspect of physical fitness improvement. To improve any physical fitness aspect, one must continually increase the demands placed on the relevant body system. For example, to build strength, you need to lift objects that are progressively heavier. In running programs, overload is accomplished by running longer distances or increasing speed. Individuals often make the mistake of attempting a sudden fitness change, which can result in injury or soreness. A classic example is middle-aged men or women who haven't exercised for 20 years and then suddenly begin an intense training program. There are no hard and fast rules on how to progress to a higher level of activity, but the subjective impression of whether the body can tolerate increased training serves as a good guide. In general, it may be reasonable not to increase activity levels more often than every one or two weeks.

Starting and finishing workouts gradually is a crucial habit that we should adopt. Our body's systems can adapt to higher metabolic demands, such as elevated heart rate, blood flow, and muscle temperatures, by warming up before exercise. This is a more pleasant and safe method to start a fitness routine. It may warm up by gradually increasing the level of difficulty of the workouts or the pace at which we walk. At the conclusion of each workout, it's equally critical to cool down by progressively lowering the level of intensity. Sudden stops to intense activity can cause blood to pool in the legs, which can lead to fainting or, more dangerously, heart problems. After an exercise session, it's a good idea to take a five-minute stroll and stretch. The heart rate should progressively drop during the cool-down; at the conclusion of the five minutes, it should be fewer than 120 beats per minute for those under 50 and less than 100 beats per minute for people over 50.

Extensive research has been conducted to provide guidance on the ideal amount of exercise an individual should do to develop and maintain physical fitness. It is generally agreed that the exercise must be performed on a regular basis. A frequency of about every other day or three days per week appears to be minimally sufficient. However, many individuals exercise more frequently than this, and it is acceptable provided that they do not become overstrained and suffer illness or injury.

The appropriate intensity of exercise required to experience health benefits has been studied extensively. Many individuals believe that exercise only produces results when it causes pain or discomfort. However, this is not true. Engaging in regular exercise at an intensity of 45 to 50 percent of one's maximum capacity is sufficient to improve physiological functioning and overall health. This level of intensity is usually comfortable for most people. A reliable method to determine exercise intensity is to measure the heart rate while exercising. An exercise heart rate that is 65 percent of a person's maximum heart rate corresponds to approximately 50 percent of their maximum capacity. A person's maximum heart rate can be estimated by subtracting their age in years from 220.

Fitness was emphasised heavily in the preceding talk, and it is crucial for our general health. It's important to remember, too, that there are other forms of conditioning that have advantages as well. Stretching activities to preserve joint mobility and flexibility and skeletal muscle strengthening exercises to maintain body mass and optimum strength levels for everyday functioning are vital components of a comprehensive exercise programme. According to the previously discussed specificity principle, no one exercise is likely to result in the whole conditioning effect. Thus, to maintain optimal joint function, a well-rounded exercise regimen should include flexibility exercises, aerobics, and activities that build the strength and endurance of different skeletal muscle groups.

The principles of exercise training mentioned above should be considered as general guidelines. Every individual is unique in terms of physiological and psychological adaptations to exercise. Therefore, two people who are alike in many respects and start the same exercise program may have entirely different impressions of it. For instance, one person may find the exercise too easy, while the other may find it too difficult. Thus, it is appropriate to adjust the exercise plan based on personal preferences. The principles of exercise training should be viewed as general guidelines and not as strict rules. It's important to note that everyone progresses through exercise routines at their own pace, and that progress should be adjusted based on each person's own assessment. It's also important to remember that not everyone enjoys or can tolerate the same types of exercise - for example, jogging may not be suitable for everyone. But there are plenty of other exercise activities that can provide health and physiological benefits, such as cycling, walking, swimming, or participating in a sport. Ultimately, there is no single "best" exercise - the key is to engage in regular exercise and follow the general guidelines outlined in this section.

Exercises for strength and endurance are performed by completing many sets, or "reps," of a particular exercise before switching to a new exercise that targets a different muscle area. Experts often advise choosing a resistance that is around 65% of the maximum weight that an individual can lift for that specific activity. Twelve repetitions of that exercise should be possible with this load in twenty to thirty seconds. It is advisable to do two or three sets of a certain exercise during each training session. A set consists of eight to twelve repetitions. Strength and endurance training should be done two or three days a week for the average person. A programme known as "super circuit weight training" involves jogging or other cardiovascular workouts, this training produces vascular and strength developments.

In order to improve flexibility, muscles and tendons must be stretched. There are a few simple principles to follow when it comes to flexibility training. The muscles and connective tissue around a joint must be stretched to improve the range of motion. The best way to stretch is to slowly increase the range of motion. The stretch should be performed gradually, and the body should be held in the stretched position for 10 to 20 seconds before being returned to a relaxed posture. The exerciser should feel the muscle stretch, but not to the point of pain. By stretching each muscle group in this way as part of a strengthening and conditioning program, participants can maintain good flexibility. It's important to avoid bouncing or explosive stretching movements, as they can result in muscle or tendon tears.

Regular exercise has numerous benefits for the heart. When you engage in regular exercise, the muscle mass of the left ventricle increases, which is the pumping chamber that circulates blood throughout the body. This increase in muscle mass results in the heart being able to pump more blood with each beat. Over time, this makes the heart a bigger and stronger pump that can perform more work with less effort.

In addition to strengthening the heart muscle, regular exercise also produces changes in the circulation that are essential for optimal health. One of the most significant changes is an increase in blood flow to the working muscles, which is critical for delivering oxygen and fuel to the muscle cells. This increased blood flow can enhance muscle performance and endurance, making it easier to perform physical activities and reducing the risk of injury.

Another benefit of regular exercise is an increase in the number of red blood cells, which are responsible for carrying oxygen in the blood. This increase in red blood cells means that more oxygen can be delivered to the muscles during exercise, improving overall performance and endurance. Exercise also results in an increase in blood volume, which means that more blood is available to transport oxygen to the muscles. Taken together, these changes in the heart and circulation indicate a greater capacity to transport oxygen to the working muscles, leading to improved physical performance and overall health.

The primary role of lungs is to aid the transfer of oxygen from the atmosphere into the blood and of carbon dioxide from the blood into the atmosphere. For this to happen, air must enter and exit the lungs, and respiratory gases should diffuse through the lungs into the circulation and vice versa. Exercise does not affect this diffusing ability, but it does strengthen the muscles of respiration. This means that a trained person can take in more air through the lungs per unit time, and the forced vital capacity, which is the maximum volume of air that can be exhaled after taking full inspiration, may increase.

Exercise programs can bring about a host of benefits that can help improve overall fitness. With appropriate exercises, one can enhance their muscular strength and endurance, body composition, flexibility, and cardiorespiratory endurance. Although the level of maximal oxygen intake or cardiorespiratory endurance may not matter to most individuals, it's important to note that their sustained energy expenditure ability is directly related to maximal levels of performance. To illustrate, even a simple task like walking at a rate of three miles per hour requires an energy expenditure of approximately three times the resting metabolic rate. However, people who are extremely unfit may only have a maximal aerobic power of six times their resting metabolic rate. Therefore, it's crucial to maintain a regular exercise routine to improve your overall fitness and maximize your energy expenditure ability to perform optimally.

The energy-expenditure requirement of an individual's life can be calculated by determining their maximal cardio respiratory endurance. This will help to determine the level of physical activity that can be sustained without causing chronic fatigue. Those who lead more active lives than their fitness level can support may experience chronic fatigue. On the other hand, individuals with adequate or optimal fitness levels can easily meet the physical demands of an active lifestyle. Research studies have shown that people who exercise regularly often report feeling better and experience an overall improvement in their well-being.

1.3 Water exercise

Water exercise has been popular since 1978, and it is becoming more popular as an effective and gentle form of exercise. It is a great way to stay active regardless of the age and body shape. Water is an environment that keeps the joints virtually free of impact, supports to be in an upright position and cools the internal body temperatures.

To have more intense workout, water can provide resistance to the movement that is not found on land and can also be manipulated to challenge the conditioned athlete‘s fitness. People with medical concerns, water is a gentle and forgiving environment because it allows to take the weight off an injured body part while still engaging and strengthening the muscle surrounding that joint.

From the sedentary to the fit, aquatic exercise is adaptable to all. It is especially helpful for those with limitations in moving on land. Water exercise introduces the unique properties of water that make the pool such a safe and effective place to exercise. The cooling and buoyant properties keep us comfortable while adding physiological benefit such as increased cardiorespiratory endurance.

Water exercise offers a great way to get in shape, stay in shape, or rehabilitate an injured part of the body. The pool is a forgiving environment because the water cushions and supports the body while reducing the impact on the bones and joints. Water exercise improves all of the fitness components addressed by land exercise. Over time, aquatic exercise can improve overall health, increase longevity, and make the activities of daily life easier while also protecting the body from unnecessary physical stress.

1.3.1 Properties of water

The properties of water that make the aquatic exercise safe and effective are buoyancy, hydrostatic pressure, and viscosity. These properties enable a balance, low-impact workout that is safe both for people who want to increase their overall fitness and for those seeking rehabilitation after injury. The dynamics of thermoregulation in the pool help the body cool, thus making aquatic activity a safer and more comfortable mode of exercise, especially for people with certain health conditions.

1.3.2 Buoyancy

The greatest advantage provided by working in the pool is buoyancy, which is the upward pressure exerted by fluid. In other words, the opposite of gravity's downward pull. It can easily observe the effect of buoyancy by holding an object, such as a ball, at the bottom of the pool, then releasing it and watching it pop up to the water's surface. Buoyancy accounts for the feeling of relative weightlessness that we experience in water. It also decreases the compressive forces experienced by the joints, including those in the spine. As a result, aquatic exercise is a low-impact activity.

The amount of benefit provided by buoyancy for exercise depends on the depth of the water. Exercising at depth water reduces impact by 90 percent and makes it more difficult to maintain the balance. When the balance is challenged, the core muscles in the torso will be forced to contract so the abdominal muscles are more greatly challenged.

Buoyancy also aids flexibility, the range of motion around a joint which is primary component of rehabilitation after injury. Because water provides buoyancy and reduces gravitational force, it allows the exerciser to move his/her limbs more freely, and possibly without pain, toward the surface of the water. Because buoyancy is greatest in deep water, rehabilitation often begins in water deep enough to eliminate gravitational pull on the injured body part and allow the joint to float freely to the water's surface.

1.3.3 Hydrostatic pressure

The pressure that a fluid applies or transmits to an object is known as hydrostatic pressure. The hydrostatic pressure of water molecules creates equal pressure on all parts of the body, and this pressure increases with the depth of the water. This characteristic of water provides great benefits for person with swelling due to injury or cardiac concerns. Specifically edema or swelling of a joint is decreased when the joint is submerged in water because the fluid in the joint is forced into the capillaries by the hydrostatic pressure of the water against the body, thus returning to the bloodstream and it is eliminated through kidney.

The hydrostatic pressure of water also facilitates the efficiency of the cardiovascular system, thus making the pool a popular environment for persons recovering from a cardiac incident. Because hydrostatic pressure causes constriction of blood vessels, the heart is pumping blood through a smaller area and the heart rate decreases. Even if we work in the water more intensely the heart rate would be fewer.

1.3.4 Viscosity

Water molecules also provide resistance in every direction, which means that work is given to opposing muscle groups at the same time. This resistance is caused by the fact that water molecules are cohesive. Water molecules stick to each other, and this quality is often referred as “drag”. To push through these sticky molecules, body must exert muscular force that is 12 to 15 times greater than the force needed when moving through air.

Therefore, water’s viscosity helps to develop muscular fitness. It also provides a stabilizing effect that helps the body remain upright, which makes the water a safe place to exercise for people with conditions that affect balance. Water molecules also possess a property called adhesion, which causes them to stick to other things in the pool, such as webbed gloves, clothing and even skin. A tight fitting swimsuit, however, provides less surface area to which molecules can stick, thus making workout easier.

Water‘s viscosity helps to develop strength and endurance in the injured joint and surrounding muscles. Specifically, the viscosity provides with balanced resistance regardless of the direction in which the limb moves.

1.3.5 Thermoregulation

Thermoregulation is a property of the body that increases the comfort level during exercise in the water. In the case of water exercise, the dynamics of thermoregulation means that, as long as we exercise in water that is cooler, it can be regulated the body temperature by transferring body heat directly to the water rather than by sweating. Thermoregulation becomes more important as we age due to changes in sweat glands that occur with age.

Water exercises are a great way to help to get in shape without the heavy impact of activities like running. For those of us out there with bad joints, water activities and sports can keep the stress off the joints allowing focus on workout. Many facilities offer a number of different aerobic and training activities. A personal trainer can develop a routine perfect for the needs, whether it is for strength, endurance, or rehabilitation. As a person that suffers from joint pain after running, exercising in the water is a great alternative.

Strength exercise tones the muscles, increases stamina, and gives the appearance of length and leanness. Performing such exercises in the water increases resistance on the muscle and prevents stress on the joints, helping to gain strength quickly without straining joints or aggravating chronic pain conditions (MaryBeth Pappas Baun, 2008).

Combining strength training with aerobic exercise can be done through water exercises. Start by warming up in the pool for five minutes and stretching for another five minutes before moving onto the aerobic and strengthening portions of the workout. Once you're done with the training, it's important to cool down for 10 minutes before leaving the pool to prevent any risk of injury.

The resistance of water against the body results in an increase in the amount of energy that muscles must exert during any movement. For those looking to increase resistance even further, moving to deeper water or using equipment specifically designed for water strength training, such as water dumbbells, paddles, a kick-board, cuffs, or booties, can be beneficial.

Exercises in the water are excellent for those who have joint discomfort from high-impact sports like jogging. Water workouts are a fantastic alternative because they have no effect. Engaging in aquatic exercise is highly beneficial for those with conditions like arthritis and expectant mothers. Engaging in water sports is an excellent way to increase cardiovascular fitness and aid with weight loss. You can do everything in the water that you can do on land. Water inherently opposes movement, so it adds a new intensity routine. Running in water is far more difficult than on dry land. Exercises in the water only put pressure on the targeted muscle group. The reason for this is that the body is suspended in water. Similar to any other training regimen, physical therapy includes a significant portion of water rehabilitation

Exercises performed in water are easier on the body than those performed on land. This allows for better maintenance of flexibility and muscle tone. The aim is to make movements more fluid and rhythmic. Strength training can be done using ankle weights and dumbbells, as well as through squats, leg lifts, lateral raises, water jumps, and running.

Working out in the water is a great method to tone your body without having to deal with the physical strain of jogging. Sports and activities in the water can relieve joint stress and focus on the workout for those of us with joint issues. Numerous establishments provide an array of aerobic and training exercises, according to the needs of strength, endurance, or recuperation. Since I've had joint problems from jogging on the land, I personally prefer swimming and water exercise to running. Exercise in the water is also a terrific option.

1.4 Benefits of water exercise

In addition to providing the specific exercise benefits water also provides the same general benefits offered by land exercise. These benefits can help to increase the fitness, improve quality of life and handle daily life activities more comfortably and perhaps more easily.

1.4.1 Improved cardiac health

Cardiovascular fitness, another name for heart health, is enhanced in every way by water exercise. The capacity of the heart, lungs, and blood arteries to provide oxygen to working muscles is referred to as cardiovascular fitness. Cardiovascular fitness is developed with activities that use large muscle groups in continuous movement, including water exercise. It causes drop in resting heart rate which means heart is becoming more efficient.

Resting heart rate is one of the most effective indicators of heart‘s health. Heart gets bigger and stronger, it can pump more blood per stroke. Thus, heart becomes stronger, it will be able to fulfill its function with less stress. Regular exercise also decreases blood pressure partly because it strengthens heart and also it reduces the plaque lining in the veins and arteries. Regular exercise causes liver to make healthy cholesterol (HDL), which acts as a scavenger to remove the unhealthy (LDL) cholesterol from the walls of the arteries. This process gives blood more room to pass freely through the blood vessels, which decreases blood pressure.

Water resistance exercise reduces blood pressure by prompting the body to create more capillaries. As we push the arms and legs through the water, it slowly increases the size of the muscle fibers. As these fibers increase in size, body creates more capillaries to carry blood to various muscles. The more capillaries makes flood to flow freely, thus decreasing blood pressure.

Heart works closely with the lungs, exercise improves lung capacity and breathing efficiency. Through this improvement in breathing processes, exercise also aids in the circulation of oxygen and nutrients throughout the body, thereby helping it operate more efficiently.

1.4.2 Improved body composition

Water exercise that causes the body to burn more calories for energy increases the chance of changing the body composition, which is determined by the proportions of lean and non-lean tissue in the body mass. Lean tissue components are tendons, ligaments and muscle, whereas non-lean tissue is adipose or fat tissue. Burns more fat cells as a form of energy when increase caloric expenditure by exercising in the pool.

1.4.3 Reduced stress

Psychological stress can damage DNA and increase the risk of age-related disease. Water exercise protects DNA and slows down the aging process, memory loss and improve short term memory. Exercise itself constitutes a certain type of stress called hormesis, which is good for the body. Moderate intensity exercise increases certain brain-derived factors that maintain brain health.

1.4.4 Improved musculoskeletal fitness

Water exercise benefits bones and muscles in many ways. The benefits of working the musculoskeletal system include improved posture, reduced blood pressure, and decreased risk of injury in daily life. Muscular exercise also makes the bones stronger and increases their density. Exercise increases the flow of synovial fluid around the joints and slows the degeneration of joints. The muscular improvements provided by exercise also reduce the risk of injury by strengthening the tendons, ligaments thus helping to keep the balance. (**Melissa Layne, 2015)**

There are several advantages to working out in the water, such as decreased stress, blood pressure, tension, weight, pain, body fat, effect on joints, chance of accident, and need for prescription medication. Strength, flexibility, energy, range of motion, muscular tone, oxygen circulation, endurance, balance, coordination, fun, self-worth, safety, and life satisfaction may all be enhanced by it. It can also improve sleep patterns, recuperation from injuries, social joys, emotions of well-being, and the reversal or slowing of physical and mental ageing. Joints are shielded from the impact of land-based activities by the buoyancy that water provides. When compared to activities performed on land, the resistance of water (hydrostatic pressure) to all body motions leads to higher training intensities. Water has a rubbing impact on muscles as well. Compared to motions on land, it offers 12% more resistance and relieves the discomfort and strain of gravity. Everyone's requirements, preferences, and skill level may be accommodated through water exercise.

1.5 Plyometric exercise

Will and Freeman (1980) claim that the word "plyometrics" comes from the Greek word "plethyoin," which meaning "equal length." A muscle will contract significantly more forcefully if it is quickly extended right before it does so. This is the basis for plyometric workouts, or "plyos" for short.

Plyometric exercises encompass depth jumping, hopping, and bouncing drills. These exercises are highly dynamic and utilise gravitational force, as well as the contractibility and elasticity of muscle tissue, to enhance the stress on the relevant muscles Plyometric training is a method used for muscle building by athletes. It is seen as a continuation of the "shock" approach advocated by Russian coach Verkhoshonki (1966). His shock approach involved rebounding leaps from a height to train the athlete's reactive neuromuscular system. Plyometric training involves both concentric and eccentric muscular contractions.

Will and Freeman (1980) plyometric (plyo-more or greater, metric measure or quantity) exercise is based upon the belief that a rapid lengthening of a muscle just prior to the contraction will result in a much stronger contraction.

The term "plyometric" originates from the Greek words "pilo" and "metric," meaning "more" and "measure," respectively. It can also be derived from the word "plyetheyeim," which means to grow. Plyometric training is also known as depth leaping, box jumping, and jump training. The premise of plyometric training is that rapidly stretching the muscles just before contraction can produce a much stronger contraction. The strength of the muscle spindles, which involves the reflex and causes an increase in the frequency of motor unit discharge, is believed to be the reason behind the increased contraction strength.

One of the various plyometric exercises is the depth jump. During this exercise, an athlete steps up onto a platform that is usually two meters above the ground. They immediately perform a maximal effort vertical or horizontal jump after landing on the ground **(Will and Freeman, 1980)**.

One of the best ways to build explosive power for sports is through plyometric exercise. Plyometric workouts essentially assist in striking the perfect balance between strength and speed, resulting in explosive power. Nowadays, practically every sport makes use of these workouts. It is important to start a plyometric training regimen with a foundational level of strength. The exercises chosen ought to be suitable for the person's age, gender, and stage of physical development, with a steady rise in intensity over the course of the training cycle. The participant's body weight should determine how valuable the leaps are in the exercise. Plyometric training should ideally be done twice or three times a week.

Plyometric exercise is a relatively new idea in training that involves using the current strength of a muscle before making an explosive contraction. Even though plyometric exercises have been studied to see if they can improve vertical jumping ability, it has not yet been determined if they are more beneficial than kinetic workouts **(Will and Freeman, 1980)**.

1.5.1 Box drills

Box workouts incorporate depth jumps along with several hops and jumps. They can be low in intensity or extremely stressful, depending on the height of the boxes used **(Young, 1991).**

1.5.2 Bounding

Exaggerating the typical running stride, bounding workouts highlight a particular part of the stride cycle. Usually done over distances longer than 30 metres, they are meant to increase stride length and frequency **(Young, 1991)**.

1.5.3 Hops and jumps

Hop and jumps combine the skills developed by jumps-in-place and standing jumps **(Young, 1991)**. Plyometrics, commonly known as "plyos," are a type of exercise designed to improve athletes' speed, quickness, and power. This type of training incorporates a range of explosive movements, such as jumping, hopping, and bounding, to enhance muscular strength, endurance, and flexibility. Plyometrics originated from research conducted by Soviet Bloc scientists during the Cold War, with Yuri Verkhoshansky being the leading researcher. Dr. Verkhoshansky created a system of exercises called "Jump Training" that involved repetitive jumping to increase the speed and explosiveness of Russian track and field athletes. Since then, plyometrics have become popular worldwide among athletes seeking to improve their athletic performance. Plyometrics are now widely used by various sports teams and fitness enthusiasts as an effective method to enhance power, speed, and agility.

The stretch-shortening cycle has to be activated in order to experience the potential advantages of plyometric exercise. This calls for paying close attention to the method employed in the practice or drill. In plyometric training, it is more important to focus on the pace of stretch than the amplitude of stretch. Additionally, the coupling time—also known as the ground contact time—must be as brief as feasible. Choosing or designing an exercise that is appropriate for the event and requires the right muscle movement is a problem for coaches and athletes alike. The only thing limited by your creativity is being particular and making sure there is a pre-stretch beforehand. To build explosive power, advanced training sessions might incorporate plyometric activity and weight training.

Plyometric workouts feature fast, explosive movements intended to enhance speed and power, in contrast to traditional strength training exercises that require lengthy, gradual motions intended to increase muscle strength and bulk. Plyometric exercises are divided into three stages. The first is the eccentric phase, which is characterised by a quick extension of the muscles. The amortisation phase, a brief time of rest, follows. Lastly, the participant performs the concentric phase, an explosive muscular shortening exercise. This three-part cycle is repeated by the athlete as fast as possible. Reducing the duration between eccentric and concentric movements is the aim of plyometric workouts. A guy can increase his speed and strength by shortening the distance between these two actions.

Plyometric training helps athletes run faster, leap higher, and strike harder by improving the function of their muscles, tendons, and nerves. The capacity to swiftly transform strength into speed is known as physical power. Strengthening the fast-twitch muscle fibres, which are accountable for transforming force into velocity, is necessary to enhance one's power output. Plyometric exercises have the ability to both build and strengthen the muscles' fast-twitch fibres. Muscle contraction speed increases with the strength of the fast-twitch fibre.

Strengthening the tendons is necessary to enhance the force and velocity of muscle contractions. In addition, less injuries result from stronger tendons. Plyometric exercises put stress on the tendons under regulated conditions, strengthening and increasing their suppleness. The nervous system is the last element that increases strength and velocity. A signal is transmitted from the brain to the muscles via the neuromuscular system each time a muscle contracts. Athletic speed and power are increased when the neuromuscular system communicates this signal more quickly, allowing the muscles to contract and rest more quickly. Enhance this efficiency using plyometrics.

Plyometric exercises, by their very nature, are intense and require individuals to build up strength and flexibility through regular cardio, weight training, and stretching. This is essential to prevent excessive load on joints and tendons. While there is no evidence to suggest that plyometric training poses an increased injury risk to adults, it is prudent to follow recommended safety guidelines to minimize any potential risks.

However, due to the limited scientific research on plyometrics compared to conventional strength training, there are currently no definitive guidelines regarding sets, repetitions, and frequency. In this regard, the National Strength & Conditioning Association and several leading experts in the field have proposed parameters to assist coaches and athletes in designing an effective training plan.

To ensure safe and effective plyometric training, it is important to prioritize the development of strength and flexibility through comprehensive pre-training routines. This will help to minimize the risk of injury and maximize the benefits of plyometric exercises.

Achieving optimal performance in sports requires a comprehensive training program. Plyometric exercises are an essential component of a well-rounded training regimen. However, not all plyometric exercises are created equal. It's essential to choose the appropriate exercises that align with the athlete's fitness level and goals. Skipping exercises may be suitable for those just starting, whereas more advanced athletes may benefit from single leg bounds or depth jumps.

To maximize results, it's essential to progress gradually from lower intensity drills to more advanced plyometric exercises. This is particularly important for individuals with less strength training experience. Keeping the number of plyometric exercises to a minimum is also crucial. A typical session might only include two or three lower body plyometric exercises, with upper body plyometric exercises added if they're appropriate for the sport.

While there are many plyometric exercises to choose from, only a select few will be suitable for a particular sport or event. It's crucial to select the exercises that align with the athlete's goals and the specific requirements of their sport. By incorporating these plyometric exercises into their training regimen, athletes can improve their explosive power, speed, and agility, ultimately leading to better athletic performance.

It is essential to remember that plyometric training must follow a phase of maximum strength training for optimal results. The primary goal of plyometric training is to increase an athlete's force application velocity, enabling them to convert a bigger amount of their initial maximum strength into power that is specific to their sport. The intensity of plyometric workouts varies widely, with skipping being the lowest intensity exercise, and reactive drop jumping from 32 inches (80 cm) or higher being the most intense activity.

Plyometric volume pertains to the number of repetitions executed during a workout session. For lower body exercises, each repetition constitutes a ground contact. It is not advisable to schedule plyometric training on the day after a heavy strength training session when the muscles may still be sore. This can pose a challenge for athletes who need to engage in strength training three to four times per week. To facilitate effective plyometric training, it is recommended to alternate upper and lower body strength training with upper and lower body plyometrics. The phase of the training program will also determine the number of suitable plyometric training sessions per week.

Maximum effort and rapid movement throughout each repetition are necessary for a plyometric training session to be effective. The amount of time spent resting between sets and repetitions should be sufficient to allow for almost full recovery. A labour to rest ratio of 1:10 is advised, and a minimum of 5 to 10 seconds may be needed in between depth leaps.

It is absolutely essential to warm up adequately before starting a plyometric training session. The National Strength & Conditioning Association insists on including toe jogging and straight leg jogging as part of your warm-up routine to prepare your body for the high-impact nature of plyometric drills. To get the most out of your workout and reduce the risk of injury, it is crucial to perform plyometrics at the beginning of your workout when your body is at its freshest and most alert.

There isn't enough data to suggest whether plyometric training poses an increased risk of injury. However, since repeated shock-tension exercises can stress joints and connective tissue, several safety guidelines have been proposed to ensure safe performance. According to these guidelines, athletes should be able to complete a one repetition maximum squat at a weight that is 1.5 times their body weight. Additionally, they must be able to bench press a weight ranging from 1 to 1.5 times their body weight. Balance is another crucial factor in executing plyometric exercises safely. Therefore, athletes should be able to stand on one leg for 30 seconds to complete less intense exercises. For more advanced exercises, they should be able to stand on one leg for 30 seconds in a semi-squat position. Plyometric training is not recommended for prepubescent children because it may harm the epithyseal plates that have yet to close. Although, it is worth noting that children do routinely perform jumping movements during unstructured play. Nonetheless, effective plyometric training entails numerous maximal efforts, which is why the structured nature of training may pose an over-training risk to younger individuals. Lastly, the landing surface must have adequate shock-absorbing qualities to minimize the risk of injury. Some good choices include grass, a suspended floor, and exercise mats. By adhering to these guidelines, athletes can safely undertake plyometric training with the assurance that they are less likely to suffer injuries.

There have been two versions of plyometrics since its debut in the early 1980s. Plyometrics has its origins in the shock technique, which was defined by Dr. Yuri Verkhoshansky of the former Soviet Union. The competitor would descend from a height and feel a "shock" when they touched the ground. As the athlete sprang forward, this would cause an unconscious, forced eccentric contraction that would be quickly followed by a concentric contraction. Between 0.1 and 0.2 seconds was all that was took to complete the takeoff and landing. Once a strong strength basis has been developed, the shock technique is the most efficient way for athletes to increase their power, speed, and agility.

If you are looking to enhance your athletic performance, it might be worth considering incorporating true plyometrics into your fitness routine. These exercises are designed to improve explosive movements such as running and jumping. It is important to note that true plyometrics vary from standard plyometrics as they do not rely on the shock method to create an impact.

Dr. Verkhoshansky, a well-known sports scientist, is the creator of true plyometrics. Through his research on the movements involved in running and jumping, he discovered that the landings and take-offs in these movements generate high ground reaction forces that must be executed quickly and explosively. By incorporating true plyometrics into your fitness routine, you can improve your power, speed, and agility.

To ensure proper technique, it is essential to use the right terminology when performing plyometric exercises. Instead of merely using the term "plyometrics," it is recommended to use terms such as "explosive" or "true plyometrics" to convey their true nature. This will help ensure that you are incorporating the appropriate techniques into your workouts and achieving the best possible results.

If you are ready to elevate your fitness routine to the next level, consider incorporating some true plyometrics. Regardless of whether you are a seasoned athlete or a beginner, true plyometrics can help you boost your performance and take your skills to the next level.

The Soviet researchers set out to find practical training methods to enhance athletic performance, and Dr. Verkhoshansky was tasked with discovering how to replicate the explosive forces generated during execution through exercise. After experimenting with various exercises, he created the depth jump, which proved to be the most effective in duplicating the forces generated during take-off and landing. This exercise improved the athletes' ability to take off and perform well on running or jumping events.

The second version of plyometrics, which is more prevalent in the United States, involves doing all forms of jumps regardless of execution time. However, this type of jump cannot be considered truly plyometric due to its lesser intensity of execution and the longer time required for transitioning from the eccentric to the concentric contraction. While the term plyometrics gained popularity with the publication of many books, it now seems impossible to revert to its original meaning and method of execution.

As a result, it is important to distinguish which type of "plyometric" exercise is used in order to determine its effectiveness and potential to receive the stated benefits. Understand that even though the name plyometrics is given to all jumps, not all jumps are plyometric. Fred Wilt, a former US Olympic long-distance runner, is credited with coining the term plyometrics. He admits that it is not a very good term but it was the best he could come up with after watching the Russians execute jumps in their warm-ups prior to their event in track and field. He could not understand why the Russians were doing all of these jumps while the Americans were doing multiple static stretches. But he firmly believed it was one of the reasons why they were so successful in many events. From its beginnings in the early 1980s, the term plyometrics gained greater popularity and is now well established. Still, he was convinced that it contributed to their great success in several competitions. The term "plyometrics" first appeared in the early 1980s and has since grown in popularity.

Soviet researchers sought to enhance athletic performance via practical training methods. Dr. Verkhoshansky's depth jump replicated explosive forces during take-off and landing. Plyometrics, doing all jump types regardless of execution time, is less intense and requires longer transitions. The term became popular, but a return to its original method is unlikely.

1.5.4 Main power conditioning phase

For athletes who are skilled enough to undergo a training phase, it is essential to incorporate drills from the medium-intensity categories mentioned on page five. To improve their performance, runners should focus on single-leg variations, which are most relevant to their sport. Additionally, lower leg drills such as straight leg jumps are crucial to enhancing specific calf and Achilles tendon power, thereby promoting optimal foot-strike and force return while running.

Middle and long-distance runners can also benefit from incorporating bounding and hopping exercises into their warm-up routines. These exercises help develop running-specific power and can be coupled with hill training to enhance performance. Maintaining plyometric drills within their circuit training can also help runners achieve their training goals.

1.5.5 Pre-competition phase

Athletes should focus on performing plyometric drills that accurately replicate the speed and movement patterns of their respective sports. For this purpose, they can choose high-intensity drills from the table, but it is crucial to maintain the quality of each drill and avoid letting fatigue affect their performance.

1.5.6 Competition phase

When it comes to power sports, nothing prepares the body for maximum power expression like the action itself. Athletes should, however, undertake high-caliber plyometric activities in small groups during training, and they should refrain from executing them too soon before significant events (about 7–10 days beforehand). For endurance athletes, they may still incorporate medium-to high-intensity drills into their low-intensity workouts or as part of their warm-up.

1.5.7 Volume and intensity

The recommended volume of specific jumps in a single session varies depending on the intensity and progression goals. For jumps on the spot or from a standing position, the volume should be measured in terms of foot contacts. As a general guide, a beginner may perform 60-100 foot contacts of low-intensity exercises in a single pre-season workout. An intermediate plyometrics exponent can do 100-150 foot contacts of low-intensity exercises in one workout and 100 moderate-intensity exercises in another. Meanwhile, an advanced athlete can perform 150-200 foot contacts of low-to-moderate intensity exercises in a single session. Intensity plays a vital role; the more dynamic the move and the greater the power generated, the fewer foot contacts required. As training phases progress, quality becomes crucial, and the number of foot contacts should be reduced. Optimum power and speed must govern the performance.

Bounding and hops are best measured in terms of sets and reps, distance covered, and whether they are performed from a standing start or with a run-on. Verhoshansky recommends incorporating a maximum of 5-10 bounds per set into a session with no more than 50-75 ground contacts. If a run-on is used, the number of reps should be reduced. For optimum sports-specific training effects, it is advisable that performers do not allow themselves to become fatigued. Resting between sets should be for 1-2 minutes. Successive depth jumps or drop jumps should be separated by intervals of at least 15-30 seconds, or even longer if very intense multiple hops and jumps routines are being performed. Such recovery intervals will allow the stretch reflex mechanism to return to optimum capability.

In terms of the number of sessions, 2-3 per week should suffice, but they should not be performed on consecutive days or 7-10 days before important competitions. Those new to this form of training may experience an initial decline in their performance until they become accustomed to the training method. It is essential to maintain consistent quality and gradually reduce the number of foot contacts as training progresses. This approach ensures that optimum power and speed are achieved, resulting in optimal performance.

1.6 Physical variables

Physical fitness is determined by various factors, and physical variables are just one of them. There are two primary groups of factors that determine physical fitness, which are linked to skills and health, respectively. The health-related components of fitness include flexibility, physical strength, muscular endurance, cardiovascular endurance, and body composition. On the other hand, the skill-related components of fitness are speed, power, agility, balance, coordination, and response time.

In this study, the investigator selected six physical variables, three physiological variables and one performance variables. These variables are closely related to the performance of triple jumpers.

1.6.1 Cardiovascular endurance

Endurance is essential in sports. Endurance testing evaluates an athlete's ability to perform prolonged physical activity. It measures the efficiency of their circulatory and respiratory systems in supplying oxygen to the working muscles. Aerobic endurance requires oxygen to generate energy, and the objective of endurance training is to develop and improve the body systems responsible for producing and delivering energy. Triple jumping requires robust cardiovascular endurance to ensure an adequate oxygen supply to the working muscles.

1.6.2 Muscular endurance

"Sports movements with the appropriate quality and speed can be performed even when fatigued" is the definition of endurance. It is the ability to work at the appropriate speed and quality even when exhausted. The ability to maintain endurance allows an athlete to perform at a high level during physical exercise and to recuperate from exhaustion rapidly. That is working on a task until it is completely finished. A popular exercise to gauge this quality is the bend-knee sit-up.

1.6.3 Flexibility

Flexibility is a valuable attribute that allows us to move with greater range and execute physical activities with ease. In the face of uncertainty in the world, physical fitness can give us the confidence to navigate challenging situations without tension or fear. Whether you're a bodyguard or just someone looking to maintain good health, physical fitness is strongly linked to rest, sleep, nutrition, exercise, and emotional and mental well-being. We can think of it as a source of organic energy and vitality that helps us feel better and move more gracefully in any direction. By prioritizing physical health, we can cultivate a sense of confidence and capability that can positively impact all areas of our lives.

1.6.4 Speed

The ability to execute motor actions within a specified time frame and under particular conditions is a fundamental prerequisite for optimal performance. The capacity to move at a specific pace is commonly referred to as speed and is influenced by the range of motion of the nervous system and muscles. The ability to achieve optimal performance requires the integration of these two components in a timely and efficient manner. Therefore, speed is a crucial factor that impacts the overall success of an individual's performance.

In order to excel in the triple jump, speed is a crucial factor, just as it is in the long jump. The disparity between the two events, however, lies in the amount of force that must be absorbed upon landing. The most elite male triple jumpers achieve take-off speeds of approximately 10 meters per second, while their female counterparts attain speeds of around 9 meters per second during the hop. Experts have estimated that the impact of a hop landing may require triple jumpers to absorb between 15-20 times their own body weight. If the force is not returned within milliseconds during contact, the leg can even break under such a load.

During the 2017 London World Championships, Christian Taylor, an exceptional triple jumper, only needed 0.15 seconds to absorb and return force from the hop to step and 0.184 seconds to jump. Even though she cleared the competition with a jump of 17.68 metres, these numbers show how the triple jump inevitably slows down throughout the jump phase.

Usually, the jumper spends longer time on the ground during landings as they go through the phases because they lose horizontal velocity. With ideal technique, approach speed, and highly focused conditioning, the best jumpers are able to limit speed loss.

Excellent flat speed is still necessary for the triple jumper; the faster the jumper can get off the ground, the faster they can step, jump and cover distance. In other words, there is more speed to lose for the speedier jumper. The take-off angles can have a significant impact on "phase speed." Said to skim like a stone tossed at a shallow angle across water, the finest triple jumpers are.

The triple jump style can have an impact. This is about accurate: the hop is executed at an angle of about 15 to 18 degrees, the step is taken off from an angle of about 15.5 degrees, and the jump is made from an angle of about 22 degrees. As said, when horizontal velocity is lost and vertical velocity increases, contact times increase for the step and most obviously for the jump.

1.6.5 Explosive power

The triple jump style can have an impact. This is about accurate: the hop is executed at an angle of about 15 to 18 degrees, the step is taken off from an angle of about 15.5 degrees, and the jump is made from an angle of about 22 degrees. As said, when horizontal velocity is lost and vertical velocity increases, contact times increase for the step and most obviously for the jump.

The lengthening part of the muscle is known as eccentric muscular action. It happens when the ankle, knee, and hip come into triple contact with the earth. In order to absorb the impact and lessen the downward force, a variety of muscles (as well as other soft tissues) stretch. The energy is then restored by concentric motions that shorten the muscles. To increase eccentric ability, there are several leaping and strength workouts available.

The ability to exert force in a short period of time is called explosive power. The triple jump shows explosive power during the jump. During a sprint, the muscles contract rapidly to produce the force needed to lift the body into the air. Players with more explosive power can fly higher and go horizontally with more power.

For triple jumpers, explosive strength is crucial because it can enhance performance in high-speed or high-power triple jump activities like running and leaping. For leaping and speed, this is crucial. In essence, a climber can run faster and leap higher if they have more energy.

1.6.6 Agility

Each jumping event requires agility, explosive power and speed. Jumping events can broken down into approach run, take off, flight and landing. Triple jump is the combination of all these events.

The third part of the third jump can be completed by using the momentum gathered during the build-up to achieve a flat-footed landing, sometimes called a "powerful" landing. When the foot hits the toe, the athlete's rhythm is disrupted because they lose balance and speed. Players who take a step and fall on their heels. This is because your hips are dropping, making it harder to maintain speed as you jump. Bruised heels are another result. It takes an expert person to perform the triple jump technique correctly and avoid injury. A triple jump with quick leg power can complete all three parts of the triple jump and land on top.

1.7 Physiological variables

Physiological variables are vital capacity, pulse rate and breath holding capacity.

1.7.1 Vital capacity

The total volume of air expelled following maximum inhalation. Depending on body type and age, the 4800 ml capacity varies. Tidal volume, inspiratory reserve volume, and expiratory reserve volume are added to determine it. After exhaling as much air as possible, an exhalation is the greatest amount of air that may be released. It has been demonstrated that frequent sports training enhances a person's quality of life.

The more air, especially oxygen, an athlete can inhale, the greater their lung capacity. Therefore, improving lung capacity improves endurance, allowing athletes to compete longer and without fatigue.

1.7.2 Pulse rate

A healthy heart does not beat its clocks at once. Our activities vary throughout the day and can be faster or slower to meet different health needs. "Normal" heart rate varies from person to person. At rest, the heart pumps less blood to keep the body healthy. It's 66 to 78 beats per minute, but for most healthy adults it's 55 to 75 beats per minute. Our breathing is healthy in many ways. Neck, inner elbows, hands, upper legs. This is probably the easiest and most reliable.

Place your index and middle fingers under the fat pad of your thumb. Be still and feel your potential. If you press too hard, it may slip. You can get an accurate number by counting the number of beats in 15 seconds and multiplying that number by 4. The best time to measure your resting respiratory rate is first thing in the morning, even before you get out of bed.

Exercise is a excellent way to reduce your resting breathing rate and increase your respiratory and aerobic capacity. Since your heart rate can't be sustained for more than a few minutes, physical therapists recommend aiming for a maximum heart rate during exercise.

1.7.3 Breath holding capacity

A person's typical breath hold time is between thirty and ninety seconds. Your physiology and genes determine how long you can hold your breath comfortably.

In the respiratory system, breath holding capacity (BHC) has been utilised as a ventilatory response indicator. This is comparable to the size of the lungs when you first begin to hold your breath, in part because it significantly affects the amount of oxygen stored. In good health, breathing exercises are possible. keeps lips healthy. Patients might strive to extend the amount of time they hold their breath by training once every hour. If you hold your breath for more than twenty-five seconds, it is deemed safe.

1.8 Triple Jump

Another name for the triple leap is the hop step hop. The competitor must launch, land on the same leg, then land on the following leg in opposition before landing in the pit. Numerous traits that the long jump exhibits throughout the approach are also present in this event. Regardless of where the distinctions stop, skilled triple jumpers will launch from a far flatter angle than those competing in the long jump. The technique of the triple leap may be broken down into five smaller sections. They are,

i) Acceleration
ii) Maximum Controllable Speed
iii) Take-off and the Hop
iv) The Step and
v) The Jump and Landing.

1.8.1 Acceleration

Starting from the front, the athlete will shift their weight to the back leg, putting most of their weight on it. Pushing out of this posture and "rocking" back over their front leg requires the athlete to swing their arms against their legs. Any force applied to the earth should be horizontal. Using the momentum from the rock to help with the start, the athlete might begin in this manner. In order to ensure an accurate approach, it helps to have a constant, dependable start.

1.8.2 Maximum controllable speed

When training for running, hill running, sprinting, and distance running, you may boost your speed. Keeping your hips in the same place during the leap is one of the most crucial parts of the speed involved.

1.8.3 The take-off and hop

Other than the heel to foot (rock) on the ground, there should be no noticeable difference between steps 1 and 2 of the approach. When your feet are on the ground, trying to walk is a great sign. In mobility, horizontal mobility is the key. Instead of consciously "cycling," prepare your leg for running by stretching your hamstrings. Eliminating foot cycling eases the transition to jumping speeds. The longest of the three phases is the leap period. Above all, you have to organize the steps and keep the horizontal momentum.

1.8.4 The step

It's critical to position the athlete to follow the movement. The majority of the work is done with routes and leaps in mind. To get gamers ready for this significant change, there are a few things they may do. Climbers need to have patience and pace themselves. Swinging the leg fully, like in the earlier phases, produces the finest contact.

1.8.5 The jump and landing

In order to achieve a successful jump, it is absolutely crucial for the athlete to make ground contact underneath their body at this point in the jump. Failure to do so will result in significant deceleration, hindering the athlete's ability to apply forces horizontally and ultimately undermining the success of the jump.

1.9 Physical variables and triple jump performance

The triple jump is an event that tests an athlete's ability to jump for distance by combining three phases - the approach, hop, and jump. The approach is the initial stage where the athlete builds up speed and momentum to prepare for the hop.

The hop, step, and jump technique used in triple jump requires time, patience, and practice to master. The athlete must have strong legs to execute the technique effectively. The triple jump is a unique combination of technique, form, and momentum, and explosive jumping power that requires speed and agility.

The take-off in the triple jump is similar to the long jump approach, with the goal being to generate enough speed to create momentum that will carry the athlete through the hop, step, and jump phases. During the hop phase, the athlete must fully extend their take-off leg to put their driving leg parallel to the ground. The take-off foot will be pulled up, and the driving leg will move from in front of the athlete's body to the back. This is when the take-off leg will be driven forward, and the athlete will use their arms to maintain balance.

When the thigh of the take-off leg is parallel to the ground, the athlete will maintain a flexed foot while the rest of the leg goes past the knee. The hop phase is crucial, as it sets the tone for the remaining phases of the triple jump. It requires not only physical strength but also mental focus and precision.

In conclusion, the triple jump is a challenging event that requires a combination of skills, strength, and technique. The athlete must be able to execute each phase of the jump with precision, while maintaining their speed, balance, and momentum.

The triple jump is a complex athletic endeavor that requires the athlete's power leg to extend explosively upon landing, while the opposite leg's thigh rises to waist level, and the arms pull the body upward and forward. It is essential that the athlete maintain their focus on a point beyond the pit and keep their chin up. At this point, the athlete's legs will be suspended under the core, with both knees bent and the arms positioned above the head. As the arms pull forward, the legs follow suit, driving the heels into the sand on landing.

To execute the triple jump successfully, an athlete must possess a robust core with mobility and flexibility. Developing strength and endurance is crucial to achieving this. Cardiovascular endurance training serves as the foundation of all training, as it strengthens the heart and lungs, which, in turn, supply sufficient nutrients and oxygen to all the active muscles. In particular, triple jumpers must have an efficient cardiovascular system.

Muscular endurance is another critical component of the triple jump. The strength and power of the muscles are paramount to executing the hop, step, and jump with great precision. To work under extreme conditions against resistance without getting fatigued, muscles must develop endurance.

The performance of a triple jumper is influenced by both speed and agility. During take-off, it's crucial to shift your feet and maintain agility. When running up for a triple leap, rhythm is crucial. Using the power leg on the take-off board ensures a precise take-off with the proper rhythm. The triple jump sequence includes the hop and jump. An athlete can hop and leap farther due to their explosive leg force. The explosiveness of the muscle produces a strong contractile force in the leg muscles. The muscular and neurological systems cooperate to send the neural impulse to the muscle. The skeletal muscle contracts forcefully to increase explosive power.

1.10 Physiological variables and triple jump performance

Structured sports training **(Mickleborough et al., 2010)** in athletes resulted in significant increase in strength, endurance, maximal power, and inspiratory muscle work capacity by influencing the breathing mechanics and improving oxygen consumption, ventilation, heart rate, blood lactate concentration, perceptual response during continuous exercise. (**Mackala et al., 2019)**

Sport training attenuates the perceptual response to maximal incremental exercise. **(Chang et al., 2021).** Researches proved that well planned physical training had a positive effect on athletic performance. (**Lemaitre et al., 2013).** Vital capacity, breath holding capacity are the indicators of lung‘s ability and capacity. Stronger lungs can uphold the athlete in the peak performance.

Larger vital capacity leads to efficient oxygen distribution in the body. Physically active athletes have stronger lungs and heart, which work harder to supply oxygen to the muscles. Regular exercise strengthens muscles, lungs, and heart, making the body more efficient at transporting oxygen to working muscles. This reduces the likelihood of athletes becoming short of breath during exercise over time.

The rate at which we inhale and exhale is controlled by the respiratory center, within the Medulla Oblongata in the brain. Inspiration occurs due to increased firing of inspiratory nerves and so the increased recruitment of motor units within the intercostals and diaphragm. Exhalation occurs due to sudden stop in impulses along the inspiratory nerves. Breathing rate is controlled by chemoreceptors within the main arteries which monitor the levels of oxygen and carbon dioxide within the blood. If oxygen saturation falls, ventilation accelerates to increase the volume of oxygen inspired. **(Shyamala Koley, 2020)** Triple jumpers‘ develops efficient neuromuscular coordination through regular training. Effective neuromuscular coordination coordinates with brain and lungs to supply sufficient oxygen to the muscle of triple jumpers.

Lung volume is fairly well predicted on the basis of age, height and weight, but lung volumes which are larger than predicted have been repeatedly observed in athletes compared to their control counterparts who are not engaged in any kind of regular physical exercise. Usually triple jumpers are tall which predicts that the jumpers are having good vital capacity, breath holding capacity and pulse rate.

Regular sports training enhances the function of heart and vascular system. Increased stroke volume and cardiac output causes the resting heart rate to be minimum. Normal resting heart rate results from the effective function of the cardiovascular system.

Triple jumpers muscle needs to have sufficient amount of nutrients, blood supply and oxygen for the effective functioning. Normal Resting heart rate of the jumpers assist to start the run up without stress. And, it helps to increase the speed to take powerful take-off during triple jump.

1.11 The rationale for the selection of the study

Plyometric training is used to improve strength, power, and speed. The improvement of all or one of these factors may help in enhancing the triple jumpers' performance. **(Pearson & Gehlsen, 1998)**

Plyometric training and water exercise training plays a role in improving muscular strength, agility, power, balance, physiological characteristics, and reducing the risk of injury. Hence, regular participation in progressive resistance and plyometric training program has the potential to positively influence several measurable health and fitness factors. It can provide an opportunity for aspiring young athletes to learn proper exercise technique, gain confidence in their abilities to be physically active, and receive basic education on program design, safety concerns, and healthy lifestyle choices that include proper nutrition and adequate sleep. Filled with the latest research and application of water exercises for athletic performance and injury prevention, plyometrics features exercises and drills are designed to improve footwork and basic movement skills ranging from beginning to advance.

Selected variables cardiovascular endurance, muscular endurance, flexibility, speed, explosive power, agility, vital capacity, pulse rate and breath holding capacity are contributing to the triple jump performance. Triple jump consists of a hop, a step and a jump. To initiate the hop athlete used to run from 20 meters to 35 meters to generate speed by increasing his velocity and acceleration. At the time of take off from the take-off board athlete needs to tap the board forcefully to make horizontal jump longer. Triple jumper needs explosive power on the legs.

The scholar was very much anxious in finding the effect of plyometrics and water exercise on the selected physical and physiological variables. The subject selected from Malapurram district of Kerala were in the age group of 15 to 17 years. As the research studies revealed there would be relationship between the plyometrics, water exercises with selected physical and physiological variables, triple jump performance. The scholar wished to find the degree of influence of plyometrics and water exercise training on the triple jump performance of boys. Definitely the results of the research study will help the coaches, trainers, physical education teachers and athletes to understand the concept of plyometrics and water exercises on selected physical, physiological and performance variables. During off season cardiovascular endurance, muscular endurance and vital capacity parameters are supporting the athlete to undergo the build-up training. Physiological variables selected for the study forms the base for the triple jumpers to undergo the strenuous sports training. Selected physiological variables promotes the blood supply, nutrients and oxygen supply to the working muscles to produce stronger reaction and reflexes. Heart and lungs of the triple jumper becomes strong and efficient through the regular water exercise training and plyometrics training. The scholar aimed to carry out the research study where minimum amount of work has been done previously. The research surely will enlighten the sports fraternity to adopt the training methods used in the study.

1.12 Statement of the problem

The purpose of the study was to investigate the effect of water exercises, plyometric exercises and a combination of both on selected physical variables, physiological variables and performance of triple jumpers.

1.13 Objectives of the study

1. To find out the effect of water exercises on selected physical and physiological variables and triple jump performance of boys.
2. To find out the effect of plyometric exercises on selected physical and physiological variables and triple jump performance of boys.

3. To find out the effect of combination of water exercises and plyometric exercises on selected physical and physiological variables and triple jump performance of boys.

4. To find out best training groups on selected physical and physiological variables of triple jump performance of boys.

1.14 Hypotheses

1. It was hypothesized that there would be significant difference on cardiovascular endurance between control group and experimental groups.

2. It was hypothesized that there would be significant difference on Muscular endurance between control group and experimental groups.

3. It was hypothesized that there would be significant difference on Flexibility between control group and experimental groups.

4. It was hypothesized that there would be significant difference on Speed between control group and experimental groups.

5. It was hypothesized that there would be significant difference on Explosive power between control group and experimental groups.

6. It was hypothesized that there would be significant difference on Agility between control group and experimental groups.

7. It was hypothesized that there would be significant difference on Vital capacity between control group and experimental groups.

8. It was hypothesized that there would be significant difference on Pulse rate between control group and experimental groups.

9. It was hypothesized that there would be significant difference on Breath holding capacity between control group and experimental groups.

10. It was hypothesized that there would be significant difference on Triple jump performance between control group and experimental groups.

11. It was hypothesized that there would be significant difference in the Physical variables of combination groups as compared to water and plyometric exercises groups.

12. It was hypothesized that there would be significant difference in the Physiological variables of combination groups as compared to water and plyometric exercises groups.

13. It was hypothesized that there would be significant difference in the Triple jump performance variables of combination groups as compared to water and plyometric exercises groups.

1.15 Operational definition and explanation of key terms

In the research study different dependent and independent variables are used. Definition and explanation of all the terms used in the study is given below;

1.15.1 Cardiovascular endurance

Cardiovascular fitness is the ability to exercise the entire body for extended periods of time without undue fatigue. A strong heart is necessary to supply oxygenated blood to the muscles of the body effectively. Refers to the ability of the body to perform prolonged, large muscle, dynamic exercise at moderate-to-high levels of intensity. Cardiovascular endurance is an important part of overall physical fitness. (**Haradayal Singh, 1991)**

1.15.2 Muscular endurance

Muscular endurance is the ability to continue contracting a muscle, or group of muscles, against resistance, such as weights or body weight, over a period of time. Increasing the performance of these muscles can assist the muscles to continue contraction and work against these forces. **(Patrick Hagerman, 2015)**

1.15.3 Flexibility

Flexibility is the ability of a joint to move through its complete range of motion. (**Franklin et al., 2009)**

1.15.4 Speed

Speed is the ability to execute any motor movements in shortest possible time. **(Haradayal Singh, 1991)**

1.15.5 Explosive power

Explosive power is the ability to produce a maximum amount of force in a very short period of time. (**David Sandler, 2005)**

1.15.6 Agility

Agility task is a rapid, whole-body change of direction or speed in response to a stimulus. Agility can be broken down into subcomponents made up of both physical and cognitive abilities. Change of direction speed involves straight sprinting speed and leg muscle qualities. Perceptual and decision making factors are achieved through visual scanning and anticipation, knowledge of situations and pattern recognition. (**Jaromir Simonek and Pavol Horicka, 2020)**

1.15.7 Vital capacity

It is the total amount of air exhaled after maximal inhalation. The value is about 4800mL and it varies according to age and body size. It is calculated by summing tidal volume, inspiratory reserve volume, and expiratory reserve volume. VC = TV+IRV+ERV. (**John E. Sarah J. Pearce, 2020)**

1.15.8 Pulse rate

Pulse rate, also known as heart rate, is the number of times heart beats per minute. Pulse rate of the normal adult is 66 to 78 beats per minute. Heart beats every minute of every day of our life. With each beat, heart pushes blood through blood vessels. Feeling of pulse is feeling this push of blood. (**Carol Ballard, 2011)**

1.15.9 Breath holding capacity

The longest instance of someone holding their breath without inhaling pure oxygen. Normal breath holding capacity of an adult is 30 seconds to 120 seconds. Holding breath for few seconds may also help to improve the health of cardiovascular system. **(Lutz Schneider, 2020)**

1.15.10 Water exercise

Performing any type of exercise in the water such as in a swimming pool is known as water exercise. The buoyancy of water is easier on the body and provides support for the athlete with weakness, balance problems or pain. Additionally, the viscosity of water slows movement and provides resistance during exercise, making aquatic exercise a great workout. **(Mimi Rodriguez Adami, 2002).**

1.15.11 Plyometric exercise

Plyometric exercises enable a muscle to reach maximal force in the shortest amount of time. They promote quick, powerful movements using a pre-stretch, or counter movement, involving something known as stretch shortening cycle. **(Neal Pire, 2006)**

1.15.12 Triple jump

Triple jump – a track and field even in which each contestant, after a running start, makes three consecutive jumps for total distance, landing after the first on the same foot used in the takeoff, after the second on the opposite foot, and after the third on both feet **(Webster's New World College Dictionary)**.

The triple jump consists of three different types of jumps that must be coordinated to produce the longest total distance. It consists of a hop, a long step, then a jump. For the hop, athletes must land on the same foot they used for take-off. For the step, they land on the opposite foot. For the jump, they land with both legs outstretched and together. The triple jump was an Olympic event for men in the first modern games in 1896. (**Housewright, 2010)**

1.16 Delimitations of the study

1. The study was delimited to 40 students of 15 - 17 years aged boys from Malappuram District, Kerala State, India
2. The study was delimited to12 weeks of observation period.
3. The study was further delimited to 6 physical variables and the testing was delimited to the ten mentioned against each variables
   - i. Cardiovascular endurance (1600 mts.)
   - ii. Muscular endurance (Sit ups in one minute)
   - iii. Flexibility (Sit & reach test)
   - iv. Speed (50 mts dash)
   - v. Explosive power (Standing broad jump)
   - vi. Agility (4x10 mts shuttle run)
4. The study was further delimited to the three physiological fitness variables
   - i. Vital Capacity (Wet Spirometer)
   - ii. Pulse Rate (Pulse rate in 1 minute)
   - iii. Breath holding capacity (Minutes 1/100 seconds)
5. The study was delimited to the following performance variable
   - i. Triple jump performance (Metre in centimetre).

1.17 Limitations of the study

The following were the limitations of the present study;

1. All subjects resided in their own home; the dietary and nutritional habits, daily habits, lifestyle and other activities were not under the control of the investigation.
2. Certain factors like habits, daily routine, work, diet, etc., may influence the results which are not considered in the study. The status and living habits of the subject cannot be controlled.
3. The subjects for the study do not come from the same socio-economic and cultural background. Socio-economic and cultural background were not taken into consideration.

1.18 Significance of the study

1. The study would be of great use to the physical educationist, coaches and athletes to identify the effect of water exercises on the triple jump performance.
2. The findings of the study will highlight the effect of plyometric exercises on the triple jump performance.
3. The result of the study will enlighten the physical education fraternity about the influence of water and plyometric exercise on selected physical variables.
4. This study will reveal the impact of water and plyometric exercises on the physiological variables.
5. The result of the study will highlight the best training methods to be adopted for the triple jump performance.

6. Findings of the study by using the boys in the age group of 15 to 17 years on their selected physical, physiological variables and triple jump performance can be applied on girls, college boys and girls.

7. The study will help to find out the best exercises for the triple jumpers. It may also lead to conduct further research by using greater sample with more training weeks.

8. The study will provide a feedback to the athlete and the means and methods to improve their performance.

9. The study will help the athlete, coaches and physical education teachers / trainers to inculcate with the knowledge of water and plyometric exercise effects on the physical, physiological variables and triple jump performance.

CHAPTER II

REVIEW OF RELATED LITERAURE

In any research work, a review of literature is most important that would facilitate the researcher in the finalization of the research problem. The main objective of the review of related literature is to understand the earlier research on the topic of the study. It is a measure to strengthen the present research.

2.1 Need for related literature

The review of literature is instrumental in the selection of the topic, formulation of hypothesis and deductive reasoning leading to the problem. It helps to get a clear idea and supports the finding with regard to the problem under study.

Literature review is comprehensive information of previous research on a topic .The related literature with regard to the present study was essential to have an insight into the work already done. Although very little research has been done in the area of triple Jump, water and plyometric training. The scholar with the available literature has gained valuable methodological hints from their procedures and findings, which were of great importance and help during the course of this study.

The researcher came across several books, periodicals and journals and published thesis, while searching for relevant facts and finding that were related to this present study, such as those were given below for the better understanding and to justify the study.

The related literatures were broadly classified into the following categories:

1. Studies on water exercise training
2. Studies on plyometric training
3. Studies on physical variables
4. Studies on physiological variables
5. Studies on performance variables

2.2 Studies related to water exercise training

Kim Y, Vakula MN, Waller B, Bressel E. (2020) determined Balance impairments are the leading causes of falls in older adults. Aquatic-based exercises have been broadly practiced as an alternative to land-based exercises; however, the effects on dynamic balance have not been comprehensively reviewed and compared to land exercises. Thus, the purpose of this systematic review and meta-analysis was to compare the effectiveness of aquatic exercises (AE) to land exercises (LE) on dynamic balance in older adults. Electronic databases (PubMed, MEDLINE, CINAHL, SPORTDiscus, psycINFO), from inception to November 2019, were searched. Studies met the following eligibility criteria: Randomized controlled trials, English language, older adults aged 65 years or older, a minimum of one AE and LE group, at least one assessment for dynamic balance. For the meta-analysis, the effect sizes of dynamic balance outcomes were calculated using a standardized mean difference (SMD) and a 95% confidence interval (CI). A total of 11 trials met the inclusion criteria, and 10 studies were eligible for the meta-analysis. The meta-analysis presented that older adults in AE groups demonstrated comparable enhancements in dynamic steady-state balance (SMD = - 0.24; 95% CI, -.81 to .34), proactive balance (SMD = - 0.21; 95% CI, -.59 to .17), and balance test batteries (SMD = - 0.24; 95% CI, -.50 to .03) compared with those in LE groups. AE and LE have comparable impacts on dynamic balance in older adults aged 65 years or older. Thus, this review provides evidence that AE can be utilized as a reasonable alternative to LE to improve dynamic balance and possibly reduce the risk of falls.

Heywood, Sophie, et al. (2019) study was conducted closed kinetic chain and plyometric exercises are commonly used in aquatic rehabilitation because they are believed to reduce joint loading whilst replicating functional tasks. However, the forces and relationship to land-based functional movement is unknown. This study aims to compare vertical ground reaction force during squats, calf raises and jumping in older adults with and without knee osteoarthritis on land and in water. Forty one participants (Healthy n = 21; Knee osteoarthritis n = 20; Age 68.5 (4.4) years) completed squats and calf raises at slow, medium and maximal speeds and jumping at maximal speed on land and in waist and chest depth water. Vertical ground reaction force and pain rating was measured in each environment. Force in all exercises was significantly greater on land than in chest depth water ($p < 0.005$). Peak force was significantly greater at maximal speed compared to slow speed ($p < 0.001$). The pattern of force in squats at slow speed in water was different to on land, with force highest at the start and end of the exercise and decreasing in the central phase. Pain ratings were significantly lower ($p < 0.001$) in water compared to on land in squats. Closed kinetic chain exercises offer inherently different loading in an aquatic environment. Body weight squats and calf raises in water could be defined as either neuromotor or low load, high velocity training. Maximal speed exercise in water produces higher relative load compared to slow speed and minimal pain providing an opportunity for clinicians to use greater speed to address power deficits.

Louder T, Dolny D, Bressel E. (2018) conducted a study aquatic environment provides a low-impact alternative to land-based exercise and rehabilitation in older adults. Evaluate the biomechanics of older adults and young adults performing jumping movements on land and in water. Fifty-six young adults (age = 22.0 [3.9] y) and 12 healthy older adults (age = 57.3 [4.4] y). Each participant performed 6 maximal effort countermovement jumps: 3 jumps were performed on land, and 3 other jumps were performed with participants immersed in chest-deep water. Using data from the amortization and propulsive phases of jumping, the authors computed the following kinetic and kinematic measures: peak and mean mechanical power, peak force, amortization time and rate, unweighting and propulsive times, and lower-extremity segment kinematics. Mechanical power outputs were greater in younger adults (peak: 7322 [4035] W) versus older adults (peak: 5661.65 [2639.86] W) and for jumps performed in water (peak: 9387 [3981] W) versus on land (peak: 4545.84 [1356.53] W). Peak dorsiflexion velocities were greater for jumps performed in water (66 [34] deg/s) versus on land (4 [7] deg/s). The amortization rate was 26% greater in water versus on land. The amortization time was 20% longer in older adults versus young adults. Countermovement jumps performed in water are mechanically specific from those performed on land. Older adults jumped with longer unweighting times and increased mechanical power in water. These results suggest that aquatic-based exercise and rehabilitation programs that feature jumping movements may benefit older adults.

Jurado-Lavanant, A., et al. (2018) this study was to compare the effects of land- vs. aquatic based plyometric training programs on the drop jump, repeated jump performance and muscle damage. Sixty-five male students were randomly assigned to one of 3 groups: aquatic plyometric training group (APT), plyometric training group (PT) and control group (CG). Both experimental groups trained twice a week for 10 weeks performing the same number of sets and total jumps. The following variables were measured prior to, halfway through and after the training programs: creatine kinase (CK) concentration, maximal height during a drop jump from the height of 30 (DJ30) and 50 cm (DJ50), and mean height during a repeated vertical jump test (RJ). The training program resulted in a significant increase (P<0.01–0.001) in RJ, DJ30, and DJ50 for PT, whereas neither APT nor CG reached any significant improvement APT showed likely/possibly improvements on DJ30 and DJ50, respectively. Greater intra-group Effect Size in CK was found for PT when compared to APT. In conclusion, although APT seems to be a safe alternative method for reducing the stress produced on the musculoskeletal system by plyometric training, PT produced greater gains on reactive jumps performance than APT.

Heywood, Sophie, et al. (2016) conducted an investigation Exercises replicating functional activities are commonly used in aquatic rehabilitation although it is not clear how the movement characteristics differ between the two environments. A systematic review was completed in order to compare the biomechanics of gait, closed kinetic chain and plyometric exercise when performed in water and on land. Studies were included where a functional lower limb activity was performed in water and on land with the same instructions. Standardized mean differences (SMD) and 95% confidence intervals were calculated for spatiotemporal, kinematic, force and muscle activation outcomes. 28 studies included walking or running (19 studies), stationary running (three), closed kinetic chain exercise (two), plyometric exercise (three) and timed-up and go (one). Very large effect sizes showed self-selected speed of walking (SMD >4.66) and vertical ground reaction forces (VGRF) (SMD >1.91) in water were less than on land, however, lower limb range of movement and muscle activity were similar. VGRF in plyometric exercise was lower in water when landing but more similar between the two environments in propulsion. Maximal speed of movement for walking and stationary running was lower in water compared to on land (SMD > 3.05), however was similar in propulsion in plyometric exercise. Drag forces may contribute to lower self-selected speed of walking. Monitoring speed of movement in water assists in determining the potential advantages or limitations of aquatic exercise and the task specificity to land-based function**.**

Fabricius, David Leslie (2011) Conducted this study was to compare the effectiveness of an aquatic- and land based plyometric programme upon selected, sport-specific performance variables in adolescent male, rugby union players. A group of 52 rugby players (age: 16.3 ± 0.8 years, height: 176 ± 6.9 cm and body mass: 76.1 ± 11.9 kg) were randomly assigned to one of three groups: aquatic group (n=18), land group (n=17), and a control group (n=17). Prior to and after the seven weeks of training, the power, agility and speed of participants were assessed by means of Fitrodyne repeated counter movement jumps, the Sergeant vertical jump, the Illinois agility test, a standing broad jump, and a 10- and 40- metre sprint. All three groups maintained their summer extra-curricular sport commitments during the intervention period. When the three groups were analyzed, no significant differences were found between the groups with regard to all tested performance variables. With regard to within group changes, the aquatic group improved significantly ($p<0.05$) in the Illinois agility test, performed to the right. The land group showed significant ($p<0.05$) improvements in peak concentric power during Fitrodyne repeated counter movement jumps. All groups reflected highly significant ($p<0.01$) improvements in the Sergeant vertical jump. None of the groups displayed any improvements in sprint speed. The control was the only group to improve significantly in the standing broad jump ($p<0.05$). Land-based plyometric training might be a functionally superior training modality for athletes, although aquatic plyometrics could also offer an effective training modality for performance enhancement in power-based sports such as rugby union football. Aquatic-based plyometrics should not completely replace land-based plyometrics, as it might not adequately develop the specific neuromuscular patterns or functional needs of explosive sports.

Jensen, Randall L. (2010). Examined drop jumps from 46 cm, a single leg jump, counter movement jump, and squat jump on a hard surface, wrestling mat and in water. Ground reaction force data obtained via a force platform were used to determine the time to takeoff, takeoff peak ground reaction force, power, jump height, and landing peak ground reaction force. A one way repeated measures ANOVA demonstrated differences between plyometic exercises assessed for all of the variables assessed ($P \leq 0.05$), with post hoc analysis demonstrating the specific differences. Results indicate that the hard surface and mat conditions were similar for almost all of the plyometric exercises assessed for most outcome variables whereas the plyometric exercises performed in water were different than those performed on the hard surface or mat in most cases.

Fifteen men and women (mean ± SD; age = 21.2 ± 2.2 years, height = 170.3 ± 6.5 cm; body mass = 68.81 ± 12.15 kg) who were familiar with and used the studied exercises served as subjects in this study. Subjects provided informed consent prior to participating in the study, which was approved by the institutional review board. Prior to the test subjects warmed up with at least 3 minutes of low intensity work on a cycle ergometer and stretched for approximately 12 seconds using one exercise for each major muscle group. Subjects then rested at least 5 minutes rest prior to beginning the test plyometric exercises. The test plyometric exercises included a drop jump (DJ) from 46 cm, single leg jump using the right leg (SLJ), counter movement jump (CMJ), and a squat jump (SJ), each performed in a randomly assigned order. A one minute rest interval was maintained between test plyometrics. The plyometric exercises were performed on a hard surface, mat, and in water. The hard surface condition included performing the plyometric exercises on a 2cm thick aluminum plate (76 X 102 cm) bolted directly to a force platform (OR6-5-2000, AMTI, Watertown, MA, USA). Attachment of the plate resulted in a natural frequency of not less than 142 Hz, within limits recommended for this system. For the mat condition, a section of 5 cm thick closed cell wrestling mat was attached to the surface of the force platform. The water condition included performing the plyometric exercises on a force platform (OR6-WP-2000, AMTI, Watertown, MA, USA) which was placed on the pool bottom at a depth of 140 cm. Ground Reaction Force data were collected at 1000 Hz, real time displayed and saved with the use of computer software (Net Force 2.0, AMTI, Watertown, MA, USA) for later analysis. Takeoff peak GRF, time to takeoff, power, jump height, and landing peak GRF were calculated from methods previously used.

Aquatic plyometrics are less intense which may lead to less chronic muscle soreness, plyometrics performed on a hard surface and a mat demonstrates similar take off and landing kinetics. Compared to plyometrics performed on hard surfaces and mats, plyometrics performed in water produce lower take off and landing ground reaction forces, slower times to take off, but produce elevated power and jump heights which may be falsely inflated due to flight time based equations.

Jakeman, J. R, R. Macrae, and R. Eston.(2009)This study was to examine the effectiveness of a single bout of cold-water immersion on recovery from exercise-induced muscle damage. Eighteen physically active female volunteers (age 19.9 (+/-0.97 years), height 1.66 (+/-0.05 m), mass 63.7 (+/-10 kg), completed 10 sets of 10 counter-movement jumps to induce muscle damage and were randomly allocated to a control or treatment group. The treatment group was given a single 10-min bout of lower limb cold-water immersion therapy at 10 degrees C immediately following damage-inducing exercise. Indicators of muscle damage (plasma creatine kinase activity, perceived soreness and maximal voluntary contraction of the quadriceps) were assessed immediately prior to counter-movement jumps, and at 1, 24, 48, 72 and 96 h, following the damaging exercise. Significant ($p = 0.05$) time effects were recorded on all indicators of muscle damage, but there were no significant group or group x time interaction effects found on any of the measured variables. The results indicate that a single bout of cold-water immersion after a damaging bout of exercise has no beneficial effects on the recovery from exercise-induced muscle damage.

Triplett, N. Travis, et al.(2009) study investigated the kinetic and the kinematic differences in female athletes in single-leg static jumps in an aquatic environment compared with those performed on dry land. Methods: Twelve healthy, junior national team handball players participated. Subjects completed a familiarization and a testing session. The subjects performed a series of single-leg jumps, dry land and aquatic with and without devices, which were randomized to avoid fatigue effects. Peak concentric force, rate of force development, impact force, and time of the jumps were determined using a force plate. Results: Peak concentric force and rate of force development were significantly (P G 0.05) higher in the aquatic jumps, whereas impact force was significantly (P G 0.05) lower. There was a shorter total jump time (P G 0.05) for the aquatic jump without devices, whereas the time required to reach peak force was not significantly different between the two environments, despite the greater resistance to movement in the aquatic medium. Aquatic jump exercises result in greater force production and rate of force development in the same amount of time with less impact and can thus offer a viable alternative to traditional dry-land jump exercises, which may also be beneficial for rehabilitating or aging populations. The benefits of this type of exercise include an exercise mode that can be performed without compromising speed while reducing the potential for joint injury.

Miller, Michael G., et al.(2007)study conducted to compare effects of chest- and waist-deep water aquatic plyometrics on average force, power and vertical jump. Methods: Twenty-nine male and female participants were assigned to either a control group or 1 of 2 aquatic groups (waist deep and chest deep) and participated in a 6-wk, twice per wk plyometric training program. Average force and power were measured on a force plate using 3 jumps: squat, countermovement, and drop jump. Vertical-jump heights were also recorded. A repeated-measures ANOVA was used to determine significant differences between testing and groups on average force, power and vertical jump. Results: No significant differences were found with average force and power with the squat, countermovement, and vertical jumps. There were significant changes in drop jump average in the control group from the pretest to posttest. Conclusions: With the water depths chosen and held constant, there appears to be no increased benefit in performance variables.

Martel, Gregory F., et al (2005) Conducted a study improve muscular strength, joint stability, and vertical jump (VJ) in athletes. Performance of aquatic plyometric training (APT) could lead to similar benefits, but with reduced risks due to the buoyancy of water. The purpose of this study was to examine the effects of APT on VJ and muscular strength in volleyball players. Nineteen female volleyball players (aged 15 +/- 1 yr) were randomly assigned to perform 6 wk of APT or flexibility exercises (CON) twice weekly, both in addition to traditional preseason volleyball training. Testing of leg strength was performed at baseline and after 6 wk, and VJ was measured at baseline and after 2, 4, and 6 wk. Similar increases in VJ were observed in both groups after 4 wk (APT = 3.1%, CON = 4.9%; both $P < 0.05$); however, the APT group improved by an additional 8% ($P < 0.05$) from week 4 to week 6, whereas there was no further improvement in the CON group (-0.9%; P = NS). After 6 wk, both groups displayed significant improvements in concentric peak torque during knee extension and flexion at 60 and 180 degrees x s(-1) (all $P < 0.05$). The combination of APT and volleyball training resulted in larger improvements in VJ than in the CON group. Thus, given the likely reduction in muscle soreness with APT versus land-based plyometrics, APT appears to be a promising training option.

Robinson, Leah E., et al. (2004) conducted a study compare changes in performance indicators (power, torque, and velocity) and muscle soreness between plyometric training on land and in water. Thirty-two college age women were randomly assigned to 8 weeks of an identical plyometric training program on land or in an aquatic setting. Performance indicators were assessed pretraining, midtraining, and post-training. Muscle soreness (ordinal scale) and pain sensitivity (palpation) were assessed after a training bout (0, 48, and 96 hours) during the first week of training and when training intensity was increased (weeks 3 and 6). Performance indictors increased for both groups (pretraining < midtraining < posttraining, p < or = 0.001). Muscle soreness was significantly greater in the land compared to the aquatic plyometric training group at baseline and each time training intensity was increased, $p = 0.01$. Aquatic plyometrics provided the same performance enhancement benefits as land plyometrics with significantly less muscle soreness.

Thein, Jill M., and Lori Thein Brody.(1998) study was conducted Elite athletes are competing for longer seasons, training more hours, and taking less time off. This schedule may predispose the elite athlete to overuse injuries. When an injury occurs, aquatic-based rehabilitation may expedite the recovery process, as effective cardiovascular and musculoskeletal training may be accomplished by aquatic exercise. The pool may be used both during rehabilitation and postrecovery as an adjunctive tool. Knowledge of the unique physical properties of water, as well as the physiological responses to immersion both at rest and during exercise, will aid the physical therapist when designing a rehabilitation or training program for the athlete. Understanding the principles of movement in water will provide a foundation for creative use of water's unique properties.

2.3 Studies related to plyometric training

Sammoud, Senda et al. (2019) study conducted Swimming performance can be improved not only by in-water sport-specific training but also by means of dry land-training (e.g., plyometric jump training [PJT]). This study examined the effects of an 8-week PJT on proxies of muscle power and swimming performance in prepubertal male swimmers. Participants were randomly allocated to a PJT group (PJT; n = 14; age: 10.3 ± 0.4 years, maturity-offset = -3±0.3) or a control group (CG; n = 12; age: 10.5 ± 0.4 years, maturity-offset = -2.8 ± 0.3). Swimmers in PJT and CG performed 6 training sessions per week. Each training session lasted between 80 and 90 minutes. Over the 8 weeks in-season training period, PJT performed two PJT sessions per week, each lasting between 25 to 30 minutes (~1 hour per week) in replacement of sport-specific swimming drills. During that time, CG followed their regular sport-specific swimming training (e.g., coordination, breathing, improving swimming strokes). Overall training volume was similar between groups. Pre- and post-training, tests were conducted to assess proxies of muscle power (countermovement-jump [CMJ]), standing-long-jump [SLJ]) and sport-specific swimming performances (15-, 25-, and 50-m front-crawl, 25-m kick without push [25-m kick WP], and 25-m front-crawl WP). No training or test-related injuries were detected over the course of the study. Between-group analyses derived from magnitude-based inferences showed trivial-to-large effects in favour of PJT for all tests (ES = 0.28 to 1.43). Within-group analyses for the PJT showed small performance improvements for CMJ (effect-size [ES] = 0.53), 25-m kick WP (ES = 0.25), and 50-m front crawl (ES = 0.56) tests. Moderate performance improvements were observed for the SLJ, 25-m front-crawl WP, 15-m and 25-m front-crawl tests (ES = 0.95, 0.60, 0.99, and 0.85, respectively). For CG, the within-group results showed trivial performance declines for the CMJ (ES=-0.13) and the 50-m front-crawl test (ES = -0.04). In addition, trivial-to-small performance improvements were observed for the SLJ (ES = 0.09), 25-m kick WP (ES = 0.02), 25-m front-crawl WP (ES = 0.19), 25-m front-crawl (ES = 0.2), (SLJ [ES = 0.09, and 15-m front crawl (ES = 0.36). Short-term in-season PJT, integrated into the regular swimming training, was more effective than regular swimming training alone in improving jump and sport-specific swimming performances in prepubertal male swimmers.

Louder, T, Bressel, E, Nardoni, C, and Dolny,(2019)This investigation was to evaluate the kinetics and kinematics of loaded countermovement jumps performed in water versus land. Twenty young men and 24 National Collegiate Athletic Association (NCAA) Division I female soccer and gymnastics athletes were asked to perform unloaded and loaded countermovement jumps on land and in chest-deep water immersion. A triaxial force platform and 2-dimensional videography produced various kinetic and kinematic measures of jump performance. Peak and mean mechanical power outputs (W) were 88% (8,919 ± 3,744 vs. 4,734 ± 1,418 W; $p < 0.001$) and 81% (3,640 ± 1,807 vs. 2,011 ± 736 W; $p < 0.001$) greater for jumps performed in water vs. land. Peak dorsiflexion velocity was 688% faster (44 ± 39 vs. 5.6 ± 5.4 degree·s; $p < 0.001$) for jumps performed in water and tended to model similarly with measures of mechanical power and amortization rate. Body weight normalized peak and mean mechanical power outputs decreased by 23.6 ± 2.7 and 23.8 ± 1.9% when load was added in the water. The addition of load on land was associated with an 8.7 ± 2.3 and 10.5 ± 4.4% decrease in body weight normalized peak and mean mechanical power. Results suggest that the aquatic environment alters movement primarily at amortization and may provide a unique training stimulus. Also, it can be concluded that fluid resistance and buoyancy combine to influence the mechanics of jumping movements performed in the water.

Held, Nicholas James, et al. (2019) study was conducted Plyometric exercises are often prescribed for enhancing athletic performance, however, this form of training can elicit significant skeletal loading which may defer practitioners from utilizing these exercises throughout rehabilitation. complete a systematic review to critically examine the efficacy of plyometric training performed in water when compared to land for eliciting changes in musculoskeletal markers of performance, and to provide evidence-based recommendations for practitioners on how best to utilize this form of training in rehabilitation and return-to-play.A systematic review was undertaken with relevant studies identified that compared changes in performance markers (e.g., strength, sprinting, and jumping) between the same aquatic- and land-based plyometric program were eligible for inclusion. Data was extracted using a standardized extraction form as confirmed by three reviewers. Data extraction included population characteristics, program design, and pre- and post- adaptations in strength, speed, and vertical jump. Eight studies were included comparing performance outcomes following aquatic- and land-based plyometric training. The results of this review suggest that aquatic plyometric training is as effective as land-based plyometric training at improving lower body strength, sprint, and vertical jump performance. The utilization of aquatic plyometric training can be an important piece of the rehabilitation and return-to-play process in order to improve lower body strength, speed, and power while reducing the physical stress of land-based plyometric training.

Sporri, Daniel, et al. (2018) study was conducted higher vertical stiffness is related to superior athletic performance, training has traditionally been aimed at augmenting this variable to enhance neuromuscular output. However, research has linked elevated stiffness with increased injury risk; therefore, this study examined the effect of a novel training intervention on vertical stiffness and athletic performance. Vertical stiffness, jump performance and athletic performance were assessed in two randomly allocated groups, prior to, and following, an eight-week period. One group was exposed to a training intervention involving aqua-based plyometrics ($n = 11$) over the 8 weeks while the other acted as a control group ($n = 9$). The training intervention involved hopping, jumping and bounding in water at a depth of 1.2m whilst control participants performed their normal training. There were no significant changes in vertical stiffness in either group. Countermovement jump height and peak power significantly increased within the aqua plyometric group ($p < 0.05$). Athletic performance markers improved in the aqua plyometric group as measured using an agility and a 5-bound test exhibiting superior values at the post-test ($p < 0.05$). The results suggest that an aqua plyometric training program can enhance athletic performance without elevating stiffness. The increase in athletic performance is likely due to a reduction in ground reaction forces created by the buoyancy of the water, causing a shorter amortization phase and a more rapid application of concentric force. The findings from this study can inform exercise professionals and medical staff regarding the ability to enhance neuromuscular performance without elevating vertical stiffness. This has implications for improving athletic performance while concurrently minimising injury risk.

Louder, Talin J., Cade J. Searle, and Eadric Bressel (2016) conducted a study that Plyometric jumping is a commonly prescribed method of training focused on the development of reactive strength and high-velocity concentric power. Literature suggests that aquatic plyometric training may be a low-impact, effective supplement to land-based training. The study was to quantify acute, biomechanical characteristics of the take-off and flight phase for plyometric movements performed in the water. Kinetic force platform data from 12 young, male adults were collected for counter-movement jumps performed on land and in water at two different immersion depths. The specificity of jumps between environmental conditions was assessed using kinetic measures, temporal characteristics, and an assessment of the statistical relationship between take-off velocity and time in the air. Greater peak mechanical power was observed for jumps performed in the water, and was influenced by immersion depth. Additionally, the data suggest that, in the water, the statistical relationship between take-off velocity and time in air is quadratic. Results highlight the potential application of aquatic plyometric training as a cross-training tool for improving mechanical power and suggest that water immersion depth and fluid drag play key roles in the specificity of the take-off phase for jumping movements performed in the water.

Asadi, Abbas, et al. (2016) To show a clear picture about the possible variables of enhancements of change-of-direction (COD) ability using longitudinal plyometric-training (PT) studies and determine specific factors that influence the training effects. A computerized search was performed, and 24 articles with a total of 46 effect sizes (ESs) in an experimental group and 25 ESsin a control group were reviewed to analyze the role of various factors on the impact of PT on COD performance. The results showed that participants with good fitness levels obtained greater improvements in COD performance ($P < .05$), and basketball players gained more benefits of PT than other athletes. Also, men obtained COD results similar to those of womenafter PT. In relation to the variables of PT design, it appears that 7 wk (with2 sessions/wk) using moderate intensity and 100jumps per training session with a 72-h rest interval tends to improve COD ability. Performing PT with a combination of different types of plyometric exercises such as drop jumps + vertical jumps + standing long jumps is better than 1 form of exercise. It is apparent that PT can be effective at improving COD ability. The loading parameters are essential for exercise professionals, coaches, and strength and conditioning professionals with regard to the most appropriate dose-response trends tooptimize plyometric-induced COD-ability gains.

Ramírez-Campillo, Rodrigo, David C. Andrade, and Mikel Izquierdo(2013) examine the effects of different volume and training surfaces during a short-term plyometric training program on neuromuscular performance. Twenty-nine subjects were randomly assigned to 4 groups: control group (CG, n = 5), moderate volume group (MVG, n = 9, 780 jumps), moderate volume hard surface group (MVGHS, n = 8, 780 jumps), and high volume group (HVG, n = 7, 1,560 jumps). A series of tests were performed by the subjects before and after 7 weeks of plyometric training. These tests were measurement of maximum strength (5 maximum repetitions [5RMs]), drop jumps (DJs) of varying heights (20, 40, and 60 cm), squat and countermovement jumps (SJ and CMJ, respectively), timed 20-m sprint, agility, body weight, and height. The results of the present study suggest that high training volume leads to a significant increase in explosive performance that requires fast stretch-shortening cycle (SSC) actions (such as DJ and sprint) in comparison to what is observed after a moderate training volume regimen. Second, when plyometric training is performed on a hard training surface (high-impact reaction force), a moderate training volume induces optimal stimulus to increase explosive performance requiring fast SSC actions (e.g., DJ), maximal dynamic strength enhancement, and higher training efficiency. Thus, a finding of interest in the study was that after 7 weeks of plyometric training, performance enhancement in maximal strength and in actions requiring fast SSC (such as DJ and sprint) were dependent on the volume of training and the surface on which it was performed. This must be taken into account when using plyometric training on different surfaces.

Benito Martínez, Elisa María, et al. (2013).study was counted to analyze the effects of training combining plyometrics (PT) and neuromuscular electrostimulation (ES) on speed training and triple jump. The study consisted on the application of an electrostimulation protocol and plyometric jumps to four groups of young athletes (C ontrol, G II, G III and G IV). Methods: Eighty-four young athletes took part in the study (40 girls and 44 boys). All of them were sprinters (100 and 200 meters dash, and 100 and 110 hurdles meters), their mean age, weight and height being 15.9±1.4 years old, 58.53±8.05 kg, and 1.68±0.07 m, respectively. After 8 weeks of training, a 30-meter sprint launched test time being measured by photoelectric cells and a triple jump test from static position were completed. Repeated measures ANC OVA were used. Results: The only group that improved significantly in the speed test ($P<0.001$) relative to the control group was G IV. In the triple jump test, improvements were significant, ($P<0.05$) and ($P<0.01$), in G II and G IV, respectively, relative to the control group. The results of ES + PT combined training offered no significant differences in either speed test and triple jump by gender. The most effective training aimed at improving the speed of 30 m is simultaneous combined training. Regarding triple jump, the results showed significant improvements in the performance of athletes who used both simultaneous combined training and used ES followed by plyometrics. However, no significant improvement was observed after PT training prior to ES.

Voelzke, Mathias, et al.(2012) exmanied short term training with resistance plus plyometric training (RT+P) or electromyostimulation plus plyometric training

(EMS+P) on explosive force production in elite volleyball players.Sixteen elite volleyball players of the first German division participated in a training study.The participants were randomly assigned to either the RT+P training group (n=8) or the EMS+P training group (n=8). Both groups participated in a 5-week lower extremity exercise program. Pre and post-tests included squat jumps (SJ), countermovement jumps (CMJ), and drop jumps (DJ) on a force plate. The three-step reach height (RH) was assessed using a custom-made vertec apparatus. Fifteen m straight and lateral sprint (S15s and S15l) were assessed using photoelectric cells with interims at 5m and 10m. RT+P training resulted in significant improvements in SJ (+2.3%) and RH (+0.4%) performance. The EMS+Ptraining group showed significant increases in performance of CMJ (+3.8%), DJ (+6.4%), RH (+1.6%), S15l (-3.8%) and after 5m and 10m of the S15s (-2.6%; -0.5%). The comparison of training-induced changes between the two intervention groups revealed significant differences for the SJ (p=0.023) in favor of RT+P and for the S15s after 5m (p=0.006) in favor of EMS+P. The results indicate that RT+P training is effective in promoting jump performances and EMS+P trainingincreases jump, speed and agility performances of elite volleyball players.

MacDonald, Christopher J., Hugh S. Lamont, and John C. Garner. (2012) conducted an investigation comparison of the effects of six weeks of traditional resistance training, plyometric training, and complex training on measures of strength and anthropometrics.Complex training (CT; alternating between heavy and lighter load resistance exercises with similar movement patterns within an exercise session) is a form of training that may potentially bring about a state of post activation potentiation, resulting in increased dynamic power (P_{max}) and rate of force development during the lighter load exercise. Such a method may be more effective than either modality, independently for developing strength. The purpose of this research was to compare the effects of resistance training (RT), plyometric training (PT), and CT on lower body strength and anthropometrics. Thirty recreationally trained college-aged men were trained using 1 of 3 methods: resistance, plyometric, or complex twice weekly for 6 weeks. The participants were tested pre, mid, and post to assess back squat strength, Romanian dead lift (RDL) strength, standing calf raise

(SCR) strength, quadriceps girth, triceps surae girth, body mass, and body fat percentage. Diet was not controlled during this study. Statistical measures revealed a significant increase for squat strength ($p = 0.000$), RDL strength ($p = 0.000$), and SCR strength ($p = 0.000$) for all groups pre to post, with no differences between groups. There was also a main effect for time for girth measures of the quadriceps muscle group ($p = 0.001$), the triceps surae muscle group ($p = 0.001$), and body mass ($p = 0.001$; post hoc revealed no significant difference). There were main effects for time and group × time interactions for fat-free mass % (RT: $p = 0.031$; PT: $p = 0.000$). The results suggest that CT mirrors benefits seen with traditional RT or PT. Moreover, CT revealed no decrement in strength and anthropometric values and appears to be a viable training modality.

Escamilla, Rafael F., et al.(2012) study was conducted throwing velocity is an important baseball performance variable for baseball pitchers, because greater throwing velocity results in less time for hitters to make a decision to swing. Throwing velocity is also an important baseball performance variable for position players, because greater throwing velocity results in decreased time for a runner to advance to the next base. This study compared the effects of 3 baseball-specific 6-weektraining programs on maximum throwing velocity. Sixty-eight high school baseball players 14-17 years of age were randomly and equally divided into 3 training groups and a nontraining control group. The 3 training groups were the Throwers Ten (TT), Keiser Pneumatic (KP), and Plyometric (PLY). Each training group trained 3 d·wk for 6 weeks, which comprised approximately 5-10 minutes for warm-up, 45 minutes of resistance training, and 5-10 for cool-down. Throwing velocity was assessed before (pretest) and just after (posttest) the 6-week training program for all the subjects. A 2-factor repeated measures analysis of variance with post hoc paired t-tests was used to assess throwing velocity differences ($p < 0.05$). Compared with pretest throwing velocity values, posttest throwing velocity values were significantly greater in the TT group (1.7% increase), the KP group (1.2% increase), and the PLY group (2.0% increase) but not significantly different in the control group. These results demonstrate that all 3 training programs were effective in increasing throwing velocity in high school baseball players, but the results of this study did not demonstrate that 1 resistance training program was more effective than another resistance training program in increasing throwing velocity.

De Villarreal, Eduardo Sáez, Bernardo Requena, and John B. Cronin.(2012) conducted a studymeta-analysis was to attempt to gain a clear picture of the magnitude of sprint performance improvements expected after chronic plyometric training (PT) and to identify specific factors that influence the treatment effects. Studies employing a PT intervention and containing data necessary to calculate effect size (ES) were included in the analysis. A total of 26 studies with a total of 56 ES met the inclusion criterion. Analysis of ES demonstrated that the strategies that seem to maximize the probability of obtaining significantly ($p < 0.05$) greater improvement in sprint performance included training volume for <10 weeks; a minimum of 15 sessions; and high-intensity programs with >80 combined jumps per session. To optimize sprint enhancement, the combination of different types of plyometrics and the use of training programs that incorporate greater horizontal acceleration (i.e., sprint-specific plyometric exercises, jumps with horizontal displacement) would be recommended, rather than using only one form of jump training ($p < 0.05$). No extra benefits were found to be gained from doing plyometrics with added weight. The loading parameters identified in this analysis should be considered by the professional sprinters and specialized trainers with regard to the most appropriate dose-response trends PT to optimized sprint performance gains.

Foure, Alexandre, et al.(2011) study conducted The aims of this study were to determine the effects of plyometric training on both active and passive parts of the series elastic component (SEC) stiffness, and on geometrical parameters [i.e., muscle architecture, muscle and tendon cross-sectional area (CSA)] of the plantarflexors muscle–tendon complex to assess possible specific adaptations of the elastic properties. Nineteen subjects were randomly divided into a trained group and a control group. Active and passive components of the SEC stiffness were determined using a fast stretch during submaximal voluntary isometric plantarflexor activity. Geometrical parameters of the *triceps surae* muscles and the Achilles tendon were determined using ultrasonography. A significant increase in the passive component of the SEC stiffness was found ($p < 0.05$). In contrast, a significant decrease in the active part of the SEC stiffness was observed ($p < 0.05$). No significant changes in plantarflexor muscles CSA, architecture and Achilles tendon CSA were seen ($p > 0.05$). Thus, plyometric training led to specific adaptations within each part of the SEC. Theses adaptations could increase both the efficiency of the energy storage–recoil process and muscular tension transmission leading to an increase in jump performances.

Donoghue, Orna A. Hirofumi Shimojo, and Hideki Takagi. (2011) conducted an investigation on landing kinetics during a range of typical lower limb plyometric exercises performed on land and in water. Eighteen male participants performed ankle hops, tuck jumps, a countermovement jump, a single-leg vertical jump, and a drop jump from 30 cm in a biomechanics laboratory and in a swimming pool. Land and underwater force plates (Kistler) were used to obtain peak impact force, impulse, rate of force development, and time to reach peak force for the landing phase of each jump. Significant reductions were observed in peak impact forces (33%-54%), impulse (19%-54%), and rate of force development (33%-62%) in water compared with land for the majority of exercises in this study ($P < 0.05$). The level of force reduction varies with landing technique, water depth, and participant height and body composition. This information can be used to reintroduce athletes to the demands of plyometric exercises after injury.

Arazi, Hamid, and Abbas Asadi. (2011). The study was to compare the effect of eight weeks of aquatic and land plyometric training on leg muscle strength, 36.5 and 60 meters sprint times, and dynamic balance test in young male basketball players. Eighteen young male basketball players (age=18.81±1.46 years, height=179.34±6.11 cm, body mass=67.80±9.52 kg, sport experience=4.8±2.47 years) volunteered in this study and divided to three groups; aquatic plyometric training (APT), land plyometric training (LPT) and control group (CON). Experimental groups trained; ankle jumps, speed marching, squat jumps, and skipping drills for eight weeks and 3 times a week for 40 min. The data were analyzed by one way analysis of variance with repeated measures, a Tukey post hoc testing and independent-sample t-test. The results showed there were not any significant differences between the APT and LPT groups in any of the variables tested (P>0.05). Significant increases were observed in posttraining both APT and LPT groups in 36.5-m and 60-m sprint times record compare to pretraining.

King, Jeffrey A., and Daniel J. Cipriani.(2010) Examined the evaluate whether frontal plane (FP) plyometrics, which are defined as plyometrics dominated with a lateral component, would produce similar increases in vertical jump height (VJH) compared to sagittal plane (SP) Plyometrics. Thirty-two junior varsity high-school basketball players participated in 6 weeks of plyometric training. Players participated in either FP or SP plyometrics for the entire study. Vertical jump height was measured on 3 occasions: pre intervention (baseline), at week 3 of preparatory training, and at week 6 of training. Descriptive statistics were calculated for VJH. A 2-way analysis of variance (ANOVA) with repeated measures was used to test the difference in mean vertical jump scores using FP and SP training modalities. Results showed a significant effect over time for vertical jump ($p< 0.001$). Moreover, a significant time by protocol interaction was noted ($p< 0.032$). A 1-way ANOVA demonstrated that only the SP group demonstrated improvements over time, in VJH, $p< 0.05$. The FP group did not improve statistically. The data from this study suggest that FP plyometric training did not have a significant effect on VJH and significant improvement in VJH was seen in subjects participating in SP plyometrics thus reinforcing the specificity principle of training. Study discovered both training modalities can improve power and quickness among basketball players.

Markovic, Goran, and Pavle Mikulic (2010) Study was conducted Plyometric training (PLY) is a very popular form of physical conditioning of healthy individuals that has been extensively studied over the last 3 decades. In this article, we critically review the available literature related to lower-body PLY and its effects on human neural and musculoskeletal systems, athletic performance and injury prevention. We also considered studies that combined lower-body PLY with other popular training modalities, as well as studies that applied PLY on non-rigid surfaces. The available evidence suggests that PLY, either alone or in combination with other typical training modalities, elicits numerous positive changes in the neural and musculoskeletal systems, muscle function and athletic performance of healthy individuals. Specifically, the studies have shown that long-term PLY (i.e. 3-5 sessions a week for 5-12 months) represents an effective training method for enhancing bone mass in prepubertal/early pubertal children, young women and premenopausal women. Furthermore, short-term PLY (i.e. 2-3 sessions a week for 6-15 weeks) can change the stiffness of various elastic components of the muscle-tendon complex of plantar flexors in both athletes and non-athletes. Short-term PLY also improves the lower-extremity strength, power and stretch-shortening cycle (SSC) muscle function in healthy individuals. These adaptive changes in neuromuscular function are likely the result of (i) an increased neural drive to the agonist muscles; (ii) changes in the muscle activation strategies (i.e. improved intermuscular coordination); (iii) changes in the mechanical characteristics of the muscle-tendon complex of plantar flexors; (iv changes in muscle size and/or architecture; and (v) changes in single-fiber mechanics. Our results also show that PLY, either alone or in combination with other training modalities, has the potential to (i) enhance a wide range of athletic performance (i.e. jumping, sprinting, agility and endurance performance) in children and young adults of both sexes; and (ii) to reduce the risk of lower-extremity injuries in female athletes. Finally, available evidence suggests that short-term PLY on non-rigid surfaces (i.e. aquatic- or sand-based PLY) could elicit similar increases in jumping and sprinting performance as traditional PLY, but with substantially less muscle soreness. Although many issues related to PLY remain to be resolved, the results of this review allow us to recommend the use of PLY as a safe and effective training modality for improving lower-extremity muscle function and functional performance of healthy individuals. For performance enhancement and injury prevention in competitive sports, we recommend an implementation of PLY into a well designed, sport-specific physical conditioning programme.

Lephart, Scott M., et al. (2005) determined to improve neuromuscular and biomechanical characteristic deficits in female athletes, numerous injury prevention programs have been developed and have successfully reduced the number of knee ligament injuries. However, few have investigated the neuromuscular and biomechanical changes following these training programs. It is also largely unknown what type of program is better for improving the landing mechanics of female athletes. To investigate the effects of an 8 week plyometric and basic resistance training program on neuromuscular and biomechanical characteristics in female athletes. Twenty seven high school female athletes participated either in a plyometric or a basic resistance training program. Knee and hip strength, landing mechanics, and muscle activity were recorded before and after the intervention programs. In the jump-landing task, subjects jumped as high as they could and landed on both feet. Electromyography (EMG) peak activation time and integrated EMG of thigh and hip muscles were recorded prior to (preactive) and subsequent to (reactive) foot contact. Both groups improved knee extensor isokinetic strength and increased initial and peak knee and hip flexion, and time to peak knee flexion during the task. The peak preactive EMG of the gluteus medius and integrated EMG for the gluteus medius during the preactive and reactive time periods were significantly greater for both groups. Basic training alone induced favorable neuromuscular and biomechanical changes in high school female athletes. The plyometric program may further be utilized to improve muscular activation patterns.

Cossor, Jodi M., Brian A. Blanksby, and Bruce C. Elliott (1999) this study examined the effects of a plyometric training program on freestyle tumble turns. Thirty-eight age group swimmers were assigned to a control group which swam 1.5 hours, three times per week for 20 weeks; or an experimental group which supplemented 1.25 hours of swimming with 15 minutes of plyometrics for the same time frame. The same coach conducted all swimming and plyometric sessions to ensure uniformity. Swimming performance was assessed from 50 m time. Freestyle turning performance was measured by 2.5 m round trip time (RTT), 5 m RTT, wall contact time and selected kinematic and kinetic variables associated with the turn. A Plyopower system was also used to test jump height and velocity. Repeated measures, multivariate analysis of variance showed no significant differences between the groups (pre-, mid- and post-intervention) over the period of the study for any swimming, kinetic or plyopower measures. Thus, equal benefits were derived from normal practice time in the water or land based plyometric exercises.

2.4 Studies related to physical variables

N. Jayakumar and J. Asath Ali Khan (2023) conducted an examination means to look at the impact of plyometric training and strength training on speed perseverance and essential limit among men basketball players. To accomplish the reason for the examination 45 (N=45) men basketball players as subjects from Chengalpattu region, Tamil Nadu, India matured between 17 to 21 years at arbitrary. Three groups with fifteen subjects each were chosen as experimental group A - plyometric training group, experimental group B - strength training group and group C - control group. The subjects were tried when the two months (8 weeks) of experimentation. The training protocol was trailed by appropriate warm up and cooling down regimens. For speed endurance 300 meters run and vital capacity peak flow measurement is used as test parameters. The information data from the experimental and control group with the underlying and final readings were analyzed statistically with analysis of variance (ANOVA). The level of confidence was fixed 0.05. After effect of the investigation plyometric training and strength training has showed better execution on speed endurance and vital capacity it showed better improvement.

M Mathiyazhagan and PJ Sebastian (2018) conducted a study to find out the effects of plyometric with functional training on selected physical fitness physiological and skill performance variables of intercollegiate male football players. To achieve the purpose of the study, forty intercollegiate men football players from AVVM Sri Pushpam College, Poondi, Tanjore, Tamilnadu and Adaikala Madha Arts and Science College Tanjore, Tamilnadu were selected as subjects (20 from each college). They were divided into two equal groups in which each group consisted of twenty subjects (n=20). Group-I was the experimental group and Group-II served as control group (CG). The experimental group underwent plyometric training along with their Functional Training for 12 weeks and control group was not engaged in any training other than their routine football training. The following are the criterion variables (a). Physical fitness variables namely speed, leg explosive power and agility, (b). Physiological variables namely vital capacity, resting pulse rate and breath holding capacity (c). Skill variables namely dribbling, shooting and passing. They were tested using standard test methods and instruments before and after training. In order to analyze the training effects of each group on the selected physical fitness, physiological and skill variables, "t" ratio was used. The findings of the study showed that there was a significant reduction in the resting pulse rate and there were significant improvements in the variables namely speed, agility, leg explosive power, vital capacity, breath holding capacity, dribbling, shooting and passing between pretest and post-test of the experimental group. There was no significant difference in all of the selected variables between pretest and post-test of the control group.

Usman T, K B Shenoy (2015) Plyometric exercises increase the speed of muscular contraction and elevates athletic prowess. The purpose of this study was to assess the effects of lower body plyometric training on vertical jump performance and pulmonary function in male and female collegiate volleyball players. Methods: The programme was conducted twice a week, for an 8- week period on a group of 120 male and female collegiate volleyball players, 18-22 years of age. The samples were divided into four equal groups. All the players were tested for vertical jump height (VJH), forced vital capacity (FVC), and forced expiratory volume in one second (FEV1), using Sargent jump test and pulmonary function test prior to starting the training programme. Assessments were done at the end of 2, 4, 6, and 8 weeks of training period. Result: The findings of the study showed significant change in vertical jump height, forced vital capacity, and forced expiratory volume in one second, at the end of 2 weeks onwards, and the highest response was obtained at the end of 8 weeks. The effect was significantly higher as compared to the control group ($P<0.05$), and male players showed greater improvement than females. Conclusion: From the study, it can be concluded that lower body plyometric training twice a week, for 8 weeks showed significant improvement in vertical jump performance and pulmonary function in both male and female collegiate volleyball players.

2.5 Studies related to physiological variables

I. John Parthiban & K.A. Ramesh (2020) explored to find out the land and aquatic plyometric training on vital capacity among college men athletes. For the purpose of the study, forty five (n=45) men college athletes from Pudukkottai, Tamilnadu, India during the year 2019-2020 were selected as subjects. Their ages were from 18 to 21 years. The selected participants were divided at random into three groups of fifteen each (n=15). Group-I underwent land plyometric training, group-II aquatic plyometric training, and group-II acted as control group. The duration of the training period was restricted to eight weeks and the number of sessions per week was confined to five. The selected variable vital capacity was assessed by wet spirometer. The data were collected prior to and immediately after the training period of twelve weeks. The data obtained from the experimental groups before and after the experimental period were statistically analyzed with analysis of covariance (ANCOVA). Whenever the 'f' ratio for adjusted post-test means was found to be significant, the scheffe's post hoc test was applied to determine the paired mean differences. The level of confidence was fixed at 0.05 level for all the cases. The results of the study showed that aquatic plyometric training group is better than land plyometric training group and control group on improving vital capacity.

The objective of the study was to investigate the significant effect of plyometric exercise intervention on haemoglobin and vital capacity of U-17 girl football players. Forty (N=40) girls football players who participated in National level leagues or competitions between 15 to 17 (M=16) years of age were randomly selected as the subjects of this study and designated as experimental and control groups. Only the experimental group was treated with plyometric exercises for 6 weeks (42 days) and the control group remained without giving specific training intervention except for regular football practices. The analysis of covariance (ANCOVA) was employed and tested at 0.05 level of confidence. There was found a significant improvement in haemoglobin level and vital capacity of U-17 girls football players. Therefore, it was evidenced that plyometric training is an effective means to develop high motor quality and make changes to the haematology and cardio-respiratory functions of players.

Patel Vijaybhai Devalbhai and Milan P. Patel (2020) The purpose of the study was to see the effect of Plyometric and Circuit Training on Selected Physiological Variables on school children. In order to draw an adequate representative sample, 150 boys from the 03 Schools Vasnda, Dist. Navsari were selected with age ranging between 14 to 16 years. Further they were divided into 3 groups of 50 each. The pretest of aspects of physical fitness was conducted on each group. Then, Group A was provided plyometric training and group–B, circuit training for 12 weeks. Group – C was accepted as the control group. Finally, the posttest was executed on all three groups. To test the effect of training on physiological variables following test were included for the present study Pulse Rate, Vital Capacity, Systolic Blood Pressure and Diastolic Blood Pressure. Results showed significant improvement in Pulse Rate and Vital Capacity of the subjects who participated in Plyometric and Circuit training compared to Control group, where as no significant improvement was seen in Systolic Blood Pressure and Diastolic Blood Pressure in the subject of Plyometric, Circuit and Control groups.

Rajaram Shankar (2019) conducted a study to find out the effect of plyometric training on vital capacity and resting plus rate in rowing sculling event players in Nasik city. The sample for the present study consists of 40 male state levels rowing sculling event players whose are practiced K.T.H.M. college boat clubs in Nasik. The subject are divided in two group i.e. control group (N=20) and experimental group (N=20) between the age group of 18 to 25 years. Plyometric exercises such as standing long jump, Side to side ankle hop, Hip twist ankle hop, Trunk rotation, Pull over pass, Power skipping, Split squat jump, Double leg trunk jump, Double leg hops, Incline push up depth jump, Alternate bounding with single arm action, Split pike jump, Standing long jump with sprint, Medicine ball backward throw, Stadium hops, Wave squat, Combination bounding with double arm action, Power drop etc. were given three times a week for eight weeks for experimental group and controlled group were given regular Rowing practice. To assess the vital capacity was measure on computerized spirometer and resting plus rate was measure on finger pulse oximeter test. This study shows that due to the plyometric exercises there is a significant improvement of experimental group in the vital capacity and resting plus rate of rowing sculling event players.

Physiological stress induced by intense exercise is associated with energy substrate depletion, hyperthermia, mechanical muscle damage, oxidative stress, inflammation and nervous system fatigue. The resulting symptoms manifest as reduced performance potential, likely due to increased muscle soreness and decreased muscle function,2 disturbed muscle position sense and reaction time3 as well as increased stiffness and swelling that can last for several days.4 The aetiology of reduced performance potential will vary depending upon the exact physiological stress being recovered from. For example, eccentric exercise is associated with a large mechanical stress and relatively low metabolic cost,5 whereas intermittent sprint exercise may involve both a large mechanical stress and a heightened metabolic cost.6 It is possible that the underlying time course of recovery between different exercise stressors is different, and this consequently may influence how recovery strategies could be implemented. For the purpose of this review, exercise will be subdivided into two categories: ‘eccentric exercise’ that refers to the stress caused from exercise incorporating high mechanical stress (eg, eccentric contractions) and ‘high-intensity exercise’ that refers to stress caused from exercise with a high metabolic cost as well as some elements of eccentric muscle contractions.

Nagle, Elizabeth F., Mary E. Sanders, and Barry A. Franklin. (2017) study was conducted High-intensity interval training (HIIT) has emerged as an attractive alternative to traditional continuous exercise training (CT) programs for clinical and healthy populations who find that they can achieve equal or greater fitness benefits in less time. Land-based HIIT may not be an appropriate choice for some participants. Few studies have explored the acute responses and chronic adaptations of HIIT in an aquatic environment, and no study has compared the cardiometabolic responses of an aquatic-based program to a land-based HIIT program. Shallow-water aquatic exercise (AE) programs utilizing HIIT have elicited comparable and, in some cases, greater physiological responses compared with constant-intensity or continuous AE regimens. Factors that may explain why HIIT routines evoke greater cardiometabolic responses than CT protocols may be based on the types of exercises and how they are cued to effectively manipulate hydrodynamic properties for greater intensities. Favorable aquatic HIIT protocols such as the S.W.E.A.T. system may serve as a beneficial alternative to land-based HIIT programs for clinical and athletic populations, potentially reducing the likelihood of associated musculoskeletal and orthopedic complications. Hence, the purpose of this review is to examine the role of AE as an alternative safe and effective HIIT modality.

Sakti Ranjan Mishra, Palas Biswas, Dhananjoy Banerjee (2016) conducted a study was to compare the effect of Plyometric Training and Circuit Training on selected physiological variables such as Vital Capacity, Resting Heart Rate and Resting Respiratory Rate. Ninety professional trainees, age ranging between 20 to 23 years acted as subjects and assigned to three groups (two experimental and one control group) with 30 students each. The two experimental groups were Circuit Training and Plyometric Training groups. Selected physiological variables were measured before and after training. All the experimental Groups (Circuit training and Plyometric training) were administered with the selected exercises, thrice in a week for a duration of 12 weeks under direct supervision of the researcher. The analysis of data revealed that the two experimental groups, showed significant gains in performance of selected physiological variables after administration of training for duration of 12 weeks. The control group did not show any significant increase in the performance.

Leeder, Jonathan, et al. (2012) conducted an ingestion Elite-level athletic training and competition is accompanied by the recovery of a series of physiological stressors. The physiological stress will vary considerably depending upon the specific exercise type, duration and intensity and also on the athletes' familiarization to the exercise insult. It is well documented that when the exercise stress incorporates a novel eccentric component or the exercise is of considerable intensity or duration,1 athletes will likely experience numerous signs and symptoms of fatigue and cellular disturbance that have the potential to reduce performance.

Y Hutzler 1, A Chacham, U Bergman, A Szeinberg (1998). Conducted swimming and aquatic exercise are known for their effects on respiration in normal and asthmatic people. Thepurpose of the present study was to evaluate the effect of a 6-month movement and swimming program on the respiratory function and water orientation skills of children with cerebral palsy (CP). Forty-six kindergarten children aged 5 to 7 years were assigned either to a treatment or control group. The intervention program consisted of swimming sessions twice weekly and sessions of group physical activity in a gym once weekly, each session lasting 30 minutes, for a period of 6 months. Children in the control group were treated (30 minutes, 4 days per week) with Bobath physical therapy. The children in the treatment and control groups had comparable disability types, age, and anthropometric measurements. A 2 x 2 (group x test period) repeated measures ANOVA design confirmed a significant effect of interaction of time with group. The results also confirmed that children with CP have reduced lung function compared with normative data for children in the same age category. The treatment program improved baseline vital capacity results by 65%, while children in the control group improved by only 23%. The movement and swimming exercise program had a better effect than a physical therapy routine implemented in a previous study, consisting of respiratory exercise alone.

2.6 Studies related to performance variables

Horgan BG and et.al., (2022) conducted a study on Acute inflammatory, anthropometric, and perceptual (muscle soreness) effects of post resistance exercise water immersion in junior international and subelite male volleyball athletes. J Strength Cond Res 36(12): 3473-3484, 2022-Athletes use water immersion strategies to recover from training and competition. This study investigated the acute effects of postexercise water immersion after resistance exercise. Eighteen elite and subelite male volleyball athletes participated in an intervention using a randomized cross-over design. On separate occasions after resistance exercise, subjects completed 1 of 4 15-minute interventions: control (CON), cold water immersion (CWI), contrast water therapy (CWT), or hot water immersion (HWI). Significance was accepted at $p \leq 0.05$. Resistance exercise induced significant temporal changes (time effect) for inflammatory, anthropometric, perceptual, and performance measures. Serum creatine kinase was reduced ($g = 0.02$-0.30) after CWI ($p = 0.007$), CWT ($p = 0.006$), or HWI ($p < 0.001$) vs. CON, whereas it increased significantly ($g = 0.50$) after CWI vs. HWI. Contrast water therapy resulted in significantly higher ($g = 0.56$) interleukin-6 concentrations vs. HWI. Thigh girth increased ($g = 0.06$-0.16) after CWI vs. CON ($p = 0.013$) and HWI ($p < 0.001$) and between CWT vs. HWI ($p = 0.050$). Similarly, calf girth increased ($g = 0.01$-0.12) after CWI vs. CON ($p = 0.039$) and CWT ($p = 0.018$), and HWI vs. CON ($p = 0.041$) and CWT ($p = 0.018$). Subject belief in a postexercise intervention strategy was associated with HSP72 ("believer">"nonbeliever," $p = 0.026$), muscle soreness ("believer">"nonbeliever," $p = 0.002$), and interleukin-4 ("nonbeliever">"believer," $p = 0.002$). There were no significant treatment × time (interaction effect) pairwise comparisons. Choice of postexercise water immersion strategy (i.e., cold, contrast, or hot) combined with a belief in the efficacy of that strategy to enhance recovery or performance improves biological and perceptual markers of muscle damage and soreness. On same or subsequent days where resistance exercise bouts are performed, practitioners should consider athlete beliefs when prescribing postexercise water immersion, to reduce muscle soreness.

Elisa Dell'Antonio, et.al., (2022) aimed to analyze the effect of aquatic plyometric training (APT) on jump performance in volleyball players. Twelve female athletes (16.6 ± 0.9 years) were assessed through the following jump tests: spike height (SH), squat jump (SJ), countermovement jump (CMJ) and CMJ with an arm swing (CMJA). Jump height in each test and the eccentric utilization ratio (EUR) were the outcome measures. APT consisted of sets of drop jumps for 6 weeks (2 sessions/week) at a water depth of 0.75 m. Tests were performed at the beginning of a five-week pre-season period, before and after APT, and four weeks later for the follow-up. Repeated measures ANOVAs were used to analyze data and Hedges' g to estimate effect size (ES). Performance of all jumps did not change from baseline to Pre-APT. Performance improved in SH ($p < 0.001$, ES: 1.09), the SJ ($p = 0.045$, ES: 0.76) and the CMJA ($p < 0.001$, ES: 0.78) after APT when compared to Pre-APT. No changes were observed after the follow-up period. In conclusion, including six weeks of APT in the training routine of youth volleyball players improved performance of a sport-specific task (SH), the SJ and CMJA, with gains preserved after a four-week follow-up.

Rodrigo Ramirez-Campillo, et. al., (2021) aimed to examine the effects of plyometric jump training (PJT) on measures of physical fitness in amateur and professional volleyball players. A systematic electronic literature search was carried out in the databases PubMed, MEDLINE, Web of Science, and SCOPUS. Controlled studies including pre-to-post intervention tests of physical fitness and involving healthy volleyball players regardless of age and sex were considered. A random-effects model was used to calculate effect sizes (ES) between intervention and control groups. Moderator analyses considered programme duration, training frequency, total number of training sessions and jumps, participants' sex, age, and expertise level. The Physiotherapy Evidence Database scale was used to assess the methodological quality of the included studies. Eighteen moderate-to-high quality (median of 5 PEDro points) studies were eligible, comprising a total of 746 athletes. None of the included studies reported injuries related to the PJT intervention. The main findings showed small-to-moderate effects ($p < 0.05$) of PJT on linear sprint speed (ES = 0.70), squat jump (ES = 0.56), countermovement jump (CMJ) (ES = 0.80), CMJ with arm swing (ES = 0.63), drop jump (ES = 0.81), and spike jump height (ES = 0.84). Sub-analyses of moderator factors included 48 data sets. Only age had a significant effect on CMJ performance. Participants aged ≥16 years achieved greater improvements in CMJ performance compared to <16 years old (ES = 1.28 and 0.38, respectively; p = 0.022). No significant differences (p = 0.422) were identified between amateur (ES = 0.62) and professional volleyball players (ES = 1.01). In conclusion, PJT seems safe and is effective in improving measures of physical fitness in amateur and professional volleyball players, considering studies performed in both male and female.

The examination (**Usman T, K B Shenoy, 2015).**means to look at the impact of plyometric training and tabata training on speed perseverance and essential limit among men volleyball players. To accomplish the reason for the examination 45 (N=45) men volleyball players as subjects from Sivagangai region, TamilNadu, India matured between 17 to 21 years at arbitrary. Three groups with fifteen subjects each were chosen as experimental group A-plyometric training group, experimental group B-tabata training group and group C-control group. The subjects were tried when the two months (8 weeks) of experimentation. The training protocol was trailed by appropriate warm up and cooling down regimens. For speed endurance 300 meters run and vital capacity peak flow measurement is used as test parameters. The information data from the experimental and control group with the underlying and final readings were analyzed statistically with analysis of variance (ANOVA). The level of confidence was fixed 0.05. After effect of the investigation plyometric training and tabata training has showed better execution on speed endurance and vital capacity it showed better improvement.

Jeremy M Sheppard (2011) conducted a research study on assisted jumping may be useful in training higher concentric movement speed in jumping, thereby potentially increasing the jumping abilities of athletes. The purpose of this study was to evaluate the effects of assisted jump training on counter-movement vertical jump (CMVJ) and spike jump (SPJ) ability in a group of elite male volleyball players. Seven junior national team volleyball players (18.0±1.0 yrs, 200.4±6.7 cm, and 84.0±7.2 kg) participated in this within-subjects cross-over counter-balanced training study. Assisted training involved 3 sessions per week of CMVJ training with 10 kg of assistance, applied through use of a bungee system, whilst normal jump training involved equated volume of unassisted counter-movement vertical jumps. Training periods were 5 weeks duration, with a 3-week wash-out separating them. Prior to and at the conclusion of each training period jump testing for CMVJ and SPJ height was conducted. Assisted jump training resulted in gains of 2.7±0.7 cm ($p<0.01$, ES=0.21) and 4.6±2.6 cm ($p<0.01$, ES=0.32) for the CMVJ and SPJ respectively, whilst normal jump training did not result in significant gains for either CMVJ or SPJ ($p=0.09$ and $p=0.51$ respectively). The changes associated with normal jump training and assisted jump training revealed significant differences in both CMVJ and SPJ (p=<0.03) in favour of the assisted jump condition, with large effect (CMVJ, ES=1.22; SPJ, ES=1.31). Assisted jumping may promote the leg extensor musculature to undergo a more rapid rate of shortening, and chronic exposure appears to improve jumping ability.

Robert U Newton (2006) conducted study on anecdotal and research evidence is that vertical jump performance declines over the competitive volleyball season. The purpose of this study was to evaluate whether a short period of ballistic resistance training would attenuate this loss. Fourteen collegiate women volleyball players were trained for 11 weeks with periodized traditional and ballistic resistance training. There was a 5.4% decrease ($p < 0.05$) in approach jump and reach height during the traditional training period (start of season to midseason), and a 5.3% increase ($p < 0.05$) during the ballistic training period (midseason to end of season), but values were not different from start to end of season. These changes in overall jump performance were reflective of changes in underlying neuromuscular performance variables: in particular, power output and peak velocity during loaded jump squats, countermovement jumps, and drop jumps. During the first 7 weeks of traditional heavy resistance training, it appears that the neuromuscular system is depressed, perhaps by the combination of training, game play, and skills practice precluding adequate recovery. Introduction of a novel training stimulus in the form of ballistic jump squats and reduction of heavy resistance training of the leg extensors stimulated a rebound in performance, in some cases to exceed the athlete's ability at the start of the season. Periodization of in-season training programs similar to that used in this study may provide volleyball players with good vertical jump performance for the crucial end-of-season games.

Gregory F Martel (2005) conducted a study on land-based plyometrics can improve muscular strength, joint stability, and vertical jump (VJ) in athletes; however, due to the intense nature of plyometric training, the potential for acute muscle soreness or even musculoskeletal injury exists. Performance of aquatic plyometric training (APT) could lead to similar benefits, but with reduced risks due to the buoyancy of water. Unfortunately, there is little information regarding the efficacy of APT. Thus, the purpose of this study was to examine the effects of APT on VJ and muscular strength in volleyball players. Nineteen female volleyball players (aged 15 +/- 1 yr) were randomly assigned to perform 6 wk of APT or flexibility exercises (CON) twice weekly, both in addition to traditional preseason volleyball training. Testing of leg strength was performed at baseline and after 6 wk, and VJ was measured at baseline and after 2, 4, and 6 wk. Similar increases in VJ were observed in both groups after 4 wk (APT = 3.1%, CON = 4.9%; both $P < 0.05$); however, the APT group improved by an additional 8% ($P < 0.05$) from week 4 to week 6, whereas there was no further improvement in the CON group (-0.9%; P = NS). After 6 wk, both groups displayed significant improvements in concentric peak torque during knee extension and flexion at 60 and 180 degrees x s(-1) (all $P < 0.05$). The combination of APT and volleyball training resulted in larger improvements in VJ than in the CON group. Thus, given the likely reduction in muscle soreness with APT versus land-based plyometrics, APT appears to be a promising training option.

R U Newton (1999) determined whether ballistic resistance training would increase the vertical jump (VJ) performance of already highly trained jump athletes. Sixteen male volleyball players from a NCAA Division I team participated in the study. A Vertec was used to measure standing vertical jump and reach (SJR) and jump and reach from a three-step approach (AJR). Several types of vertical jump tests were also performed on a Plyometric Power System and a forceplate to measure force, velocity, and power production during vertical jumping. The subjects completed the tests and were then randomly divided into two groups, control and treatment. All subjects completed the usual preseason volleyball on-court training combined with a resistance training program. In addition, the treatment group completed 8 wk of squat jump training while the control group completed squat and leg press exercises at a 6RM load. Both groups were retested at the completion of the training period.

The treatment group produced a significant increase in both SJR and AJR of 5.9+/-3.1% and 6.3+/-5.1%. respectively. These increases were significantly greater than the pre- to postchanges produced by the control group, which were not significant for either jump. Analysis of the data from the various other jump tests suggested increased overall force output during jumping, and in particular increased rate of force development were the main contributors to the increased jump height. These results lend support to the effectiveness of ballistic resistance training for improving vertical jump performance in elite jump athletes.

2.7 Summary of the literatures

The review of literature helped the scholar to spot out relevant topics and variables. Further the literature helps the scholar to frame the suitable water exercise and plyometric training leading to the problems. The latest literature also helped the scholar to support his findings with regard to the problem. Further the literature collected in the study will also help the research scholar to have understanding in the similar areas. All the research studies were presented in the section proves that the water exercise training and plyometric training programme contribute significantly for better development of selected depended variables such as (cardiovascular endurance, muscular endurance, flexibility, speed, explosive power, agility, vital capacity, pulse rate and Breath holding time, triple jump performance)

Based on the experience the scholar gained, the scholar selected the suitable methodology to be followed in this research, which is presented in Chapter III.

CHAPTER III

METHODOLOGY

This chapter outlines how research has been carried out. This chapter deals with the selection of subjects, experimental design, orientation of the subjects, selection of variables, pilot study, selection of the tests, tools used for the study, reliability of the test, variables for the study, weekly workout schedule of water exercises training, plyometric exercises training and combination of water exercises and plyometric exercises training programmes and statistical analysis.

3.1 Selection of subjects

The scholar selected 40 (N=40) triple jumpers as subjects in the study to achieve the purpose from Malappuram district, Kerala, India. The age of the subjects ranged from 15 years to 17 years. The subjects were assigned to four groups of 10 each one control and three experimental groups. Experimental group I was denoted as water exercises training group (WEG), experimental group II was denoted as plyometric exercises training group (PMG), experimental training group III was denoted as combination of water and plyometric exercises training group (COG) and one control group was denoted as (CNG).

3.2 Selection of variables

The variables were selected by reviewing and studying related literature in detail. A feasible analysis on which of the important variables would be taken for the investigation were made in consultation with supervisor and experts keeping in mind the availability of equipment, acceptability of subject and the suitable time that would be devoted for the test as well as to keep the entire study integrated. Standardized test items were used to test the selected dependent variables.

3.3 Dependent variables

The following variables were selected as dependent variables.

3.3.1 Physical variables

i. Cardiovascular endurance

ii. Muscular endurance

iii. Flexibility

iv. Speed

v. Explosive power

vi. Agility

3.3.2 Physiological variables

i. Vital Capacity

ii. Pulse Rate

iii. Breath holding capacity

3.3.3 Performance Variable

i. Triple jump performance

3.4 Independent variables

The standard of sports is gaining momentum day by day. New records are coming into existence at the national and international levels. It is all because of technical as well as tactical training to compete with advanced sports countries. It will only be possible if the athletes and games are given advanced training in the field of physical education and sports. It is only possible with the help of research of high quality **(Sharma, 1997)**.

Numerous references are supporting that any form of systematic training would be an effective programme to improve performance. Regular plyometric training increases power by improving the capacity of the muscles and tendons to capture elastic energy and by enhancing the efficiency of communication between the brain and the muscles.

Water exercises are best in the development of endurance of the athlete as well as it strengthen the joints. Plyometric training exercises foster speed and agility and can improve VO2 max and vital capacity. Plyometrics and water exercises are positively associated with athletic performance **(Coetzee, 2007).**

Independent variables of the study were three types of training.

- Water exercises training
- Plyometric exercises training
- Combination of water and plyometric exercises training

3.5 Selection of tests

Table 1

List of selected variables, test and criterion measures

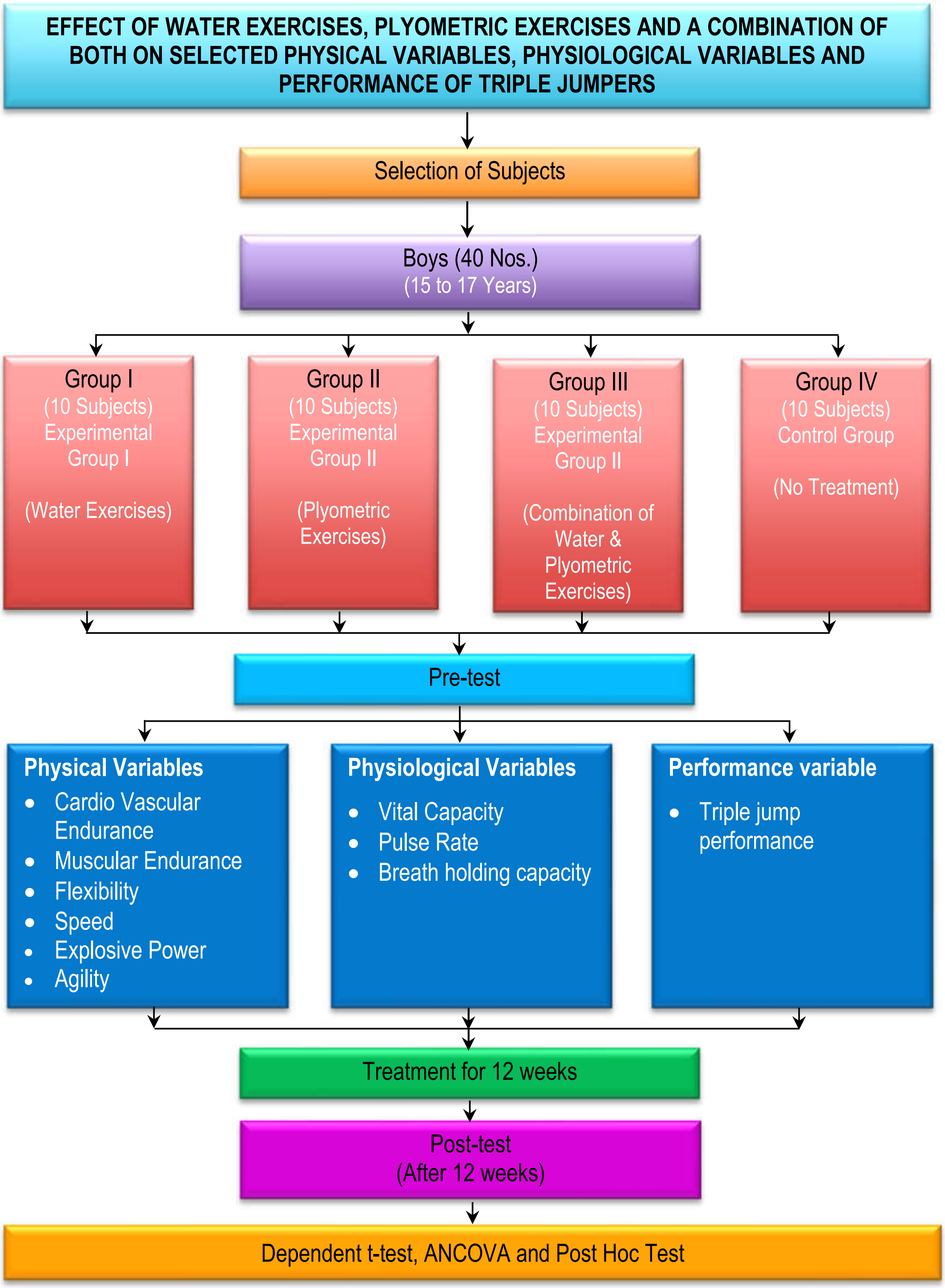
Sl No	Variables	Tests	Criterion Measures
		Physical Variables	
1	Cardiovascular Endurance	1600 Mts Run/ test	Minute 1/100 Seconds
2	Muscular Endurance	Bent Knee Sit-Ups	1 Minute
3	Flexibility	Sit and Reach test	In centimetres
4	Speed	50 mts. Dash	1/100 Seconds
5	Explosive Power	Standing Broad Jump	In centimetres
6	Agility	Shuttle Run	1/100 Seconds
		Physiological Variables	
7	Vital Capacity	Wet Spirometer	Litres
8	Pulse Rate	Pulse rate in 1 minute	Counts
9	Breath holding capacity	Minute 1/100 seconds	Counts
		Performance Variables	
10	Triple jump	Distance	Metres in centimetres

3.6 Experimental design

The 40 selected subjects were equally divided into four groups (n=10) of three experimental groups and a control group. The scholar applied pretest – post-test random group design in the research study. The experimental Group I underwent water exercises training (WEG), Group II underwent plyometric exercises training (PMG), and Group III underwent combination of water and plyometric exercises training (COG). Group IV acted as the control group (CNG) receiving no training during the experimental period. The duration of the experimental period was 12 weeks. Pre-test and post-test were conducted a day before and after the experimental period on all groups. All the training programme was administered on the experimental group thrice in a week for 12 weeks.

Figure 1

Research Design Flow Chart



3.7 Orientation of the subjects

Proper orientation was given to the subjects about the purpose of the study prior to the administration of the tests to obtain their full co-operation. The scholar explained the procedure of conducting test for the study and the three different training schedules to be carried out in the research study. The subjects voluntarily and wholeheartedly participated in the tests to get the exact results on each test.

3.8 Pilot study

A pilot study was conducted to fix the exercises, intensity, repetition, rest and training load. 15 male subjects were selected and they were randomly divided into three groups of five members each. Group I Water exercises training, group II plyometric exercises training and group III combination of water and plyometric exercises training. The pilot research was carried out with the subjects' initial ability to know the suitability of the different water and plyometric exercises training and to recognise the difficulties and limitations of the study. By analysing ease of training and the capabilities of the subjects' the modifications in training schedule were made based.

3.9 Administration of training programme

Selected subjects were trained every morning for 12 weeks from 7:00 am to 8:00 am for the purpose of the study. Training was given on Monday, Wednesday and Friday. Three days in a week training was given for 60 minutes followed by warm up and warm down. Water exercises training was given to the experimental group I (WEG), plyometric exercises training was given to the experimental group II (PMG) for the period of 12 weeks. Combination of water and plyometric exercises training was given on alternate days for the experimental group III (COG). The control group (CNG) did not receive any particular training.

Table 2

Description of the training schedule

S. No	Description	Duration		
1	Duration of Training	12 Weeks		
2	Days	3 days		
3	Training session per day	One Session (morning)		
4	Duration of one session	60 minutes		
5	Warm-up	10 minutes		
6	Training for Specific components	40 minutes		
7	Warm-down	10 minutes		
Training Programmes		Weeks		Intensity (%)
8.	Water Exercises Training	1 – 4	60 min.	60
		5 – 8	60 min.	70
		9 – 12	60 min.	80
9.	Plyometric Exercises Training	1 – 4	60 min.	60
		5 – 8	60 min.	70
		9 – 12	60 min.	80
10.	Combination of water and plyometric exercises training (with alternate days)	1 – 4	60 min.	60
		5 – 8	60 min.	70
		9 – 12	60 min.	80

Preparation of water exercises training programme, plyometric exercises training programme and combination of water and plyometric exercises training programme scheduled was designed after consulting various coaches and sports training experts who had trained university, state level triple jumpers many times bearing in mind all the guiding principles of sports training so as to develop the performance potentials of boys triple jumpers. The training schedule was prepared keeping mind, the exercise, duration, frequency, repetition of the training schedule.

3.10 Training schedule of water exercises

Table 3

Schedule for Water exercises training group (WEG)

SL No	Exercises	Weeks	Sets	Repetitions	Recovery (in Seconds)
1	Alternate Walk Lateral Travel with 3 Stepping	1-2	1	15	60
2	High Knees	1-2	1	20	70
3	Lateral bounds	1-2	1	10	80
4	Alternate Backward Foot Reach	1-2	1	15	60
5	Walk Forward & Backward 3 Stepping	1-2	1	10	50
6	Alternate A & B Skips	1-2	1	10	60
7	Alternate Walk Lateral Travel with 3 Stepping	3-4	1	17	80
8	High Knees	3-4	1	24	120
9	Lateral bounds	3-4	1	12	120
10	Alternate Backward Foot Reach	3-4	1	18	80
11	Walk Forward & Backward 3 Stepping	3-4	1	12	90
12	Alternate A & B Skips	3-4	1	15	120
13	Alternate Walk Lateral Travel with 3 Stepping	5-6	2	12	150
14	High Knees	5-6	2	15	160
15	Lateral bounds	5-6	2	10	150
16	Alternate Backward Foot Reach	5-6	2	14	140
17	Walk Forward & Backward 3 Stepping	5-6	2	8	140
18	Alternate A & B Skips	5-6	2	12	120
19	Alternate Walk Lateral Travel with 3 Stepping	7-8	2	15	160

SL No	Exercises	Weeks	Sets	Repetitions	Recovery (in Seconds)
20	High Knees	7-8	2	17	180
21	Lateral bounds	7-8	2	10	180
22	Alternate Backward Foot Reach	7-8	2	15	160
23	Walk Forward & Backward 3 Stepping	7-8	2	10	190
24	Alternate A & B Skips	7-8	2	10	180
25	Alternate Walk Lateral Travel with 3 Stepping	9-10	3	12	225
26	High Knees	9-10	3	15	250
27	Lateral bounds	9-10	3	8	250
28	Alternate Backward Foot Reach	9-10	3	12	225
29	Walk Forward & Backward 3 Stepping	9-10	3	8	250
30	Alternate A & B Skips	9-10	3	8	250
31	Alternate Walk Lateral Travel with 3 Stepping	11-12	3	14	300
32	High Knees	11-12	3	17	320
33	Lateral bounds	11-12	3	10	320
34	Alternate Backward Foot Reach	11-12	3	14	300
35	Walk Forward & Backward 3 Stepping	11-12	3	10	320
36	Alternate A & B Skips	11-12	3	10	3200

3.10.1 Alternate walk lateral travel with 3 stepping

The athlete begins the exercise by standing in hip-level water with both legs apart, body weight evenly distributed over both legs, and a slight bend in both knees. The athlete then moves three steps to the side and then takes three steps back to the starting location.

3.10.2 High Knees

The workout involves the athlete standing hip-deep in the water, maintaining a gap between both legs, and transferring their body weight equally across both legs. The athlete will then perform spot walking, which involves raising each leg to hip height in turn.

3.10.3 Lateral bounds

In this exercise the athlete bounce towards lateral side and it repeats for the opposite leg. In order to perform this exercise, the athlete must stand in hip-level water with both legs kept apart, body weight evenly distributed across both legs, and a slight bend in both knees.

3.10.4 Alternate backward foot reach

In water at hip level, the athlete performs the alternative foot reach.

3.10.5 Walk forward & backward 3 stepping

The workout consists of the person standing in a pool with water up to hip level and taking three steps forward and backward at an accelerated pace.

3.10.6 Alternate A & B Skips

During this exercise, the athlete's left knee is driven up toll their thigh is parallel to the floor. Step forward a little with the same leg's forefoot. The athlete ought to run with his arm moving in the same manner. Thus, he should extend his right arm forward in tandem with this raising of his left knee. Then instantly repeat the action with his left arm and right foot. Throughout the drill, keep the athlete's body erect and concentrate on being calm.

3.11 Training schedule of plyometric exercises

Table 4

Schedule for Plyometric exercises training group (PMG)

SL No	Exercises	Weeks	Sets	Repetitions	Recovery (in seconds)
1	Squat jumps	1-2	1	6	80
2	Reverse lunge knee-ups	1-2	1	10	60
3	Lateral bounds	1-2	1	6	90
4	Box jumps	1-2	1	6	80
5	Tuck jumps	1-2	1	6	80
6	Burpees Jump	1-2	1	6	95
7	Squat jumps	3-4	1	8	120
8	Reverse lunge knee-ups	3-4	1	12	95
9	Lateral bounds	3-4	1	8	120
10	Box jumps	3-4	1	8	120
11	Tuck jumps	3-4	1	8	130
12	Burpees Jump	3-4	1	8	140
13	Squat jumps	5-6	2	6	180
14	Reverse lunge knee-ups	5-6	2	8	190
15	Lateral bounds	5-6	2	6	160
16	Box jumps	5-6	2	6	160
17	Tuck jumps	5-6	2	6	150
18	Burpees Jump	5-6	2	6	140
19	Squat jumps	7-8	2	8	160
20	Reverse lunge knee-ups	7-8	2	10	180
21	Lateral bounds	7-8	2	8	180
22	Box jumps	7-8	2	8	160
23	Tuck jumps	7-8	2	8	190
24	Burpees Jump	7-8	2	10	180
25	Squat jumps	9-10	3	8	225
26	Reverse lunge knee-ups	9-10	3	10	250
27	Lateral bounds	9-10	3	8	250

SL No	Exercises	Weeks	Sets	Repetitions	Recovery (in seconds)
28	Box jumps	9-10	3	8	225
29	Tuck jumps	9-10	3	8	250
30	Burpees Jump	9-10	3	8	250
31	Squat jumps	11-12	3	10	300
32	Reverse lunge knee-ups	11-12	3	12	320
33	Lateral bounds	11-12	3	10	320
34	Box jumps	11-12	3	10	300
35	Tuck jumps	11-12	3	10	320
36	Burpees Jump	11-12	3	10	320

3.11.1 Squat jumps

To execute this exercise, subjects begin by standing with the feet at a distance equivalent to the width of the hips. Proceeds to descend into a squatting position by flexing the knees. Subject must keep the spine upright, chest elevated, and knees are not extending beyond the line of the toes. For balance, subjects were asked to keep the arms positioned in front of the chest. Subsequently, leap upwards while simultaneously swinging the arms overhead. Finally, return to the squat position. This exercise is highly effective in developing muscle endurance in the legs, enhancing balance, and promoting overall physical fitness.

3.11.2 Reverse lunge knee-ups

Subject took a step back with left foot kept both knees at 90°. Then extending both knees weight is transferred to right foot from the left foot. While doing this bring left foot knee to chest. Return the left leg back on the floor.

3.11.3 Lateral bounds

Laterally jumping on the left foot and landing on the same leg. Again repeat the same on right leg. Repetition of the exercise was done as per the training schedule.

3.11.4 Box jumps

Stand with the box one short step in front of the feet, shoulder-width apart. Bend knees slightly and drop down, bringing arms out behind. Use the momentum from quarter squat to propel upward as jump onto the box with the swing of arms. Subjects were adviced to land softly on the foot.

3.11.5 Tuck jumps

Stand with feet shoulder-width apart, slight bend in knees. Shoulders directly over hips, neutral head and neck position. Tucked chin throughout, weight evenly distributed, grip floor with feet for stability. Arms remain long by sides with slight bend in elbows. Pre-tension shoulders and hips with inhale and exhale, engage core.

Maintain neutral spine, vertical shin, and upright chest as lower yourself. Arms remain long with slight bend in elbows. Allow hands to travel behind body. Chest over knees. Explosively push feet through ground to jump into air. Swing arms forward, bring knees to chest. Land in quarter-squat position on balls of feet, evenly distribute weight. Keep knees in line with toes, chest ahead of hips. Land softly, jump again, repeat for designated repetitions as per the training schedule.

3.11.6 Burpees

Subject starts the exercise with knees bent, back straight, and feet shoulder-width apart. Place the hands on the floor inside the feet. Shifting the weight to the hands and kicks feet back to reach a push-up position. Body must stay straight from head to heels while doing push-up.

By doing frog kick by jumping and bringing the feet back to their initial position. Stands up, reach the arms overhead, and quickly jumps into the air to land back to the starting position. As soon as lands, bends the knees to repeat the exercise.

Table 5

Schedule for Combination of water exercises and plyometric exercises training groups (COG)

Days		Weeks											
		1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th
Mon.	Training	Water Exercises	Plyometric Exercises	Water Exercises	Plyometric Exercises	Water Exercises	Plyometric Exercises	Water Exercises	Plyometric Exercises	Water Exercises	Plyometric Exercises	Water Exercises	Plyometric Exercises
	Intensity	60	60	60	60	70	70	70	70	80	80	80	80
Tue.		Rest											
Wed.	Training	Plyometric Exercises	Water Exercises	Plyometric Exercises	Water Exercises	Plyometric Exercises	Water Exercises	Plyometric Exercises	Water Exercises	Plyometric Exercises	Water Exercises	Plyometric Exercises	Water Exercises
	Intensity	60	60	60	60	70	70	70	70	80	80	80	80
Thu.		Rest											
Fri.	Training	Water Exercises	Plyometric Exercises	Water Exercises	Plyometric Exercises	Water Exercises	Plyometric Exercises	Water Exercises	Plyometric Exercises	Water Exercises	Plyometric Exercises	Water Exercises	Plyometric Exercises
	Intensity	60	60	60	60	70	70	70	70	80	80	80	80
Sat.		Rest											
Sun.		Rest											

Table 6

Schedule for water exercises, plyometric exercises and combination of water and plyometric exercises training groups

Weeks	Exercises	Warming-up	Duration of Exercise	Intensity	Cool Down	Total Volume
1st, 2nd, 3rd and 4th	**Water exercises Group** a) Alternate Walk Lateral Travel with 3 Stepping, High Knees, Lateral bounds, Alternate Backward Foot Reach, Walk Forward & Backward 3 Stepping, Alternate A & B Skips.	10 Min.	40 Min.	60 %	10 Min.	60 Min.
	Plyometric exercises Group b) Squat jumps, Reverse lunge knee ups, Burpees, Box jumps, Tuck jumps, Lateral bounds.	10 Min.	40 Min.	60 %	10 Min.	60 Min.
	Combination of Water & plyometric exercises Group **Water Exercises** a) Alternate Walk Lateral Travel with 3 Stepping, High Knees, Lateral bounds, Alternate Backward Foot Reach, Walk Forward & Backward 3 Stepping, Alternate A & B Skips. **Plyometric Exercises** b) Squat jumps, Reverse lunge knee-ups, Burpees, Box jumps, Tuck jumps, Lateral bounds.	10 Min.	40 Min.	60 %	10 Min.	60 Min.

Weeks	Exercises	Warming-up	Duration of Exercise	Intensity	Cool Down	Total Volume
5^{th}, 6^{th}, 7^{th} and 8^{th}	**Water exercises Group** **a)** Alternate Walk Lateral Travel with 3 Stepping, High Knees, Lateral bounds, Alternate Backward Foot Reach, Walk Forward & Backward 3 Stepping, Alternate A & B Skips. Alternate A & B Skips.	10 Min.	40 Min.	70 %	10 Min.	60 Min.
	Plyometric exercises Group **b)** Squat jumps, Reverse lunge knee-ups, Burpees, Box jumps, Tuck jumps, Lateral bounds.	10 Min.	40 Min.	70 %	10 Min.	60 Min.
	Combination of Water & plyometric exercises Group **Water Exercises** a) Alternate Walk Lateral Travel with 3 Stepping, High Knees, Lateral bounds, Alternate Backward Foot Reach, Walk Forward & Backward 3 Stepping, Alternate A & B Skips. **Plyometric Exercises** b) Squat jumps, Reverse lunge knee-ups, Burpees, Box jumps, Tuck jumps, Lateral bounds.	10 Min.	40 Min.	70 %	10 Min.	60 Min.

Weeks	Exercises	Warming-up	Duration of Exercise	Intensity	Cool Down	Total Volume
9th, 10th, 11th and 12th	**<u>Water exercises Group</u>** 1. Alternate Walk Lateral Travel with 3 Stepping, High Knees, Lateral bounds, Alternate Backward Foot Reach, Walk Forward & Backward 3 Stepping, Alternate A & B Skips.	10 Min.	40 Min.	80 %	10 Min.	60 Min.
	<u>Plyometric exercises Group</u> 2. Squat jumps, Reverse lunge knee-ups, Burpees, Box jumps, Tuck jumps, Lateral bounds.	10 Min.	40 Min.	80 %	10 Min.	60 Min.
	<u>Combination of Water & plyometric exercises Group</u> **Water Exercises** 3. Alternate Walk Lateral Travel with 3 Stepping, High Knees, Lateral bounds, Alternate Backward Foot Reach, Walk Forward & Backward 3 Stepping, Alternate A & B Skips. **Plyometric Exercises** 4. Squat jumps, Reverse lunge knee-ups, Burpees, Box jumps, Tuck jumps, Lateral bounds.	10 Min.	40 Min.	80 %	10 Min.	60 Min.

3.12 Collection of the data

All the selected tests were carried out to gather data on health-related physical fitness and physiological variables, as described earlier. The data was collected before and after a 12-week training program through pre-test and post-test measurements. The data for the selected variables were collected within a single day, from 6:00 AM to 8:30 AM. The final test was a 1600-meter run (also known as a one-mile run) test.

3.13 Administration of tests

To measure the chosen physical, physiological, and performance factors for the study, standard tests were administered. Table 1 lists the chosen variables, the corresponding tests, and the tools utilised.

3.14 Physical variables

3.14.1 Cardiovascular endurance (1600 meters run)

Purpose

The purpose of the one-mile run was to assess cardiorespiratory endurance and maximal functional capacity.

Equipment

A 400 mts track and stop watch

Procedures

Subject were asked to stand in the starting line. On the signal 'Go' they will run to cover the distance of 1600 mts, (i.e., four laps in the standard 400 mts track) with minimum time duration.

Scoring

Total time duration (in seconds) taken for the completion of 1600 mts will be the score of the individual subject.

3.14.2 Muscular endurance (Sit-ups in 1 minute)

Purpose

The purpose of this test was to measure the strength endurance of the abdominal muscles.

Equipment

Mats and stopwatch

Procedure

The subject lie flat on their back, with knees bent and feet flat on the floor. The heels must be no more than 30 cm away from the buttocks, and the knee angle should be at least 90 degrees. The fingers should be interlocked and placed behind the neck, with elbows touching the mat. A partner hold the feet securely. The subject then curl up to a sitting position and touch their knees with their elbows. This exercise was repeated as many times as possible in one minute.

Scoring

One point was scored for each correct sit-up. The score was the maximum number of sit ups completed in one minute ***(Torres and Uppal, 1992).***

3.14.3 Flexibility (Sit & reach test)

Purpose

Lower back and hamstring flexibility of the subject was measured by using the test.

Equipment

A sit & reach bench with a ruler and an assistant

Procedure

The subjects sits on the floor with bare foot flat against the table, and legs straight without bending knees. Then reached forward and pushed the fingers along the table as far as possible. The distance from the finger tips to the edge of the table represented the score. After giving sufficient warm-up attempts, the test was conducted to record the best score.

Scoring

Maximum reading taken by the subject was recorded in centimeters

3.14.4 Speed (50 mts. Dash)

Purpose

Speed of the subject was measured.

Equipment

Track, stop watches with a split second timer, pen and notepad.

Procedure

Subject takes the position behind the starting line. On the command 'on your mark', 'set' and "Go". The subject will run as fast as possible.

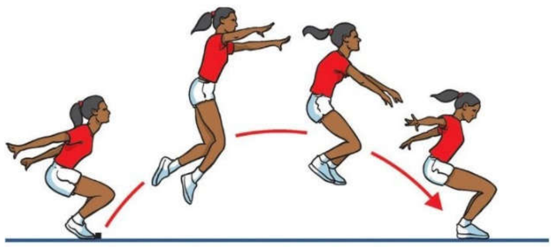
Scoring

Recorded in 1/100th of a second.

3.14.5 Explosive power (Standing broad jump)

Purpose

To measure the explosive power of legs



Equipment

Mat, floor or outdoor jumping pit and measuring tape.

Procedure

Subject was asked to stand behind the take-off line. Then the subject takes jumps from the standing position. During jumping, the subject can swing the arms backward and bend the knees to initiate momentum. The distance between the take off line and the part of subject's body which lands near to the take off line will be measured.

Scoring

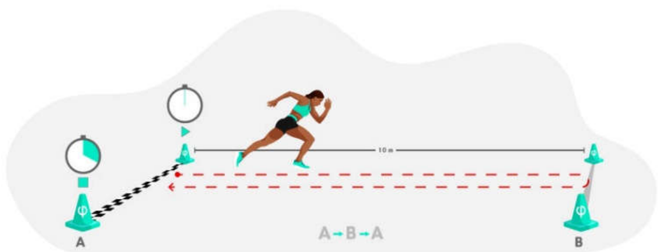
The best jump of the subject out of three trials will be considered as the final score.

3.14.6 Agility

Test: Shuttle run test

Purpose

To measure the agility of the body.



Equipment

A measuring tape, white powder and stop watch.

Procedure

The subject stands at the starting point. Two lines are drawn at the distance of 10mts. On the signal ''Ready go'' the subjects ran from one line to another line. Subject will repeat this for four times.

Scoring

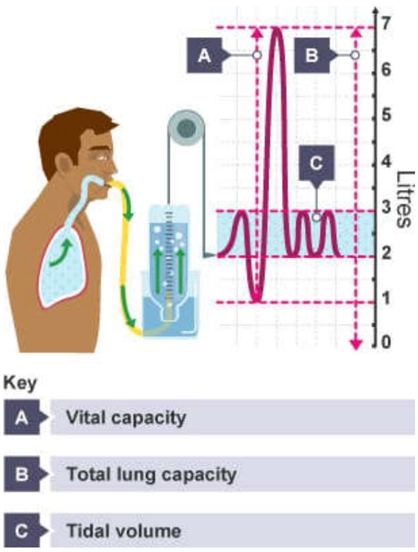
The time taken to complete the course was recorded to the nearest seconds. The better of the two trails was the final score (**Johnson & Nelson, 1988).**

3.15 Physiological variables

3.15.1 Vital capacity (Wet spirometer)

Purpose

The purpose of the test was to measure the vital capacity of the lungs.



Equipment

Wet Spirometer was used for measuring the vital capacity.

Procedure

The wet spirometer was placed at a height that allowed the subjects to stand easily and perform the test without bending the torso. The subject was asked to take deepest inhalation and exhaled twice before the test (hyperventilate). The subject was advised not to allow air to escape through the nose or around the mouthpiece to get hundred percent exact result. Then subject was asked to blow as much air possible into the spirometer after taking deepest inhalation.

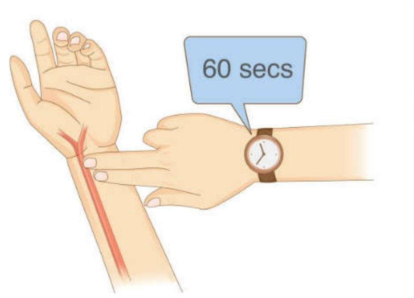
Scoring

The maximum reading shown in the wet spirometer was the score.

3.15.2 Pulse rate (Heart rate)

Purpose

To measure the pulse rate (Heart rate)



Equipment

Stop watch

Procedure

Pulse Rate was measured by measuring the palpation of radial artery which is located at the thumb side of the wrist on the anterior surface of the forearm. The beat was counted for one minute. The Pulse Rate was recorded in numbers.

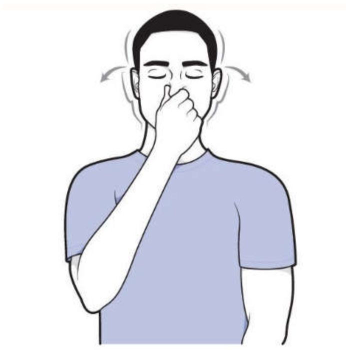
Scoring

Pulse rate was calculated for one minute.

3.15.3 Breath holding capacity (in seconds)

Purpose

The purpose was to measure the ability of the subject to hold the breath for longer time.



Equipment

A stop watch, a score sheet and a pencil and a nose clip were needed to administer the test.

Procedure

The subject was instructed to assume a standing pose of ease and inhale deeply, following which the individual was required to hold their breath for as long as possible. A nose clip was placed on the subject's nose to obstruct the passage of air through their nostrils. The duration of breath-holding time was measured with a stopwatch, from the moment the participant ceased inhaling until the moment they exhaled, to the nearest one-tenth of a second

Scoring

The time was recorded in minutes 1/100 of seconds and the best of two trials were recorded was taken as the score **(Mathew, 1988)**.

3.16 Performance variable

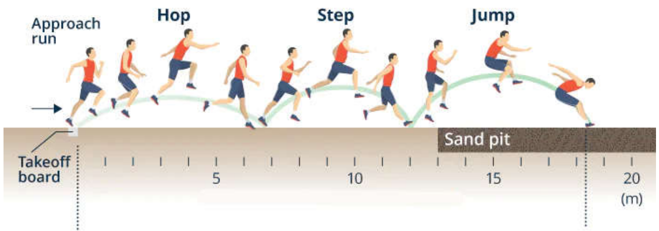
3.16.1 Triple jump performance

Purpose

To measure the triple jump performance.

Equipment

Outdoor triple jump pit, measuring tape



Procedure

Subject was asked to do triple jump. Foul during the jump was considered as failure. Subject was given three trials.

Scoring

Best of three trial score was taken. Maximum distance (in meters) covered by the subject in the triple jump was the score.

3.17 Reliability of the data

Reliability of the data was censured by tester's competency and instrument reliability. Tester's competency is the measurements on the different selected variables in this study were taken by the investigator with the help of assistants. From the research point of view, it is very important to be familiar in using the various instruments and hence, the investigator had undergone training under an expert, in order to ensure the reliability of measurements taken. After a series of practice sessions, the tester's competency was statistically analyzed and established by using the test-retest method and is presented in Table 7.

Collected data was analysed by using the correlation statistical technique to find the significant relationship between the scores. The scores were obtained by test and retest method. The level of significance was fixed as 0.05 level.

3.17.1 Tester competency

The physical variables and physiological related variables of this study were taken by the investigator with the assistance of the lecturers, physical education teachers and director of physical education, working at various schools in Malappuram, Kerala State, India. To ensure that the assistants of the investigator were well versed with the technique of conducting tests, they had a number of practice sessions in the correct testing procedure. The tester's reliability was established by test and re-test methods.

3.17.2 Instrument reliability

Instruments such as wet spirometer, stadiometer, weighing machine, stop watch and measuring tape were used to measure selected variables. All instruments were in good working condition. Their calibrations were tested and found to be accurate enough to serve the purpose of the study. Certificates of accuracy of the above instruments were obtained from appropriate instrument testing agencies, and they were put to use by recalibrating the scale by using amounts of variables wherever required. To determine the reliability of instruments, measurement on each of the tests of the variables were recorded five times under similar conditions using the same instrument. Hence, their calibrations were accepted as accurate enough for the purpose of the study.

Table 7

Intra class co-efficient of correlation on selected dependent variables

SL No	Criterion Variables	Coefficient of Correlation
1	Cardiovascular endurance	0.91*
2	Muscular endurance	0.92*
3	Flexibility	0.86*
4	Speed	0.87*
5	Explosive power	0.92*
6	Agility	0.94*
7	Vital capacity	0.91*
8	Pulse rate	0.90*
9	Breath holding capacity	0.92*
10	Triple jump performance	0.91*

Level of significance 0.05

3.18 Statistical techniques

Various descriptive statistics like mean, median, mode, standard deviation, variance, skewness, kurtosis, standard error of skewness, the pre-test and post-:test data of the selected physical variables namely speed, flexibility, carduivascular endurance, muscular endurance, explosive power, agility, phisiological variables namely vital capacity, pulse rate, breath holding capacity, performance variable namly Triple jump performance were statistically analyzed. Data collected from the groups before and after the training programme were statistically examined for significant difference in means by applying analysis of co-variance (ANCOVA). Later wherever the F-ratio was found to be significant, LSD post-hoc test was applied, so as to test whether actual differences existed among the adjusted post-test means and the level of significance was set at 0.05.

The data was analyzed on the computer using the Statistical Package for Social Sciences (SPSS) Version 16.

CHAPTER IV

RESULT AND DISCUSSION

4.1 Overview

The purpose of this study was to find out the effect of water exercises, plyometric exercises and a combination of both on selected physical variables, physiological variables and performance of triple jumpers. To achieve the purpose of the study, the scholar selected 40 triple jumpers (N=40) as subjects from Malappuram district, Kerala, India. The age of the subjects ranged from 15 years to 17 years. Mean height of the subjects were 172cms ±1. Mean weight of the subjects were 58.6kgs ±3.0kgs. Selected subjects were assigned into four equal groups of ten subjects each. Experimental group I underwent water exercises training was denoted as (WEG), experimental group II was denoted as plyometric exercises training group (PMG), experimental training group III was denoted as combination of water exercises and plyometric exercises training group (COG) and one control group that did not receive any special training was denoted as (CNG). Each group consisted ten subjects each (n1=n2=n3=n4=10).

The physical variables cardiovascular endurance, muscular endurance, flexibility, speed, explosive power, agility, physiological variables vital capacity, pulse rate, breath holding capacity and performance variable triple jump performance were selected as dependent variables for the study. Independent variables were water exercises training, plyometric exercises training and combination of water and plyometric exercises training.

To determine the significant difference between pre and post-test scores of various group dependent 't' test was used. To determine the significant difference between the groups on the dependent variable the statistical procedure analysis of covariance (ANCOVA) was applied. To find out the significant difference on adjusted means of the group, LSD Post-hoc test was administered.

4.2 Test of significance

As **Clarke and Clarke, (1972)** said "These data must be analysed in an appropriate to the research design. Such analysis can only be appropriate to the research design. Such analysis can only be accomplished through the application of pertinent statistics".

This section is crucial for the thesis as it helps to draw conclusions by examining the hypotheses. The hypotheses were tested by either accepting or rejecting them based on the results obtained with a certain level of confidence. This test is commonly known as the test of significance, which determines whether the differences between the scores of the four groups are significant or not. In this study, the research hypothesis was accepted if the obtained F-value was greater than the required table value, and it was rejected if the obtained F-value was lesser than the required table value.

Table 8

t-test done on Pre-test and post-test means of selected physical, physiological and performance variables of water exercises training group (WEG)

Variables	Test	Mean	N	Std. Deviation	df	't'-ratio
Cardiovascular endurance	Pre-test	6.92	10	.34	9	2.828*
	Post-test	6.62		.23		
Muscular endurance	Pre-test	37.30	10	3.86	9	18.762*
	Post-test	43.20		3.39		
Flexibility	Pre-test	7.70	10	3.68	9	14.500*
	Post-test	13.60		2.91		
Speed	Pre-test	7.19	10	.48	9	6.047*
	Post-test	6.95		.41		
Explosive power	Pre-test	1.97	10	.05	9	6.180*

Variables	Test	Mean	N	Std. Deviation	df	't'-ratio
	Post-test	2.09		.06		
Agility	Pre-test	11.04	10	.07	9	5.050*
	Post-test	10.90		.11		
Vital capacity	Pre-test	602.00	10	4.21	9	5.997*
	Post-test	840.00		126.49		
Pulse rate	Pre-test	68.80	10	1.87	9	4.023*
	Post-test	66.00		2.05		
Breath holding capacity	Pre-test	46.00	10	4.29	9	7.498*
	Post-test	54.60		4.00		
Triple jump performance	Pre-test	11.44	10	.35	9	2.775*
	Post-test	11.89		.38		

*significant at 9df ($p<0.05$, Table value = 2.26)

As revealed in the table 8, pre-test and post-test scores of water exercises training group had significant difference at 0.05 level of significance. The obtained t-ratio values on the ten selected variables are Cardiovascular endurance (2.828), Muscular endurance (18.762), Flexibility (14.5), Speed (6.047), Explosive power (6.180), Agility (5.05), Vital capacity (5.997), Pulse rate (4.023), Breath holding capacity (7.498) and Triple jump performance (2.775) were greater than the required table value of df_9 = 2.093 with 0.05 level of significance. Hence, there was a significant difference between the pre-test and post-test scores of cardiovascular endurance, muscular endurance, flexibility, speed, explosive power, agility, vital capacity, pulse rate, breath holding capacity and triple jump performance of water exercises training group.

Table 9

t-test done on Pre-test and post-test means of selected physical, physiological and performance variables of Plyometric exercises training group (PMG)

Variables	Test	Mean	N	Std. Deviation	df	‘t’-ratio
Cardiovascular endurance	Pre-test	6.96	10	.44	9	3.403*
	Post-test	6.43		.17		
Muscular endurance	Pre-test	37.30	10	2.63	9	7.204*
	Post-test	47.40		3.27		
Flexibility	Pre-test	7.70	10	1.95	9	6.267*
	Post-test	15.00		3.56		
Speed	Pre-test	6.96	10	.44	9	2.411*
	Post-test	6.61		.24		
Explosive power	Pre-test	1.97	10	.04	9	12.575*
	Post-test	2.21		.05		
Agility	Pre-test	11.03	10	.164	9	4.066*
	Post-test	10.72		.23		
Vital capacity	Pre-test	603.00	10	6.75	9	6.047*
	Post-test	930.00		170.29		
Pulse rate	Pre-test	68.60	10	3.95	9	2.849*
	Post-test	66.10		1.73		
Breath holding capacity	Pre-test	46.30	10	4.27	9	13.933*
	Post-test	55.60		4.45		
Triple jump performance	Pre-test	11.44	10	.34	9	6.399*
	Post-test	12.16		.14		

*significant at 9df ($p<0.05$, Table value = 2.26)

As mentioned in the table 9 pre-test and post-test scores of plyometric exercises training group had significant difference at 0.05 level of significance. The obtained t-ratio values Cardiovascular endurance (3.403), Muscular endurance (7.204), Flexibility (6.267), Speed (2.411), Explosive power (12.575), Agility (4.066), Vital capacity (6.047), Pulse rate (2.849), Breath holding capacity (13.933) and Triple jump performance (6.399) were greater than the required table value at df_9 = 2.093 with 0.05 level of significance. Hence, there was a significant difference between the pre-test and post-test scores of cardiovascular endurance, muscular endurance, flexibility, speed, explosive power, agility, vital capacity, pulse rate, breath holding capacity and triple jump performance of plyometric exercises training group.

Table 10

t-test done on Pre-test and post-test means of selected physical, physiological and performance variables of Combination of Water and Plyometric exercises training group (COG)

Variables	Test	Mean	N	Std. Deviation	df	‘t’-ratio
Cardiovascular endurance	Pre-test	6.97	10	.32	9	3.670*
	Post-test	6.30		.52		
Muscular endurance	Pre-test	38.00	10	2.11	9	11.658*
	Post-test	47.90		2.08		
Flexibility	Pre-test	8.90	10	3.11	9	12.738*
	Post-test	24.90		3.07		
Speed	Pre-test	7.20	10	.48	9	6.071*
	Post-test	6.24		.03		
Explosive power	Pre-test	1.97	10	.04	9	8.535*
	Post-test	2.31		.12		
Agility	Pre-test	11.03	10	.09	9	17.220*
	Post-test	10.07		.23		
Vital capacity	Pre-test	604.00	10	6.99	9	269.551*
	Post-test	1200.00		.00		
Pulse rate	Pre-test	68.70	10	3.65	9	2.689*
	Post-test	65.90		1.60		
Breath holding capacity	Pre-test	47.00	10	5.16	9	6.138*
	Post-test	61.10		6.45		
Triple jump performance	Pre-test	11.41	10	.31	9	6.363*
	Post-test	12.45		.39		

*significant at 9df ($p<0.05$, Table value = 2.26)

As denoted in the table 10 pre-test and post-test scores of combination of water exercises and plyometric exercises training group had significant difference at 0.05 level of significance. The obtained t-ratio values Cardiovascular endurance (3.670), Muscular endurance (11.658), Flexibility (12.738), Speed (6.071), Explosive power (8.535), Agility (17.220), Vital capacity (269.551), Pulse rate (2.689), Breath holding capacity (6.138) and Triple jump performance (6.363) were greater than the required table value at df_9 = 2.049 with 0.05 level of significance. Hence, there was a significant difference between the pre-test and post-test scores of selected physical variables such as cardiovascular endurance, muscular endurance, flexibility, speed, explosive power, agility, physiological variables vital capacity, pulse rate, breath holding capacity and performance variable triple jump performance of combination of water and plyometric exercises training group.

Table 11

t-test done on Pre-test and post-test means of selected physical, physiological and performance variables of control group (CNG)

Variables	Test	Mean	N	Std. Deviation	df	't'-ratio
Cardiovascular endurance	Pre-test	6.96	10	.44	9	.242
	Post-test	6.94		.37		
Muscular endurance	Pre-test	39.30	10	3.95	9	1.022
	Post-test	37.40		3.31		
Flexibility	Pre-test	9.90	10	1.91	9	.938
	Post-test	10.60		2.01		
Speed	Pre-test	7.15	10	.40	9	.758
	Post-test	7.12		.38		
Explosive power	Pre-test	1.94	10	.068	9	.035
	Post-test	1.94		.16		
Agility	Pre-test	11.05	10	.11	9	.408
	Post-test	11.03		.16		
Vital capacity	Pre-test	602.00	10	4.22	9	1.500
	Post-test	600.00		.00		

Variables	Test	Mean	N	Std. Deviation	df	't'-ratio
Pulse rate	Pre-test	68.80	10	4.13	9	.152
	Post-test	68.60		1.88		
Breath holding capacity	Pre-test	47.00	10	3.33	9	.338
	Post-test	47.20		3.08		
Triple jump performance	Pre-test	11.42	10	.25	9	.525
	Post-test	11.44		.34		

Not significant at 9df ($p<0.05$, Table value = 2.26)

As noted in the table 11 pre-test and post-test scores of control group had no significant difference at 0.05 level of significance. The obtained t-ratio values Cardiovascular endurance (0.242), Muscular endurance (1.022), Flexibility (0.938), Speed (0.758), Explosive power (0.035), Agility (0.408), Vital capacity (1.500), Pulse rate (0.152), Breath holding capacity (0.338) and Triple jump performance (0.525) were smaller than the required table value at df_9 = 2.093 with 0.05 level of significance. Hence, there was no significant difference between the pre-test and post-test scores of selected physical, physiological and performance variables of control group.

Table 12

Analysis of variance done on selected physical, physiological and performance variables of Water exercises training group (WEG), Plyometric exercises training group (PMG), Combination of Water and Plyometric exercises training group (COG) and Control group (CNG)

Variables	Groups	df	Pre-test			Post-test		
			Sum of Squares	Mean Square	F - ratio	Sum of Squares	Mean Square	F -ratio
Cardiovascular endurance	Between Groups	3	.015	.005	.032	2.303	.768	6.386*
	Within Groups	36	5.465	.152		4.328	.120	
Muscular endurance	Between Groups	3	26.675	8.892	.851	709.675	236.558	25.248*
	Within Groups	36	376.300	10.453		337.300	9.369	
Flexibility	Between Groups	3	33.900	11.300	1.474	1151.275	383.758	44.322*
	Within Groups	36	276.000	7.667		311.700	8.658	
Speed	Between Groups	3	.363	.121	.592	4.529	1.510	16.269*
	Within Groups	36	7.347	.204		3.341	.093	
Explosive power	Between Groups	3	.007	.002	.905	.758	.253	21.216*
	Within Groups	36	.090	.002		.429	.012	
Agility	Between Groups	3	.003	.001	.070	5.415	1.805	48.990*
	Within Groups	36	.471	.013		1.326	.037	

Variables	Groups	df	Pre-test			Post-test		
			Sum of Squares	Mean Square	F - ratio	Sum of Squares	Mean Square	F -ratio
Vital capacity	Between Groups	3	27.500	9.167	.282	1842750.000	614250.000	54.600*
	Within Groups	36	1170.000	32.500		405000.000	11250.000	
Pulse rate	Between Groups	3	.275	.092	.007	50.900	16.967	5.082*
	Within Groups	36	445.700	12.381		120.200	3.339	
Breath holding capacity	Between Groups	3	7.675	2.558	.137	980.075	326.692	15.015*
	Within Groups	36	670.100	18.614		783.300	21.758	
Triple jump performance	Between Groups	3	.005	.002	.018	5.502	1.834	16.732*
	Within Groups	36	3.645	.101		3.946	.110	

*significant at 0.05 level ($p<0.05$) (Table value = 3, 36df = 2.87)

Table 12 showed the results of analysis of variance of selected physical, physiological and performance variables of water exercises, plyometric exercises, combination of water and plyometric exercises group and control group. Table XI elaborately analyzed the pre-test and post-test scores separately.

The obtained f-ratio value of 0.032 of pre-test scores showed no significant difference among the group on cardiovascular endurance. The obtained f- ratio value of 6.386 of post-test scores showed significant difference among the groups at 0.05 level of significance with 3,36 df.

The obtained f-ratio value of 0.851 of pre-test scores showed no significant difference among the group on muscular endurance. The obtained f- ratio value of 25.248 of post-test scores showed significant difference among the groups at 0.05 level of significance with 3,36 df.

The obtained f-ratio value of 1.474 of pre-test scores on flexibility showed no significant difference among the groups. The obtained f- ratio value of 44.322 of post-test scores of flexibility showed significant difference among the groups at 0.05 level of significance with 3,36 df.

The obtained f-ratio value of 0.592 of pre-test scores of speed showed no significant difference among the groups. The obtained f- ratio value of 16.269 of post-test scores of speed showed significant difference among the groups at 0.05 level of significance with 3,36 df.

The obtained f-ratio value of 0.905 of pre-test scores of explosive power showed no significant difference among the groups. The obtained f- ratio value of 21.216 of post-test scores of explosive power showed significant difference among the groups at 0.05 level of significance with 3,36 df.

The obtained f-ratio value of 0.070 of pre-test scores showed no significant difference among the groups on agility. The obtained f- ratio value of 48.990 of post-test scores showed significant difference among the groups at 0.05 level of significance with 3,36 df on agility.

The obtained f-ratio value of 0.282 of pre-test scores showed no significant difference among the groups on vital capacity. The obtained f- ratio value of 54.600

of post-test scores showed significant difference among the groups at 0.05 level of significance with 3,36 df on vital capacity.

The obtained f-ratio value of 0.007 of pre-test scores showed no significant difference among the groups on pulse rate. The obtained f- ratio value of 5.082 of post-test scores showed significant difference among the groups at 0.05 level of significance with 3,36 df on pulse rate.

The obtained f-ratio value of 0.137 of pre-test scores of breath holding capacity showed no significant difference among the groups. The obtained f- ratio value of 15.015 of post-test scores of breath holding capacity showed significant difference among the groups at 0.05 level of significance with 3,36 df.

The obtained f-ratio value of 0.18 of pre-test scores of triple jump performance showed no significant difference among the groups. The obtained f- ratio value of 16.732 of post-test scores of triple jump performance showed significant difference among the groups at 0.05 level of significance with 3,36 df.

Table 13

Analysis of covariance done on cardiovascular endurance among the three experimental groups and control group

Variables	Group	Mean	Test	Sources of variance	Sum of squares	Mean square	df	F-ratio
Cardiovascular endurance	WEG	6.92	Pre-test	between	.015	.005	3	.032
	PMG	6.96						
	COG	6.97		within	5.465	.152	36	
	CNG	6.96						
	WEG	6.62	Post-test	between	2.303	.768	3	6.386*
	PMG	6.43						
	COG	6.30		within	4.328	.120	36	
	CNG	6.94						
	WEG	6.62	Adjusted post-test	between	2.328	.776	3	6.921*
	PMG	6.43						
	COG	6.30		within	3.924	.112	35	
	CNG	6.94						

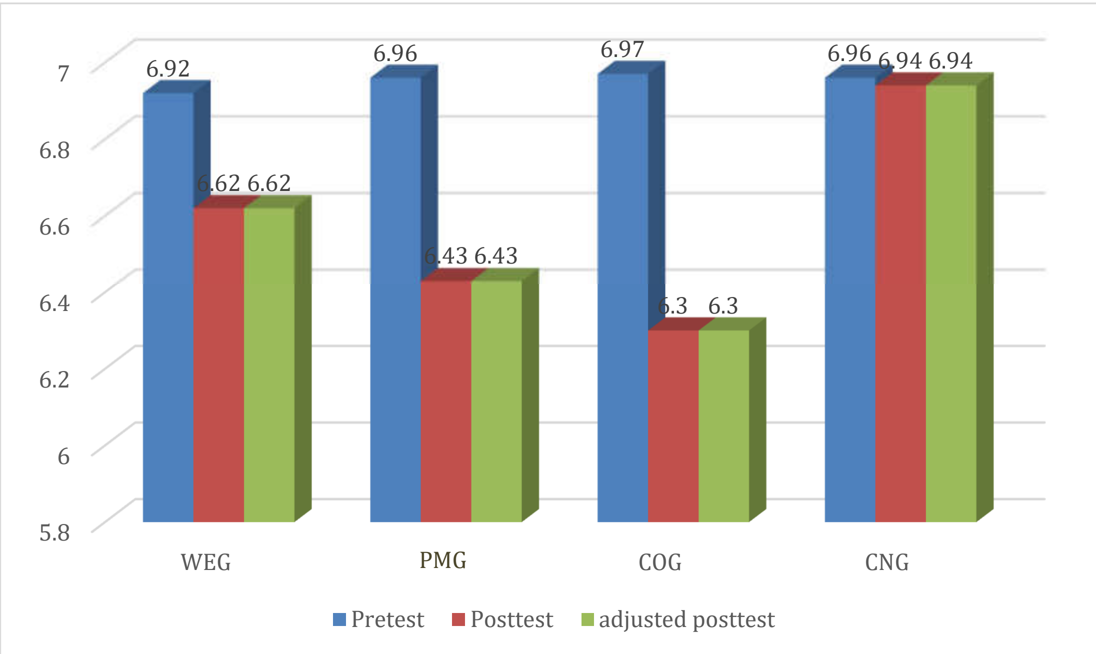
*significant at 0.05 level ($p<0.05$) (Table value = 3, 35 and 3, 36df = 2.87)

As given in table 13 the obtained f-ratio value of 0.032 showed no significant difference among the groups on cardiovascular endurance. The obtained f-ratio value of post-test scores of 6.386 at 0.05 level of significance showed significant different among the groups on cardiovascular endurance. The obtained f-ratio value of adjusted post-test scores of 6.921 showed significant difference among the groups. Hence, the null hypothesis was rejected and there was a significant difference among the groups on cardiovascular endurance at 0.05 level of significance at 3,35 df.

For the better understanding, graphical diagram of cardiovascular endurance mean values of various groups was given in Figure 2.

Figure 2

Pre-test, post-test, adjusted post-test cardiovascular endurance mean values of WEG, PMG, COG, CNG (in minutes)



To find the adjusted post-test means difference among the groups post hoc analysis was performed.

Table 14

LSD post-hoc analysis of cardiovascular endurance among the three experimental groups and control group

(I) Groups	(J) Groups	Mean Difference (I-J)	Sig.
WEG	PMG	0.194	.204
	COG	-3.28*	.036
	CNG	.314*	.043
PMG	COG	-.134	.378
	CNG	.508*	.002
COG	CNG	-.642*	.000

*Significant at 0.05 level (p<0.05)
WEG – Water exercises group, PMG – Plyometric exercises group, COG – Combination of water and plyometric exercises group, CNG – Control group

The above table 14 shows significant difference in means on cardiovascular endurance among Water exercises and Combination of water and plyometric exercises groups (MD = 0.328, Sig. = 0.036), Water exercises and Control groups (MD = 0.314, Sig. = 0.043) Plyometric exercises and Control groups (MD = 0.508, Sig. = 0.002) and Combination of water and plyometric exercises and Control groups (MD = 0.642, Sig. = 0.000) at 0.05 level of significance, as the significance value obtained were all less than 0.05. On the other hand, no significant difference was found among Water exercises and Plyometric exercises groups (MD = 0.194, Sig. = 0.204) and between Plyometric exercises and Combination of water and plyometric exercises groups (MD = 0.134, Sig. = 0.378).

Table 15

Analysis of covariance done on muscular endurance of water exercises training group (WEG), plyometric exercises training group (PMG), combination of water and plyometric exercises training group (COG) and control group (CNG)

Variables	Group	Mean	Test	Sources of variance	Sum of squares	Mean square	df	F-ratio
Muscular endurance	WEG	37.30	Pre-test	between	26.675	8.892	3	.851
	PMG	37.30						
	COG	38.00		within	376.3	10.453	36	
	CNG	39.30						
	WEG	43.2	Post-test	between	709.675	236.558	3	25.248*
	PMG	47.4						
	COG	47.9		within	337.3	9.369	36	
	CNG	37.4						
	WEG	43.34	Adjusted post-test	between	723.075	241.025	3	26.202*
	PMG	47.54						
	COG	47.90		within	321.951	9.199	35	
	CNG	37.13						

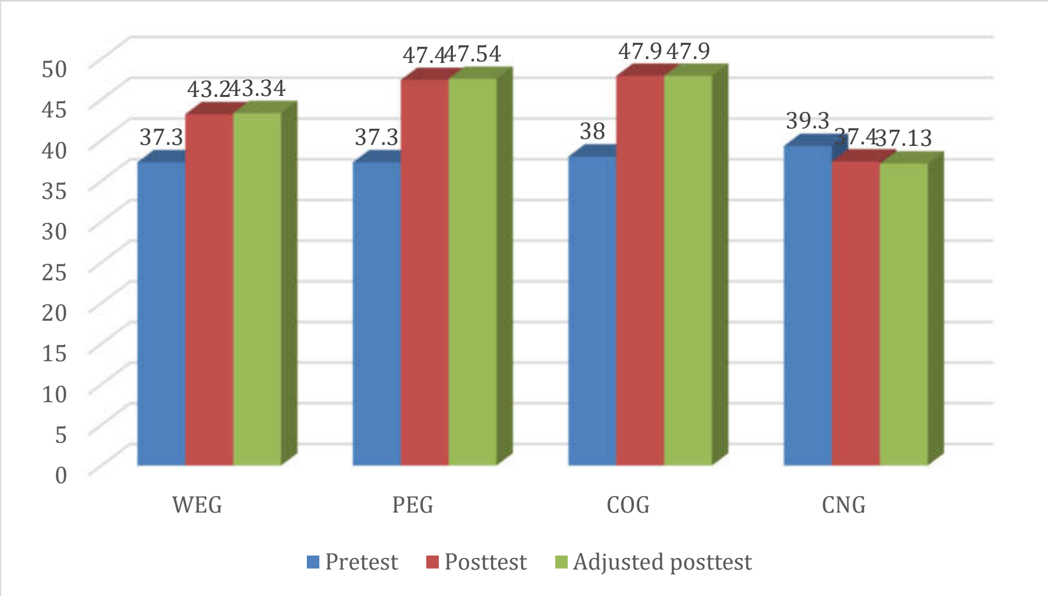
*significant at 0.05 level (p<0.05) (Table value = 3, 35 and 3, 36df = 2.87)

As noted in table 15 the obtained f-ratio value of 0.851 showed no significant difference among the groups on muscular endurance. The obtained f-ratio value of post-test scores of 25.248 at 0.05 level of significance showed significant different among the groups on muscular endurance. The obtained f-ratio value of adjusted post-test scores of 26.202 showed significant difference among the groups. Hence, the null hypothesis was rejected and there was a significant difference among the groups on muscular endurance at 0.05 level of significance at 3,35 df.

For the better understanding, graphical diagram of muscular endurance mean values of various groups was given in figure 3.

Figure 3

Pre-test, post-test, adjusted post-test muscular endurance mean values of WEG, PMG, COG, CNG (in counts)



To find the adjusted post-test means difference among the groups post hoc analysis was performed.

Table 16

LSD post-hoc analysis of muscular endurance among the three experimental groups and control group

(I) Groups	(J) Groups	Mean Difference (I-J)	Sig.
WEG	PMG	-4.200*	.004
	COG	4.559*	.002
	CNG	-6.204*	.000
PMG	COG	.359	.794
	CNG	-10.404*	.000
COG	CNG	10.763*	.000

*Significant at 0.05 level ($p<0.05$)
WEG – Water exercises group, PMG – Plyometric exercises group, COG – Combination of water and plyometric exercises group, CNG – Control group

The above table 16 shows significant difference in means on muscular endurance among Water exercises and Plyometric exercises groups (MD = 4.200, Sig. = 0.004), Water exercises and Combination of water and plyometric exercises groups (MD = 4.559, Sig. = 0.002), Water exercises and Control groups (MD = 6.204, Sig. = 0.000), Plyometric exercises and Control groups (MD = 10.404, Sig. = 0.000) and Combination of water and plyometric exercises and Control groups (MD = 10.763, Sig. = 0.000) at 0.05 level of significance, as the significance value obtained were all less than 0.05. On the other hand, no significant difference was found among Plyometric exercises and Combination of water and plyometric exercises groups (MD = 0.359, Sig. = 0.794).

Table 17

Analysis of covariance done on flexibility of Water exercises training group (WEG), Plyometric exercises training group (PMG), Combination of water and plyometric exercises training group (COG) and Control group (CNG)

Variables	Group	Mean	Test	Sources of variance	Sum of squares	Mean square	df	F-ratio
Flexibility	WEG	7.70	Pre-test	between	33.9	11.3	3	1.474
	PMG	7.70						
	COG	8.90		within	276.0	7.667	36	
	CNG	9.90						
	WEG	13.6	Post-test	between	1151.28	383.76	3	44.322*
	PMG	15.0						
	COG	24.9		within	311.7	8.658	36	
	CNG	10.6						
	WEG	14.0	Adjusted post-test	between	1168	389.3	3	54.267*
	PMG	15.40						
	COG	24.74		within	251.13	7.175	35	
	CNG	9.97						

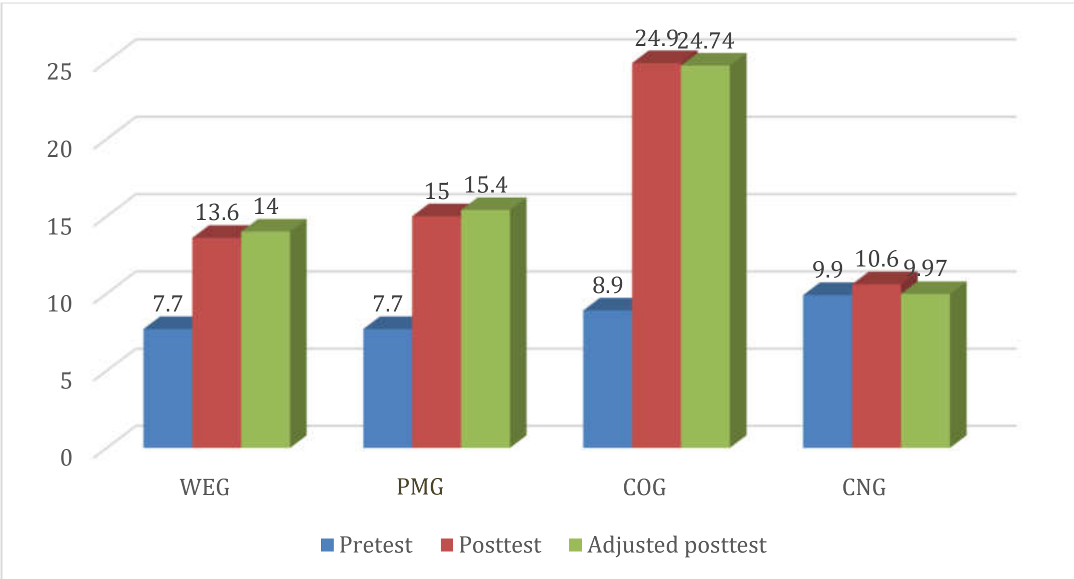
*significant at 0.05 level ($p<0.05$) (Table value = 3, 35 and 3, 36df = 2.87)

As denoted in table 17 the obtained f-ratio value of 1.474 showed no significant difference among the groups on flexibility. The obtained f-ratio value of post-test scores of 44.322 at 0.05 level of significance showed significant different among the groups on flexibility. The obtained f-ratio value of adjusted post-test scores of 54.267 showed significant difference among the groups. Hence, the null hypothesis was rejected and there was a significant difference among the groups on flexibility at 0.05 level of significance at 3,35 df.

For the better understanding, graphical diagram of flexibility mean values of various groups was given in figure 4.

Figure 4

Pre-test, post-test, adjusted post-test flexibility mean values of WEG, PMG, COG, CNG (in cms)



To find the adjusted post-test means difference among the groups post hoc analysis was performed.

Table 18

LSD post-hoc analysis of flexibility among the three experimental groups and control group

(I) Groups	(J) Groups	Mean Difference (I-J)	Sig.
WEG	PMG	-1.400	.250
	COG	10.738*	.000
	CNG	-4.031*	.003
PMG	COG	9.338*	.000
	CNG	-5.431*	.000
COG	CNG	14.768*	.000

*Significant at 0.05 level ($p<0.05$)
WEG – Water exercises group, PMG – Plyometric exercises group, COG – Combination of water and plyometric exercises group, CNG – Control group

The above table 18 shows significant difference in means on flexibility among Water exercises and Combination of water and plyometric exercises groups (MD = 10.738, Sig. = 0.000), Water exercises and Control groups (MD = 4.031, Sig. = 0.003), Plyometric exercises and Combination of water and plyometric exercises groups (MD = 9.338, Sig. = 0.000), Plyometric exercises and Control groups (MD = 5.431, Sig. = 0.000) and Combination of water and plyometric exercises and Control groups (MD = 14.768, Sig. = 0.000) at 0.05 level of significance, as the significance value obtained were all less than 0.05. On the other hand, no significant difference was found among Water exercises and Plyometric exercises groups (MD = 1.400, Sig. = 0.250).

Table 19

Analysis of covariance done on speed of water exercises training group (WEG), plyometric exercises training group (PMG), combination of water and plyometric exercises training group (COG) and control group (CNG)

Variables	Group	Mean	Test	Sources of variance	Sum of squares	Mean square	Df	F-ratio
Speed	WEG	7.19	Pre-test	between	.363	.121	3	.592
	PMG	6.96						
	COG	7.19		within	7.347	.204	36	
	CNG	7.15						
	WEG	6.95	Post-test	between	4.529	1.510	3	16.269*
	PMG	6.61						
	COG	6.24		within	3.341	.093	36	
	CNG	7.12						
	WEG	6.92	Adjusted post-test	between	4.495	1.498	3	26.446*
	PMG	6.68						
	COG	6.21		within	1.983	.057	35	
	CNG	7.11						

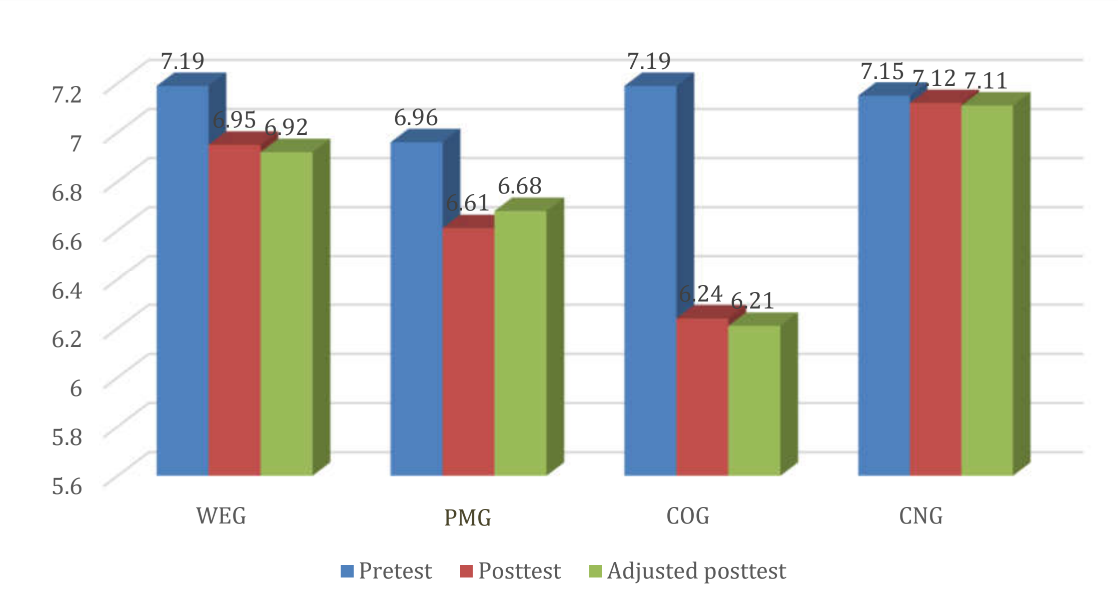
*significant at 0.05 level ($p<0.05$) (Table value = 3, 35 and 3, 36df = 2.87)

As shown in table 19 the obtained f-ratio value of 0.592 showed no significant difference among the groups on speed. The obtained f-ratio value of post-test scores of 16.269 at 0.05 level of significance showed significant different among the groups on speed. The obtained f-ratio value of adjusted post-test scores of 6.446 showed significant difference among the groups. Hence, the null hypothesis was rejected and there was a significant difference among the groups on speed at 0.05 level of significance at 3,35 df.

For the better understanding, graphical diagram of speed mean values of various groups was given in figure 5.

Figure 5

Pre-test, post-test, adjusted post-test speed mean values of WEG, PMG, COG, CNG (in seconds)



To find the adjusted post-test means difference among the groups post hoc analysis was performed.

Table 20

LSD post-hoc analysis of speed among the three experimental and control group

(I) Groups	(J) Groups	Mean Difference (I-J)	Sig.
WEG	PMG	.238*	.035
	COG	-.707*	.000
	CNG	.189	.084
PMG	COG	-.469*	.000
	CNG	.427*	.000
COG	CNG	-.896*	.000

*Significant at 0.05 level ($p<0.05$)
WEG – Water exercises group, PMG – Plyometric exercises group, COG – Combination of water and plyometric exercises group, CNG – Control group

The above table 20 shows significant difference in means on speed among Water exercises and Plyometric exercises groups (MD = .238, Sig. = 0.035), Water exercises and Combination of water and plyometric exercises groups (MD = .707, Sig. = 0.000), Plyometric exercises and Combination of water and plyometric exercises groups (MD = .469, Sig. = 0.000), Plyometric exercises and Control groups (MD = .427, Sig. = 0.000) and Combination of water and plyometric exercises and Control groups (MD = .896, Sig. = 0.000) at 0.05 level of significance, as the significance value obtained were all less than 0.05. On the other hand, no significant difference was found among Water exercises and Control groups (MD = .189, Sig. = 0.084).

Table 21

Analysis of covariance done on explosive power of water exercises training group (WEG), plyometric exercises training group (PMG), combination of water and plyometric exercises training group (COG) and control group (CNG)

Variables	Group	Mean	Test	Sources of variance	Sum of squares	Mean square	df	F-ratio
Explosive power	WEG	1.97	Pre-test	between	.007	.002	3	.905
	PMG	1.97						
	COG	1.97		within	.090	.002	36	
	CNG	1.94						
	WEG	2.09	Post-test	between	.758	.253	3	21.216*
	PMG	2.21						
	COG	2.31		within	.429	.012	36	
	CNG	1.94						
	WEG	2.09	Adjusted post-test	between	.710	.237	3	19.335*
	PMG	2.21						
	COG	2.31		within	.429	.012	35	
	CNG	1.94						

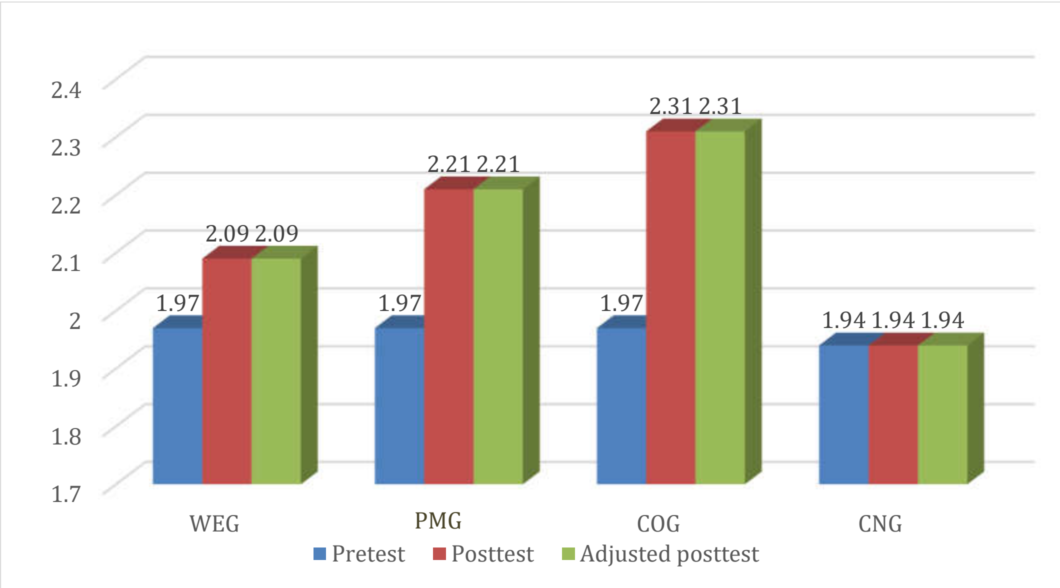
*significant at 0.05 level ($p<0.05$) (Table value = 3, 35 and 3, 36df = 2.87)

As shown in table 21 the obtained f-ratio value of 0.905 showed no significant difference among the groups on explosive power. The obtained f-ratio value of post-test scores of 21.216 at 0.05 level of significance showed significant different among the groups on explosive power. The obtained f-ratio value of adjusted post-test scores of 19.335 showed significant difference among the groups. Hence, the null hypothesis was rejected and there was a significant difference among the groups on explosive power at 0.05 level of significance at 3,35 df.

For the better understanding, graphical diagram of explosive power mean values of various groups was given in figure 6.

Figure 6

Pre-test, post-test, adjusted post-test explosive power mean values of WEG, PMG, COG, CNG (in mts)



To find the adjusted post-test means difference among the groups post hoc analysis was performed.

Table 22

LSD post-hoc analysis of explosive power among the three experimental groups and control group

(I) Groups	(J) Groups	Mean Difference (I-J)	Sig.
WEG	PMG	-.116*	.025
	COG	.218*	.000
	CNG	-.151*	.005
PMG	COG	.102*	.047
	CNG	-.267*	.000
COG	CNG	.369*	.000

*Significant at 0.05 level (p<0.05)
WEG – Water exercises group, PMG – Plyometric exercises group, COG – Combination of water and plyometric exercises group, CNG – Control group

The above table 22 shows significant difference in means on explosive power among Water exercises and Plyometric exercises groups (MD = .116, Sig. = 0.025), Water exercises and Combination of water and plyometric exercises groups (MD = .218, Sig. = 0.000), Water exercises and Control groups (MD = .151, Sig. = 0.005), Plyometric exercises and Combination of water and plyometric exercises groups (MD = 0.102, Sig. = 0.047), Plyometric exercises and Control groups (MD = 0.267, Sig. = 0.000) and Combination of water and plyometric exercises and Control groups (MD = 369, Sig. = 0.000) at 0.05 level of significance, as the significance value obtained were all less than 0.05.

Table 23

Analysis of covariance done on agility of water exercises training group (WEG), plyometric exercises training group (PMG), combination of water and plyometric exercises training group (COG) and control group (CNG)

Variables	Group	Mean	Test	Sources of variance	Sum of squares	Mean square	df	F-ratio
Agility	WEG	11.04	Pre-test	between	.003	.001	3	.070
	PMG	11.03						
	COG	11.03		within	.471	.013	36	
	CNG	11.05						
	WEG	10.90	Post-test	between	5.415	1.805	3	48.990*
	PMG	10.72						
	COG	10.07		within	1.326	.037	36	
	CNG	11.03						
	WEG	10.90	Adjusted post-test	between	5.26	1.753	3	58.180*
	PMG	10.73						
	COG	10.08		within	1.055	.030	35	
	CNG	11.02						

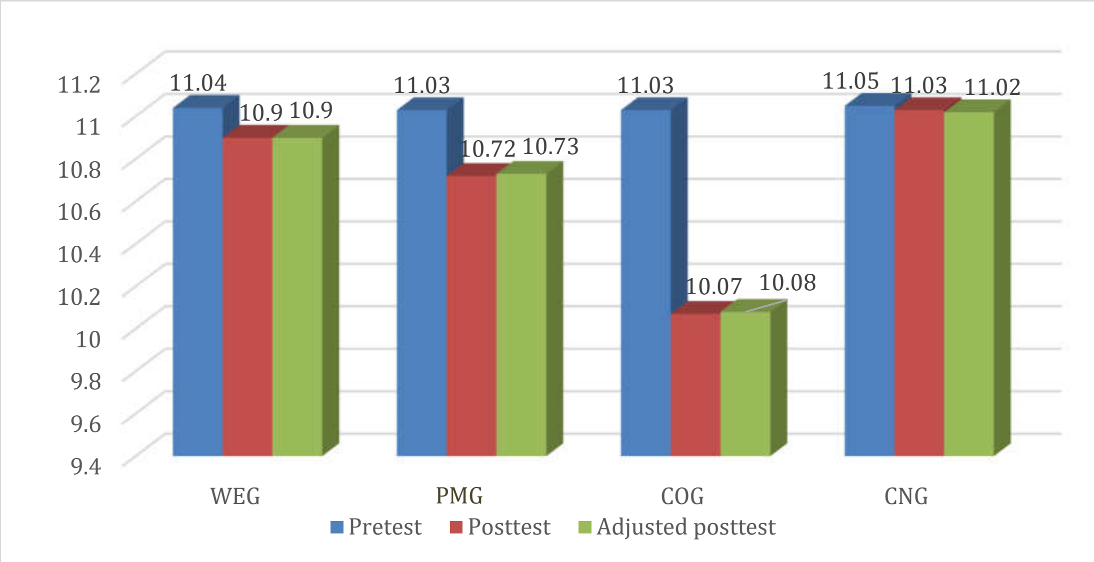
*significant at 0.05 level (p<0.05) (Table value = 3, 35 and 3, 36df = 2.87)

As shown in table 23 the obtained f-ratio value of 0.070 showed no significant difference among the groups on agility. The obtained f-ratio value of post-test scores of 48.990 at 0.05 level of significance showed significant different among the groups on agility. The obtained f-ratio value of adjusted post-test scores of 58.180 showed significant difference among the groups. Hence, the null hypothesis was rejected and there was a significant difference among the groups on agility at 0.05 level of significance at 3,35 df.

For the better understanding, graphical diagram of agility mean values of various groups was given in figure 7.

Figure 7

Pre-test, post-test, adjusted post-test agility mean values of WEG, PMG, COG, CNG (in seconds)



To find the adjusted post-test means difference among the groups post hoc analysis was performed.

Table 24

LSD post-hoc analysis of agility among the three experimental groups and control group

(I) Groups	(J) Groups	Mean Difference (I-J)	Sig.
WEG	PMG	.168*	.037
	COG	-.818*	.000
	CNG	.124	.118
PMG	COG	-.650*	.000
	CNG	.293*	.001
COG	CNG	-.943*	.000

*Significant at 0.05 level (p<0.05)
WEG – Water exercises group, PMG – Plyometric exercises group, COG – Combination of water and plyometric exercises group, CNG – Control group

The above table 24 shows significant difference in means on agility among Water exercises and Plyometric exercises groups (MD = 0.468, Sig. = 0.037), Water exercises and Combination of water and plyometric exercises groups (MD = 0.818, Sig. = 0.000), Plyometric exercises and Combination of water and plyometric exercises groups (MD = 0.650, Sig. = 0.000), Plyometric exercises and Control groups (MD = 0.293, Sig. = 0.001) and Combination of water and plyometric exercises and Control groups (MD = 0.293, Sig. = 0.001) at 0.05 level of significance, as the significance value obtained were all less than 0.05. On the other hand, no significant difference was found among Water exercises and Control groups (MD = 0.124, Sig. = 0.118).

Table 25

Analysis of covariance done on vital capacity of water exercises training group (WEG), plyometric exercises training group (PMG), combination of water and plyometric exercises training group (COG) and control group (CNG)

Variables	Group	Mean	Test	Sources of variance	Sum of squares	Mean square	df	F-ratio
Vital capacity	WEG	602	Pre-test	between	27.5	9.167	3	.282
	PMG	603						
	COG	604		within	1170	32.5	36	
	CNG	602						
	WEG	840	Post-test	between	1842750	614250	3	54.600*
	PMG	930						
	COG	1200		within	405000	11250	36	
	CNG	600						
	WEG	840.19	Adjusted post-test	between	1803928	601309	3	51.975*
	PMG	929.94						
	COG	1200		within	404923	11569	35	
	CNG	600.19						

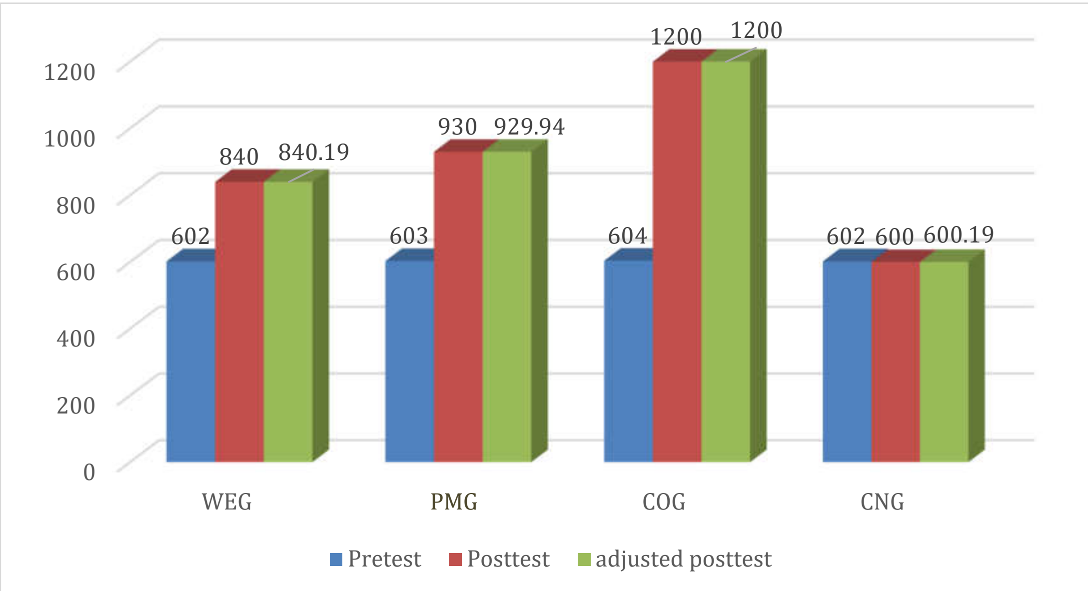
*significant at 0.05 level ($p<0.05$) (Table value = 3, 35 and 3, 36df = 2.87)

As given in table 25 the obtained f-ratio value of 0.282 showed no significant difference among the groups on vital capacity. The obtained f-ratio value of post-test scores of 54.600 at 0.05 level of significance showed significant different among the groups on vital capacity. The obtained f-ratio value of adjusted post-test scores of 51.975 showed significant difference among the groups. Hence, the null hypothesis was rejected and there was a significant difference among the groups on vital capacity at 0.05 level of significance at 3,35 df.

For the better understanding, graphical diagram of vital capacity mean values of various groups was given in figure 8.

Figure 8

Pre-test, post-test, adjusted post-test vital capacity mean values of WEG, PMG, COG, CNG (in ml/kg/Min)



To find the adjusted post-test means difference among the groups post hoc analysis was performed.

Table 26

LSD post-hoc analysis of vital capacity among the three experimental groups and control group

(I) Groups	(J) Groups	Mean Difference (I-J)	Sig.
WEG	PMG	-89.744	.071
	COG	359.487*	.000
	CNG	-240.000*	.000
PMG	COG	269.744*	.000
	CNG	-329.744*	.000
COG	CNG	599.487*	.000

*Significant at 0.05 level ($p<0.05$)
WEG – Water exercises group, PMG – Plyometric exercises group, COG – Combination of water and plyometric exercises group, CNG – Control group

The above table 26 shows significant difference in means on vital capacity among Water exercises and Combination of water and plyometric exercises groups (MD = 359.487, Sig. = 0.000), Water exercises and Control groups (MD = 240.000, Sig. = 0.000), Plyometric exercises and Combination of water and plyometric exercises groups (MD = 269.744, Sig. = 0.000), Plyometric exercises and Control groups (MD = 329.744, Sig. = 0.001) and Combination of water and plyometric exercises and Control groups (MD = 599.487, Sig. = 0.000) at 0.05 level of significance, as the significance value obtained were all less than 0.05. On the other hand, no significant difference was found among Water exercises and Plyometric exercises groups (MD = 89.744, Sig. = 0.071).

Table 27

Analysis of covariance done on pulse rate of water exercises training group (WEG), plyometric exercises training group (PMG), combination of water and plyometric exercises training group (COG) and control group (CNG)

Variables	Group	Mean	Test	Sources of variance	Sum of squares	Mean square	df	F-ratio
Pulse rate	WEG	68.8	Pre-test	between	.275	.092	3	.007
	PMG	68.6						
	COG	68.7		within	445.7	12.381	36	
	CNG	68.8						
	WEG	66	Post-test	between	50.9	16.967	3	5.082*
	PMG	66.1						
	COG	65.9		within	120.200	3.339	36	
	CNG	68.6						
	WEG	65.99	Adjusted post-test	between	50.462	16.821	3	5.161*
	PMG	66.12						
	COG	65.90		within	114.063	3.259	35	
	CNG	68.60						

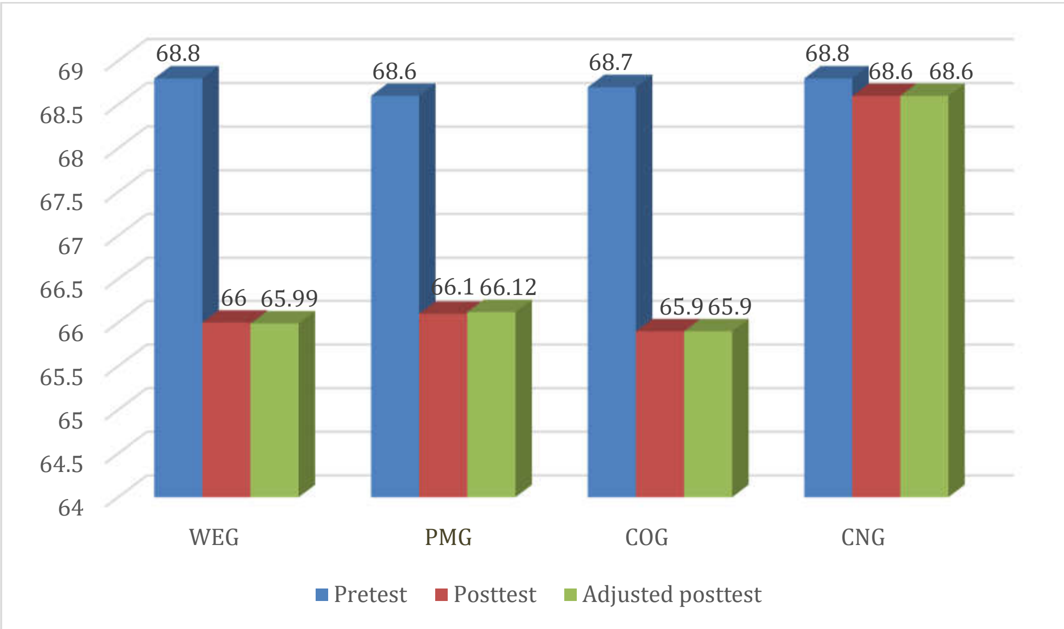
*significant at 0.05 level ($p<0.05$) (Table value = 3, 35 and 3, 36df = 2.87)

As noted in table 27 the obtained f-ratio value of 0.007 showed no significant difference among the groups on pulse rate. The obtained f-ratio value of post-test scores of 5.082 at 0.05 level of significance showed significant different among the groups on pulse rate. The obtained f-ratio value of adjusted post-test scores of 5.161 showed significant difference among the groups. Hence, the null hypothesis was rejected and there was a significant difference among the groups on pulse rate at 0.05 level of significance at 3,35 df.

For the better understanding, graphical diagram of pulse rate mean values of various groups was given in figure 9.

Figure 9

Pre-test, post-test, adjusted post-test pulse rate mean values of WEG, PMG, COG, CNG (in counts per minute)



To find the adjusted post-test means difference among the groups post hoc analysis was performed.

Table 28

LSD post-hoc analysis of pulse rate among the three experimental groups and control group

(I) Groups	(J) Groups	Mean Difference (I-J)	Sig.
WEG	PMG	-.123	.879
	COG	-.088	.914
	CNG	2.600*	.003
PMG	COG	-.212	.795
	CNG	2.477*	.004
COG	CNG	-2.688*	.002

*Significant at 0.05 level ($p<0.05$)
WEG – Water exercises group, PMG – Plyometric exercises group, COG – Combination of water and plyometric exercises group, CNG – Control group

The above table 28 shows significant difference in means on pulse rate among Water exercises and Control groups (MD = 2.600, Sig. = 0.003), Plyometric exercises and Control groups (MD = 2.477, Sig. = 0.004) and Combination of water and plyometric exercises and Control groups (MD = 2.688, Sig. = 0.002) at 0.05 level of significance, as the significance value obtained were all less than 0.05. On the other hand, no significant difference was found among Water exercises and Plyometric exercises groups (MD = 0.123, Sig. = 0.879), Water exercises and Combination of water and plyometric exercises groups (MD = 0.088, Sig. = 0.914) and Plyometric exercises and Combination of water and plyometric exercises groups (MD = 0.212, Sig. = 0.795).

Table 29

Analysis of covariance done on breath holding capacity of water exercises training group (WEG), plyometric exercises training group (PMG), combination of water and plyometric exercises training group (COG) and control group (CNG)

Variables	Group	Mean	Test	Sources of variance	Sum of squares	Mean square	df	F-ratio
Breath holding capacity	WEG	46	Pre-test	between	7.675	2.558	3	.137
	PMG	46.30						
	COG	47		within	670.1	18.614	36	
	CNG	47						
	WEG	54.6	Post-test	between	980.075	326.692	3	15.015*
	PMG	55.6						
	COG	61.1		within	783.3	21.758	36	
	CNG	47.2						
	WEG	54.94	Adjusted post-test	between	990.285	330.095	3	20.953*
	PMG	55.76						
	COG	60.85		within	551.404	15.754	35	
	CNG	46.95						

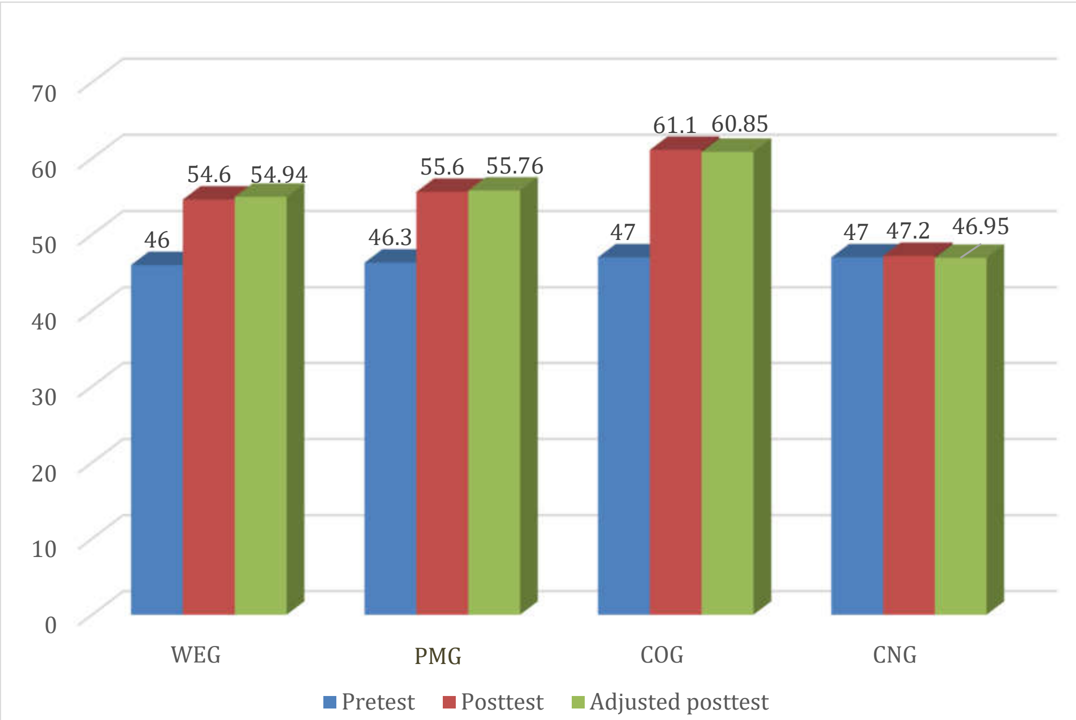
*significant at 0.05 level ($p<0.05$) (Table value = 3, 35 and 3, 36df = 2.87)

As mentioned in table 29 the obtained f-ratio value of 0.137 showed no significant difference among the groups on breath holding capacity. The obtained f-ratio value of post-test scores of 15.015 at 0.05 level of significance showed significant different among the groups on breath holding capacity. The obtained f-ratio value of adjusted post-test scores of 20.953 showed significant difference among the groups. Hence, the null hypothesis was rejected and there was a significant difference among the groups on breath holding capacity at 0.05 level of significance at 3,35 df.

For the better understanding, graphical diagram of breath holding capacity mean values of various groups was given in figure 10.

Figure 10

Pre-test, post-test, adjusted post-test breath holding capacity mean values of WEG, PMG, COG, CNG (in seconds)



To find the adjusted post-test means difference among the groups post hoc analysis was performed.

Table 30

LSD post-hoc analysis of breath holding capacity among the three experimental groups and control group

(I) Groups	(J) Groups	Mean Difference (I-J)	Sig.
WEG	PMG	-.824	.646
	COG	5.912*	.002
	CNG	-7.988*	.000
PMG	COG	5.088*	.007
	CNG	-8.812*	.000
COG	CNG	13.900*	.000

*Significant at 0.05 level (p<0.05)
WEG – Water exercises group, PMG – Plyometric exercises group, COG – Combination of water and plyometric exercises group, CNG – Control group

The above table 30 shows significant difference in means on breath holding capacity among Water exercises and Combination of water and plyometric exercises groups (MD = 5.912, Sig. = 0.002), Water exercises and Control groups (MD = 7.988, Sig. = 0.000), Plyometric exercises and Combination of water and plyometric exercises groups (MD = 5.088, Sig. = 0.007), Plyometric exercises and Control groups (MD = 8.812, Sig. = 0.000) and Combination of water and plyometric exercises and Control groups (MD = 13.900, Sig. = 0.000) at 0.05 level of significance, as the significance value obtained were all less than 0.05. On the other hand, no significant difference was found among Water exercises and Plyometric exercises groups (MD = 0.824, Sig. = 0.646).

Table 31

Analysis of covariance done on triple jump performance of water exercises training group (WEG), plyometric exercises training group (PMG), combination of water and plyometric exercises training group (COG) and control group (CNG)

Variables	Group	Mean	Test	Sources of variance	Sum of squares	Mean square	df	F-ratio
Triple jump performance	WEG	11.44	Pre-test	between	.005	.002	3	.018
	PMG	11.44						
	COG	11.41		within	3.645	.101	36	
	CNG	11.42						
	WEG	11.89	Post-test	between	5.502	1.834	3	16.732*
	PMG	12.16						
	COG	12.45		within	3.946	.110	36	
	CNG	11.44						
	WEG	11.89	Adjusted post-test	between	5.510	1.837	3	16.970*
	PMG	12.16						
	COG	12.45		within	3.788	.108	35	
	CNG	11.44						

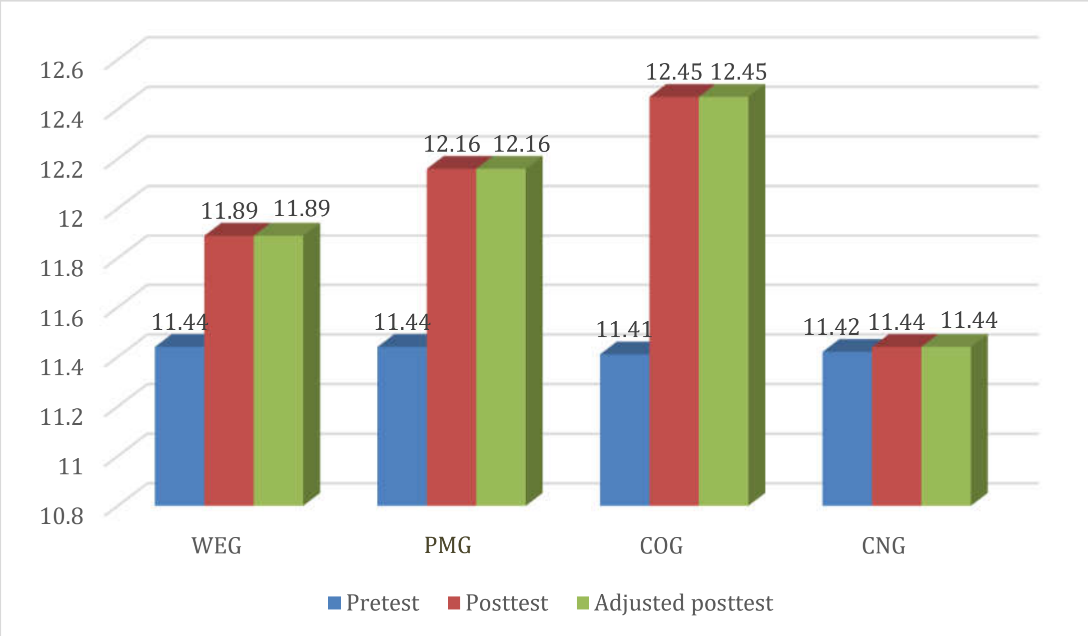
*significant at 0.05 level (p<0.05) (Table value = 3, 35 and 3, 36df = 2.87)

As denoted in table 31 the obtained f-ratio value of 0.018 showed no significant difference among the groups on triple jump performance. The obtained f-ratio value of post-test scores of 16.732 at 0.05 level of significance showed significant different among the groups on triple jump performance. The obtained f-ratio value of adjusted post-test scores of 16.970 showed significant difference among the groups. Hence, the null hypothesis was rejected and there was a significant difference among the groups on triple jump performance at 0.05 level of significance at 3,35 df.

For the better understanding, graphical diagram of triple jump performance mean values of various groups was given in figure 11.

Figure 11

Pre-test, post-test, adjusted post-test triple jump performance mean values of WEG, PMG, COG, CNG (in meters)



To find the adjusted post-test means difference among the groups post hoc analysis was performed.

Table 32

LSD post-hoc analysis of triple jump performance among the three experimental groups and control group

(I) Groups	(J) Groups	Mean Difference (I-J)	Sig.
WEG	PMG	-.268	.078
	COG	.566*	.000
	CNG	-.444*	.005
PMG	COG	.298	.050
	CNG	-.712*	.000
COG	CNG	1.010*	.000

*Significant at 0.05 level ($p<0.05$)
WEG – Water exercises group, PMG – Plyometric exercises group, COG – Combination of water and plyometric exercises group, CNG – Control group

The above table 32 shows significant difference in means on triple jump performance among Water exercises and Combination of water and plyometric exercises groups (MD = 0.566, Sig. = 0.000), Water exercises and Control groups (MD = 0.444, Sig. = 0.005), Plyometric exercises and Control groups (MD = 0.712, Sig. = 0.000) and Combination of water and plyometric exercises and Control groups (MD = 1.010, Sig. = 0.000) at 0.05 level of significance, as the significance value obtained were all less than 0.05. On the other hand, no significant difference was found among Water exercises and Plyometric exercises groups (MD = 0.268, Sig. = 0.078) and Plyometric exercises and Combination of water and plyometric exercises groups (MD = 0.298, Sig. = 0.050).

4.3 Discussion on physical variables

The purpose of this study was to find out the effect of water exercises, plyometric exercises and a combination of both on selected physical, physiological and performance variables of triple jumpers. The physical variables cardiovascular endurance, muscular endurance, flexibility, speed, explosive power and agility were selected and statistically analyzed. The level of significance was fixed as 0.05 level.

Water exercises training group, plyometric exercises training group and combination of water and plyometric exercises group showed significant improvement than the control group on cardiovascular endurance. Post-test adjusted mean values of the water exercises training group (WEG), plyometric exercises training group (PMG), combination of water and plyometric exercises training group (COG) and control group (CNG) were 6.62, 6.43, 6.30 and 6.94 respectively.

Combination of water and plyometric exercises training group (COG) and plyometric exercises training group (PMG) showed better improvement than the other water exercises group and control group.

The result of the study was in agreement with the findings of the study conducted by **C. J. Gatti, R. J. Young, and H. L. Glad (1979)** that water exercises improved the vo2max and cardiovascular endurance.

The result of the study was in accordance with the findings of the study conducted by **Martel Gregory F., et al (2005)** that plyometric exercise training improved the cardiovascular endurance, muscular strength and jumping ability.

The findings of the study was in relation to the findings of **Hirofumi Tanaka (2009)** that swimming aquatic exercises improved the heart and lungs capacity thereby increased the cardiovascular endurance.

Water exercises training group, plyometric exercises training group and combination of water, plyometric exercises group showed significant improvement than the control group on muscular endurance. Post-test adjusted mean values of the water exercises training group (WEG), plyometric exercises training group (PMG), combination of water and plyometric exercises training group (COG) and control group (CNG) were 43.34, 47.54, 47.90 and 37.13 respectively.

Combination of water and plyometric exercises training group (COG) and plyometric training group (PMG) showed better improvement on muscular endurance than the other two groups water exercises training group and control group.

The result of the present research was in line with the findings of **Usman T and K B Shenoy (2015)** that plyometric and aquatic exercise training improved the muscular endurance and speed endurance.

Water exercises training group, plyometric exercises training group and combination of water and plyometric exercises training group showed significant improvement than the control group on flexibility. Post-test adjusted mean values of the water exercises training group (WEG), plyometric exercises training group (PMG), combination of water and plyometric exercises training group (COG) and control group (CNG) were 14, 15.4, 24,74 and 9.97 respectively.

Combination of water exercises training and plyometric training group (COG) showed better improvement on the physical variable flexibility than the water exercises training group, plyometric exercises training group and control group.

The result of the study was in agreement with the findings of the study conducted by **Fabricius and David Leslie (2011)** that plyometric training and aquatic training developed the physical variables muscular endurance, agility, flexibility.

Water exercises training group, plyometric exercises training group and combination of water and plyometric exercises group showed significant improvement than the control group on speed. Post-test adjusted mean values of the water exercises training group (WEG), plyometric exercises training group (PMG), combination of water and plyometric exercises training group (COG) and control group (CNG) were 6.92, 6.68, 6.21, 7.11 respectively.

Water exercises training group, plyometric exercises training group and combination of both training group showed better improvement on speed than the control group. Combination of both training group (COG) showed better improvement than the other two experimental groups.

The findings of the study was in line with the findings of **Jayakumar N and Asath Ali Khan J (2023)** that plyometric training and combination of training improved the speed and vital capacity of the men players.

Water exercises training group, plyometric exercises training group and combination of water and plyometric exercises group showed significant improvement than the control group on explosive power. Post-test adjusted mean values of the water exercises training group (WEG), plyometric exercises training group (PMG), combination of water and plyometric exercises training group (COG) and control group (CNG) were 2.09, 2.21, 2.31, 1.94 respectively.

There was better improvement on explosive power due to water exercises, plyometric exercises and combination of both water and plyometric exercises training. Combination of water and plyometric exercises training group (COG) showed better improvement on explosive power than the other experimental groups.

The result of the present study was in accordance with the findings of the study conducted by **Rodrigo Ramirez-Campillo, et. al., (2021)** that plyometric training developed the jumping ability and explosive power of the subjects.

Water exercises training group, plyometric exercises training group and combination of water and plyometric exercises training group showed significant improvement than the control group on agility. Post-test adjusted mean values of the water exercises training group (WEG), plyometric exercises training group (PMG), combination of water and plyometric exercises training group (COG) and control group (CNG) were 10.9, 10.73, 10.08 and 11.02 respectively.

Combination of both water exercise and plyometric exercises training group (COG) showed better development on agility than the control group and other experimental groups.

The findings of the present study were in accordance with the findings of **Mathiyazhagan M and PJ Sebastian (2018)** that the plyometric training and water combination training improved the speed, agility and explosive power.

Cardiovascular endurance **(2018)** is the capacity of the cardiovascular and respiratory systems to deliver oxygen to the working muscles for sustained periods of energy production. Cardiovascular endurance is the body's physical capacity to supply fuel and eliminate wasted in order to perform large muscle movement over a prolonged period of time. It was achieved by the regular water exercise and plyometric exercise training.

Water (**Karl knopf, 2023)** is denser than air, water can apply up to 12 times greater resistance. Water resistance properly can benefit the subjects to develop the physical variables. Buoyancy gives water exercise its 'soft' capacity which reduces compression and weight bearing on joints. It reduces the risk of injury and increases the mobility. Such characteristics of water exercise increased the flexibility and range of movement of joint. Drag and turbulence are beneficial tools for increasing resistance and building strong physical fitness variables.

Lori Thein Brody and Paula Richley Geigle (2009) hydrostatic pressure, buoyancy, thermal influence, viscosity, drag and turbulence increased the somatosensory inut, motor input and other musculoskeletal functions. Cardiovascular efficiency was increased when standing in the depth upto hip level.

Physical variables cardiovascular endurance, muscular endurance, flexibility, speed, explosive power and agility were significantly influenced by 12 weeks of water exercises training and plyometric training. Buoyancy of the water and drag created resistance to the working muscles of the body while performing exercises inside the water. Resistance to the skeletal muscle fiber increased the efficiency of contraction, neural transmission and blood flow to the fibers. Plyometric exercises made significant changes on the explosive power by strengthening the lower extremity muscles. Increased muscle strength and cardiovascular efficiency in turn increased the speed and agility. Being agile is the direct proportion of effective myoneural efficiency. Combination of water exercises and plyometric exercises significantly influenced the selected physical variables of boys triple jumpers in the age group of 15 to 17 years.

4.4 Discussion on physiological variables

The purpose of this study was to find out the effect of water exercises, plyometric exercises and a combination of both on selected physical, physiological and performance variables of triple jumpers. The physiological variables vital capacity, pulse rate and breath holding capacity were selected and statistically analyzed. The level of significance was fixed as 0.05 level.

Water exercises training group, plyometric exercises training group and combination of water and plyometric exercises group showed significant improvement than the control group on vital capacity. Post-test adjusted mean values of the water exercises training group (WEG), plyometric exercises training group (PMG), combination of water and plyometric exercises training group (COG) and control group (CNG) were 840.19, 929.94, 1200 and 600.19 respectively.

Combination of both water exercises and plyometric exercises training group (COG) showed better development on vital capacity than the control group and other experimental groups.

The result of the study was in accordance with findings of **Rajaram Shankar (2019)** that plyometric exercise and aquatic exercise increased the vital capacity and improved the efficiency of cardiovascular system by reducing the rate of pulse.

The finding of the present research study was in line with the findings of **Sakti Ranjan Mishra, Palas Biswas and Dhananjoy Banerjee (2016)** that combination of plyometric training improved the vita capacity and reduced resting pulse rate.

John Parthiban I & K.A. Ramesh (2020) found that plyometric and aquatic exercise training developed the vital capacity of 18 to 21 years subjects. The findings are in line with the findings of present research study.

Water exercises training group, plyometric exercises training group and combination of water and plyometric exercises group showed significant improvement than the control group on pulse rate. Post-test adjusted mean values of the water exercises training group (WEG), plyometric exercises training group (PMG), combination of water and plyometric exercises training group (COG) and control group (CNG) were 65.99, 66.12, 65.90 and 68.60 respectively.

Experimental groups combination exercises group, water exercises group, plyometric exercises group showed better improvement on pulse rate than the control group.

The finding of the study was in agreement with the findings of **Patel Vijaybhai Devalbhai and Milan P. Patel (2020)** that 14 to 16 years subjects developed pulse rate and vital capacity after undergoing plyometric combination training.

Water exercises training group, plyometric exercises training group and combination of water, plyometric exercises group showed significant improvement than the control group on breath holding capacity. Post-test adjusted mean values of the water exercises training group (WEG), plyometric exercises training group (PMG), combination of water and plyometric exercises training group (COG) and control group (CNG) were 54.94, 55.76, 60.85 and 46.95 respectively.

Combination of both water exercises and plyometric exercises training group (COG) showed better improvement on breath holding capacity than the other two experimental groups and control group.

The result of the present was in accordance with the findings of the **Hutzler Y, A Chacham, U Bergman, A Szeinberg (1998)** that water exercises made a significant change on the breathing technique and respiratory efficiency. It enhanced the subjects to have better pulse rate and breath holding capacity.

Aquatic exercises works the heart and lungs. Combination of plyometric and water exercises trained the body to use oxygen more efficiently which is generally reflected in declining in the resting heart rate and breathing rate. It developed the efficiency of vital capacity, pulse rate and breath holding capacity (**Lori Thein Brody and Paula Richley Geigle, 2009**).

Lori Thein Brody and Paula Richley Geigle (2009) conducted a Research study and revealed that due to increasing level of immersion, significant decrements occurred in lung volume. The increased pressure on the lungs may force the subject to take a deeper breath to acquire sufficient air, and doing so could increase inspiratory reserve volume to counter the reduction in vital capacity. Minimum changes occurs in pulmonary flow resistance and partial pressure of venous oxygen and carbon dioxide.

Respiratory exchange ratio increases to compare with the land exercise. The adjustment of respiratory exchange ratio has been attributed to a redistribution of blood flow away from the lower extremities. Thus, the mechanism of Frank Starling reflex causes the heart to respond to myocardial fiber stretch with an increased in the contractile strength.

Research studies proved that pulse rate, breath holding capacity and vital capacity is the measure of efficiency of lungs. Being trained in water and land for 12 weeks improved the lungs efficiency of boys triple jumpers in the age group of 15 to 17 years. Combination of water exercise, plyometric exercise influenced the sensory and motor neurons, proprioceptors to increase the lungs function to carry more oxygen during exercise. Efficient lungs and heart decreased the resting pulse rate.

4.5 Discussion on performance variables

The purpose of this study was to find out the effect of water exercises, plyometric exercises and a combination of both on selected physical, physiological and performance variables of triple jumpers. The performance variable triple jump performance was selected and statistically analyzed. The level of significance was fixed as 0.05 level.

Water exercises training group, plyometric exercises training group and combination of water and plyometric exercises training group showed significant improvement than the control group on triple jump performance. Post-test adjusted mean values of the water exercises training group (WEG), plyometric exercises training group (PMG), combination of water and plyometric exercises training group (COG) and control group (CNG) were 11.89, 12.16, 12.45 and 11.44 respectively.

Combination of water and plyometric exercises training group (COG) showed better improvement on triple jump performance than the other two experimental groups and control group.

The findings of the present research study was in line with the findings of **Usman T and K B Shenoy (2015)**. Jumping performance was increased due to the influence of combination of both water exercise and plyometric training.

The result of the study was in accordance with the findings of **Gregory F Martel, (2005)** that plyometric training and aquatic combined training improved the jumpig performance. And, it was found that training reduced the risk of injuries.

Newton R U (1999) findings were in conformation with the findings of the present research study that plyometric and aquatic resistance training reduced the risk of injury and improved the jumping performance.

The result of the present study was in accordance with the findings of study conducted by **Jeremy M Sheppard (2011)** that jumping training such as plyometric exercise improved the jumping ability.

The result of the study was in line with the findings of the study **Elisa Dell Antonio, et.al., (2022)** that aquatic plyometric training for the period of six weeks developed the respiratory variables and jumping ability.

Neil pire (2006) found that plyometric exercise makes the neural and muscular system to work together to generate additional force. Plyometrics combined with aquatic exercises increases the myoneural efficiency and results in the increased jumping ability.

Muscle lengthening and shortening cycle enhances the ability of the muscle tendon unit to produce maximal force in the shortest amount of time to jump more. (**Donald A chu and Gregory D Myer, 2013**).

Combination of water and plyometric exercises influenced the triple jump performance of boys in the age group of 15 to 17 years. Triple jump involves hop, step and jump. Hundreds of muscles are involved in the technique. Efficiency of heart and lungs are important to supply blood, nutrients, oxygen and eliminate the fatigue causing substances from the working muscles. Combination of water exercises, plyometric exercises increased the physical and physiological efficiency of muscles, heart and lungs to hop, step and jump better. 12 weeks of combination training significantly altered the triple jump performance of 15 to 17 years boys.

Water exercises make the heart to work closely with the lungs, exercises improves lung capacity and breathing efficiency. Through this improvement in breathing processes, exercise also aids in the circulation of oxygen and nutrients throughout the body, thereby helping it operate more efficiently in the triple jump performance. Plyometric exercises have been found to be effective in improving the performance of athletes by enhancing the functioning of muscles, tendons, and nerves. This, in turn, can lead to improvements in running speed, jumping ability, and overall strength. Physical power, which is the ability to convert strength into speed rapidly, is an essential component of athletic performance. To increase power, it is crucial to strengthen the muscle fibers responsible for this conversion, commonly known as fast-twitch fibers.

Plyometric movements have been shown to stimulate fast-twitch fibers, leading to increased strength and even an increase in their number. The stronger the fast-twitch fiber, the faster the muscle contraction, which can be particularly beneficial for athletes looking to improve their performance. Additionally, plyometric exercises have been found to be effective for boys in the age group of 15 to 17 years, helping them achieve their peak triple performance.

In conclusion, plyometric exercises offer an effective means of improving athletic performance by enhancing the functioning of muscles, tendons, and nerves. The ability to convert strength into speed is a crucial aspect of athletic performance, and plyometric exercises can help strengthen fast-twitch fibers responsible for this conversion. Furthermore, these exercises are particularly useful for boys in the age range of 15 to 17 years, showcasing their effectiveness across all age groups.

4.6 Discussion on hypotheses of physical variables

1. It was mentioned in the first hypothesis that there would be significant difference on cardio-vascular endurance between the control and experimental groups. The statistical results shows that there is a significant difference on cardiovascular endurance between Water Exercises, plyometric exercises, and

combination of water and plyometric exercises groups at 0.05 level of confidence. Hence, the first hypothesis was accepted.

2. It was mentioned in the second hypothesis that there would be significant difference on muscular endurance between the control and experimental groups. The statistical results shows that there is a significant difference on muscular endurance between Water Exercises, plyometric exercises, and combination of water and plyometric exercises groups at 0.05 level of confidence. Hence, the second hypothesis was accepted.

3. It was mentioned in the third hypothesis that there would be significant difference on flexibility between the control and experimental groups. The statistical results shows that there is a significant difference on flexibility between Water Exercises, plyometric exercises, and combination of water and plyometric exercises groups at 0.05 level of confidence. Hence, the third hypothesis was accepted.

4. It was mentioned in the fourth hypothesis that there would be significant difference on speed between the control and experimental groups. The statistical results shows that there is a significant difference on speed between plyometric exercises, and combination of water and plyometric exercises groups at 0.05 level of confidence. Hence, the fourth hypothesis was partially accepted.

5. It was mentioned in the fifth hypothesis that there would be significant difference on explosive power between the control and experimental groups. The statistical results shows that there is a significant difference on explosive power between Water Exercises, plyometric exercises, and combination of water and plyometric exercises groups at 0.05 level of confidence. Hence, the fifth hypothesis was accepted.

6. It was mentioned in the sixth hypothesis that there would be significant difference on agility between the control and experimental groups. The statistical results shows that there is a significant difference on agility between Water Exercises, plyometric exercises, and combination of water and

plyometric exercises groups at 0.05 level of confidence. Hence, the sixth hypothesis was accepted.

7. It was mentioned in the seventh hypothesis that there would be significant difference on vital capacity between the control and experimental groups. The statistical results shows that there is a significant difference on vital capacity between Water Exercises, plyometric exercises, and combination of water and plyometric exercises groups at 0.05 level of confidence. Hence, the seventh hypothesis was accepted.

8. It was mentioned in the eighth hypothesis that there would be significant difference on pulse rate between the control and experimental groups. The statistical results shows that there is a significant difference on pulse rate between Water Exercises, plyometric exercises, and combination of water and plyometric exercises groups at 0.05 level of confidence. Hence, the eighth hypothesis was accepted.

9. It was mentioned in the nineth hypothesis that there would be significant difference on breath holding capacity between the control and experimental groups. The statistical results shows that there is a significant difference on breath holding capacity between Water Exercises, plyometric exercises, and combination of water and plyometric exercises groups at 0.05 level of confidence. Hence, the nineth hypothesis was accepted.

10. It was mentioned in the tenth hypothesis that there would be significant difference on triple jump performance between the control and experimental groups. The statistical results shows that there is a significant difference on triple jump performance between Water Exercises, plyometric exercises, and combination of water and plyometric exercises groups at 0.05 level of confidence. Hence, the tenth hypothesis was accepted.

11. It was noted in the eleventh hypothesis that there would be significant difference among the experimental groups on the physical variables of triple jumpers. Among the experimental groups significant difference was not observed on cardiovascular endurance, muscular endurance and flexibility.

Among the experimental groups significant difference was obtained on speed, explosive power and agility at 0.05 level of confidence. Hence, the eleventh hypothesis was partially accepted.

12. It was mentioned in the twelfth hypothesis that there would be significant difference on triple jump performance between the control and experimental groups. The statistical results shows that there is a significant difference on triple jump performance between Water Exercises, plyometric exercises, and combination of water and plyometric exercises groups at 0.05 level of confidence. Hence, the twelfth hypothesis was accepted.

13. It was denoted in the thirteenth hypothesis that there would be significant difference between the control and experimental groups on the physical variable muscular endurance of triple jumpers in the age group of 15 to 17 years. Water exercises training group, plyometric exercises training group, combination of water and plyometric exercises training group and control group had significant difference on selected physical variable muscular endurance at 0.05 level of confidence. Hence, the thirteenth hypothesis was accepted.

The combination of water and plyometric exercise experimental group would have better influence on the triple jump performance of boys in the age group of 15 to 17 years. Combination of water and plyometric exercise training group had better influence than other experimental groups and control group at 0.05 level of confidence.

CHAPTER V

SUMMARY AND CONCLUSIONS

5.1 Summary

The purpose of this study was to find out the effect of water exercises, plyometric exercises and a combination of both on selected physical variables, physiological variables and performance of triple jumpers. To achieve the purpose of the study the scholar selected 40 triple jumpers (N=40) as subjects from Malappuram district, Kerala, India. The age of the subjects ranged from 15 years to 17 years. Mean height of the subjects were 172cms ±1. Mean weight of the subjects were 58.6kgs ±3.0kgs. Selected subjects were divided into four equal groups of ten subjects each. The scholar used one control group and three experimental groups. Observational group I was denoted as water exercise training group (WEG), Observational group II was denoted as plyometric exercises training group (PMG), Observational training group III was denoted as combination of water and plyometric exercises training group (COG) and one control group was denoted as (CNG). Each group consisted ten subjects each (n1=n2=n3=n4=10).

The physical variables cardiovascular endurance, muscular endurance, flexibility, speed, explosive power, agility, physiological variables vital capacity, pulse rate, breath holding capacity and performance variable triple jump performance were selected as dependent variables for the study. Independent variables were water exercise training, plyometric training and combination of water and plyometric exercises training.

To determine the significant difference between pre and post-test scores of various group dependent ‘t’ test was used. To determine the significant difference between the groups on the dependent variable the statistical procedure analysis of covariance (ANCOVA) was applied. To find out the significant difference on adjusted means of the group, LSD Post-hoc test was administered.

5.2 Conclusions

Within the limitations of the present study, the following conclusions were drawn.

1. It was concluded that experimental groups improved cardiovascular endurance of the triple jumpers than the control group.

2. It was concluded that combination of water and plyometric exercises training group was better than other experimental groups on developing cardiovascular endurance.

3. It was concluded that experimental groups improved muscular endurance of the triple jumpers than the control group.

4. It was concluded that combination of water and plyometric exercises training group and plyometric training group was better than other experimental groups on developing cardiovascular endurance.

5. It was concluded that experimental groups improved flexibility of the triple jumpers than the control group.

6. It was concluded that combination of water and plyometric exercises training group was better than other experimental groups on developing flexibility of triple jumpers.

7. It was concluded that experimental groups except water exercise training group improved speed of the triple jumpers than the control group.

8. It was concluded that combination of water and plyometric exercises training group and plyometric training group was better than other experimental group on developing speed of triple jumpers.

9. It was concluded that experimental groups improved explosive power of the triple jumpers than the control group.

10. It was concluded that combination of water and plyometric exercises training group and plyometric training group was better than other experimental group on developing explosive power of triple jumpers.

11. It was concluded that experimental groups except water exercise training group improved agility of the triple jumpers than the control group.

12. It was concluded that combination of water and plyometric exercises training group and plyometric training group was better than other experimental group on developing agility of triple jumpers.

13. It was concluded that experimental groups improved vital capacity of the triple jumpers than the control group.

14. It was concluded that combination of water and plyometric exercises training group was better than other experimental groups on developing vital capacity of triple jumpers.

15. It was concluded that experimental groups improved pulse rate of the triple jumpers than the control group.

16. It was concluded that experimental groups improved breath holding capacity of the triple jumpers than the control group.

17. It was concluded that combination of water and plyometric exercises training group was better than other experimental groups on developing breath holding capacity of triple jumpers.

18. It was concluded that experimental groups improved triple jump performance of the triple jumpers than the control group.

19. It was concluded that combination of water and plyometric exercises training group was better than other experimental groups on developing triple jump performance of triple jumpers.

CHAPTER VI

RECOMMENDATIONS & SUGGESTIONS

6.1 Recommendations

On the basis of the findings and conclusions, the following recommendations were made.

1. The findings of the study revealed that water exercises, plyometric exercises and combination of water and plyometric exercises significantly improved the selected physical, physiological and performance variables among boys triple jumpers in the age group of 15 to 17 years. Hence, professionals in physical education, coaches and trainers in the field of sports can utilize these training programme for better performance of their players.

2. Physical education teachers, coaches and trainers may adopt the water exercises training schedule prescribed in the study for the development of selected physical, physiological and performance variables.

3. Coaches, trainers and physical education teachers, may adopt the plyometric exercises training schedule prescribed in the study for the development of selected physical, physiological and performance variables.

4. The result of the study would help the athletic coaches and athletes to understand and add the water exercises and plyometric exercises training in their training schedule of fitness and skill development.

5. In the government coaching centres like SAI, the training method adopted in the study could be used to train the young athlete.

6. The results of the study highlighted that the combination of water and plyometric exercises training was better in developing selected physical,

physiological and performance variables. Athletes could include the combination training in their schedule.

6.2 Suggestions for further research

1. There are great scopes for other researchers to carry out similar studies with different motor fitness and physiological variables.
2. Similar studies may be carried out with different intensity of training schedule.
3. Similar studies may be conducted for different age group of boys.
4. Same training programme may be extended to few more weeks.
5. Similar studies may be conducted for girls.

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APPENDIX

PhD Data Collection Details

Effect of Water Exercises and Plyometric Exercises and a Combination of both on selected physical Variables, physiological Variables and performance of Triple jumpers

PLAYER'S PROFILE

	Date	
	Pre-test	Post-test

Personal

1. Name
2. Age (In Months)
3. Height (In Cm)
4. Weight (Kilograms)

Physical Variable Data

1. 1600mts Run
2. 50 mts Dash
3. Standing Board Jump
4. Sit ups
5. Sit and Reach
6. Shuttle Run

Physiological Variable Data

1. Vital Capacity
2. Pulse Rate
3. Breath holding Capacity

Performance Variable Data

1. Tripple Jump Performance

Player Signature

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Guide