Mathematical Theory and Modeling
ISSN 2224-5804 (Paper) ISSN 2225-0522 (Online)
Vol.6, No.9, 2016

The Design of Prosthetic Rehabilitation and Special Treatment into The Water for The Amputation Below the Knee

Dr. Reem Salam

Department of prosthetic legs Engineering, College of Engineering, Al-Nahrain University, Baghdad, Iraq.

Abstract:

My project is about creation of temporary prosthetic leg for advanced stages rehabilitation underwater for the patient who had an amputation surgery under knee for his leg. And design prosthetic with mechanical movement of ankle joint like ankle joint of normal leg, suitable with mechanical movement of water for moving objects in the water, with constant kinetic analysis for prosthetic and normal leg in the water and also analyzing the angles of lower limbs. And the prosthetic leg is water resistance and easy to wear and with suitable price.

1.1 Introduction:

This study consisted through the following of researcher for many scientific research and topics of rehabilitation of people with special needs who has amputation under knee with consideration all the devices that available in the rehabilitation centers after an operation amputation where design a temporary prostheses used in the water to rehabilitate the thigh muscle for amputation leg. Preposition to the lack of rehabilitation centers to such devices of temporary prostheses for amputation under knee, it has helped researcher to design this temporary prostheses for gradual learning streamline of kinetic transport of amputation leg in the water with the need to be the temporary prostheses movement approach to the movement of normal leg.

1.2 Definition of biomechanics:

The term biomechanics combines the prefix bio, meaning “life,” with the field of mechanics, which is the study of the actions of forces. The international community of scientists adopted the term biomechanics during the early 1970s to describe the science involving the study of the mechanical aspects of living organisms. Within the fields of kinesiology and exercise science, the living organism most commonly of interest is the human body. The forces studied include both the internal forces produced by muscles and the external forces that act on the body [1].

1.3 Anthropometric measurements:

anthropometric measurements, which are systematic measurements of the size, shape and composition of the human body. This is a fairly easy term to recall if you remember that the prefix 'anthropo' refers to 'human' and 'metric' refers to 'measurement. **Purpose:** Anthropometric measurements are useful in many fields. For example, athletes understand that body size and composition are important factors in sports performance. For example, a petite man with a low percentage of body fat will be more successful as a jockey in the Kentucky Derby than he would be as a defensive lineman in the National Football League. Sports coaches can also use these measurements to monitor an athlete's body to ensure they stay in peak physical shape. Health care professionals rely on body measurements to evaluate a patient's overall health. For example, body mass index, or BMI, is a measurement of a person's weight-to-height ratio. Health care providers, insurance companies and government agencies use BMI to determine if a person is underweight, overweight or obese. A BMI of 30 or greater indicates obesity. Because obesity is linked to chronic diseases, like heart disease, diabetes and certain cancers, knowing this anthropometric measurement can be a lifesaver.

Anthropometric measurements can also be used when studying groups of people. This broader approach allows researchers to evaluate health trends and concerns in various populations. For example, anthropometry, which is the scientific study of human body measurements, has been used to assess the nutritional status of children in underdeveloped countries. These measurements can be used to determine the prevalence of undernutrition and evaluate the need for nutritional support. Methods & Tools: There is a range of ways to measure the human body. Some measurements are simple enough to be taken in a family doctor's office. These measurements require minimal tools. For instance, weight is a basic anthropometric measurement that is easily measured with a scale, and height can be determined with a simple measuring stick. As we learned earlier, height and weight are the only measurements needed to determine a person's BMI.A tape measure is the only tool needed to determine a person's waist-to-hip ratio. This is a measure of the waist circumference divided by the hip circumference. This ratio is significant because your risk of heart disease increases along with this number. Do you remember the two men we met at the beginning of this lesson? They differ in the amount of body fat they carry. We could determine just how different they are by using methods designed to measure body fat percentage. One of these methods is a skin-fold test, which is a method used to estimate a person's body fat percentage using skin fold calipers. Skin-fold calipers are simple tools used to pinch folds of skin from different areas of the body. The thickness of the skin folds is recorded and a formula is used to estimate how much body fat the person is carrying [8] [9].

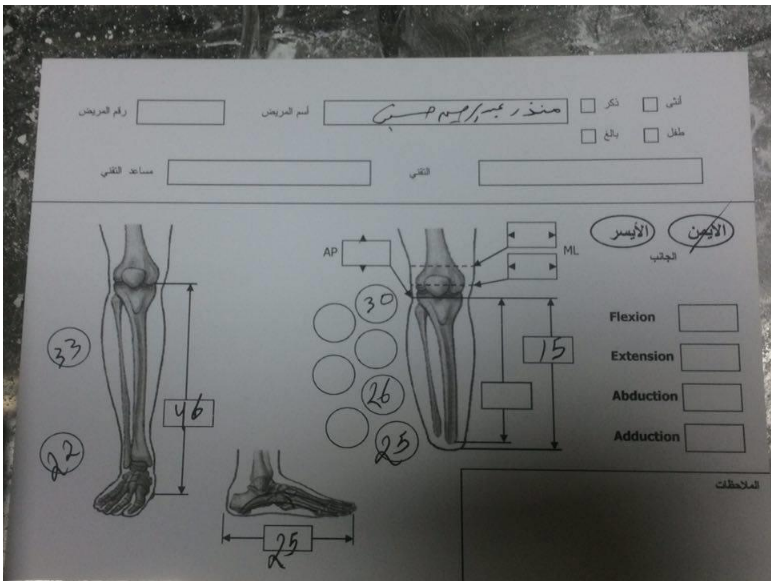

Figure (1-1) Anthropometric measurements:

1.4 Amputation:

Amputation is the surgical removal of all or part of a limb or extremity such as an arm, leg, foot, hand, toe, or finger.

About 1.8 million Americans are living with amputations. Amputation of the leg -- either above or below the knee -- is the most common amputation surgery [10].

1.4.1Reasons for Amputation

There are many reasons an amputation may be necessary. The most common is poor circulation because of damage or narrowing of the arteries, called peripheral arterial disease. Without adequate blood flow, the body's cells cannot get oxygen and nutrients they need from the bloodstream. As a result, the affected tissue begins to die and infection may set in[10] [11].

Other causes for amputation may include:

- Severe injury (from a vehicle accident or serious burn, for example)
- Cancerous tumor in the bone or muscle of the limb
- Serious infection that does not get better with antibiotics or other treatment
- Thickening of nerve tissue, called a neuroma
- Frostbite

1.4.2 The Amputation Procedure

An amputation usually requires a hospital stay of five to 14 days or more, depending on the surgery and complications. The procedure itself may vary, depending on the limb or extremity being amputated and the patient's general health. Amputation may be done under general anesthesia (meaning the patient is asleep) or with spinal anesthesia, which numbs the body from the waist down. When performing an amputation, the surgeon removes all damaged tissue while leaving as much healthy tissue as possible. A doctor may use several methods to determine where to cut and how much tissue to remove [10] [11]. These include:

- Checking for a pulse close to where the surgeon is planning to cut
- Comparing skin temperatures of the affected limb with those of a healthy limb
- Looking for areas of reddened skin
- Checking to see if the skin near the site where the surgeon is planning to cut is still sensitive to touch

During the procedure itself, the surgeon will:

- Remove the diseased tissue and any crushed bone
- Smooth uneven areas of bone
- Seal off blood vessels and nerves
- Cut and shape muscles so that the stump, or end of the limb, will be able to have an artificial limb (prosthesis) attached to it

The surgeon may choose to close the wound right away by sewing the skin flaps (called a closed amputation). Or the surgeon may leave the site open for several days in case there's a need to remove additional tissue.

The surgical team then places a sterile dressing on the wound and may place a stocking over the stump to hold drainage tubes or bandages. The doctor may place the limb in traction, in which a device holds it in position, or may use a splint.

Mathematical Theory and Modeling
ISSN 2224-5804 (Paper) ISSN 2225-0522 (Online)
Vol.6, No.9, 2016

1.4.3 Recovery from Amputation:

Recovery from amputation depends on the type of procedure and anesthesia used. In the hospital, the staff changes the dressings on the wound or teaches the patient to change them. The doctor monitors wound healing and any conditions that might interfere with healing, such as diabetes or hardening of the arteries. The doctor prescribes medications to ease pain and help prevent infection. If the patient has problems with phantom pain (a sense of pain in the amputated limb) or grief over the lost limb, the doctor will prescribe medication and/or counseling, as necessary. Physical therapy, beginning with gentle, stretching exercises, often begins soon after surgery. Practice with the artificial limb may begin as soon as 10 to 14 days after surgery.

Ideally, the wound should fully heal in about four to eight weeks. But the physical and emotional adjustment to losing a limb can be a long process [10] [11].

Long-term recovery and rehabilitation will include:

- Exercises to improve muscle strength and control
- Activities to help restore the ability to carry out daily activities and promote independence
- Use of artificial limbs and assistive devices
- Emotional support, including counseling, to help with grief over the loss of the limb and adjustment to the new body image.

Figure (1-2) Amputation under knee

Chapter Two
Principles and Theories

ISSN 2224-5804 (Paper) ISSN 2225-0522 (Online)
Vol.6, No.9, 2016

2.1 Rehabilitation:

Rehabilitation describes specialized healthcare dedicated to improving, maintaining or restoring physical strength, cognition and mobility with maximized results. Typically, rehabilitation helps people gain greater independence after illness, injury or surgery. Rehabilitation can also be explained as the process of helping an individual achieve the highest level of function, independence, and quality of life possible. Rehabilitation does not reverse or undo the damage caused by disease or trauma, but rather helps restore the individual to optimal health, functioning, and
well-being [12].

- Drug rehabilitation, medical or psychotherapeutic treatment for dependency on psychoactive substances such as alcohol, prescription drugs, and street drugs
- Physical medicine and rehabilitation
- Physical therapy or physical rehabilitation
- Psychiatric rehabilitation, a branch of psychiatry dealing with restoration of mental health and life skills after mental illness
- Rehabilitation (neuropsychology), therapy aimed at improving neurocognitive function that has been lost or diminished by disease or traumatic injury
- Rehabilitation (penology), the rehabilitation of criminal behavior
- Rehabilitation (wildlife), treatment of injured wildlife with the purpose of preparing return to the wild
- Vision rehabilitation
- Vocational rehabilitation

2.1.1 Rehabilitation for Below-Knee Amputation:

A below-the-knee amputation, where the lower portion of the leg is removed, may be performed because of disease or severe injury that eliminates the function of your lower leg. Rehabilitation following such an amputation is a long process that requires a great deal of strength and dedication. In addition to addressing physical issues, rehabilitation help a patient overcome the stress and emotional hardship caused by an amputation [12].

2.1.2 Post-Operative Care:

Taking proper care of yourself following amputation surgery is the first step in your rehabilitation process. Proper care can help reduce swelling and prevent infection from occurring at the site of your incision. A below-the-knee amputation requires several layers of stitches to hold your incision together, which means that you cannot bathe, swim or otherwise submerge the stitches in water until indicated by your doctor. You may shower quickly. Clean any dried blood or drainage from your incision site using soap and water, then gently pat the incision dry using a towel. Do not cover the incision, apply any lotions or creams to the area or get your incision dirty [12].

2.1.3 Activity at Home:

Move around as much as possible immediately following your surgery. If you do not know how to use crutches or a walker, a physical therapist can teach you prior to leaving the hospital. Avoid sitting with your legs crossed and refrain from placing pillows underneath your stump. This may reduce discomfort but it can lead to muscle shrinkage in the rest of your leg [12].

2.1.4 Recovery and Prosthetics:

Recovery from a below-the-knee amputation generally requires a few months. As part of your recovery, you may choose to learn to walk with a prosthetic leg. For a below-the-knee amputation, you may opt for a trans-femoral prosthetic, which is used for general walking. It includes a socket placed at the knee and a prosthetic shin and foot. More advanced devices -- called C-legs -- allow amputees to run, cycle and participate in sports. Made with hydraulics, these prosthetic legs are lightweight and easy to maneuver in. Your age, current fitness level, other medical conditions, the complexity of your amputation, your progress in physical therapy and the level of activity you want to reach with a prosthetic leg all influence the length of your recovery [12].

2.1.5 Physical Therapy:

Physical therapy before you receive an artificial limb focuses on strengthening your lower body to ensure that you will be strong enough to use one. Functional exercises will enable you to balance and perform your daily activities. A physical therapist will help you strengthen your knee and hamstrings on your residual limb, as well as increase the strength of your opposite leg and upper body -- which is important for the use of crutches and walkers. Exercises may include pushups, situps, balancing and hopping exercises. The loss of a limb is a life-changing event, physically and emotionally. Amputees may feel depressed, concerned and anxious about the quality of their life. Amputees may also experience phantom pains -- which are pains that occur where a limb used to be. Psychological counseling can be beneficial for patients recovering from an amputation [12].

2.1.6 Prosthetic Training:

Once your incision has healed and your doctor and physical therapist feel you are ready, you will be fitted with an artificial limb. Rehabilitation will help you learn to walk and carry out functional tasks while wearing your artificial limb. You will learn how to care for your artificial limb and how to properly wear your artificial limb. You will also work with a physical therapist on balance or coordination. If you want to learn to run or play sports while wearing an artificial limb, you will undergo more intense, sports-specific physical therapy and training [12].

2.2 Thigh muscles:

The thigh is divided up into three separate compartments, divided by fascia, each containing muscles. These compartments use the femur as an axis, and are separated by tough connective tissue membranes (or septa). Each of these compartments has own blood and nerve supply, and contains a different group of muscles [2].

- Medial fascial compartment of thigh, adductor
- Posterior fascial compartment of thigh, flexor, hamstring
- Anterior fascial compartment of thigh, extensor

2.3 Material of prosthetic:

2.3.1 Polypropylene:

Polypropylene is a type of thermoplastic polymer resin. It is a part of both the average household and is in commercial and industrial applications. The chemical designation is C3H6. One of the benefits of using this type of plastic is that it can be useful in numerous applications including as a structural plastic or as a fiber-type plastic.

- Why we used polypropylene?

The use of polypropylene in everyday applications occurs because of how versatile this plastic is. For example, it has a high melting point compared to similarly weighted plastics. As a result, this product works very well for use in food containers where temperatures can reach high levels - such as microwaves and in dishwashers. With a melting point of 320 degrees F, it is easy to see why this application makes sense.

It is easy to customize, too. One of the benefits it offers to manufacturers is the ability to add dye to it. It can be colored in various ways without degrading the quality of the plastic. This is also one of the reasons it is commonly used to make up the fibers in carpeting. It also adds strength and durability to the carpeting. This type of carpeting can be found effective for use not only indoors but also outdoors, where damage from the sun and elements doesn't affect it as readily as other types of plastics

- Other benefits include the following:
    1. It does not absorb water like other plastics.
    2. It does not mold or otherwise deteriorate in the presence of bacteria, mold or other elements.
    3. Newer versions contain an elastic element to them. This gives them a rubber-like composition and opens the door for new uses.
    4. It is unlikely to shatter and will take significant damage prior to breaking, though it is not as sturdy as other plastics such as polyethylene.
    5. It is lightweight and very flexible.
    - Chemical Properties and Uses

Understanding polypropylene is important because it is significantly different from other types of products. It's properties allow it to be effective in the use of material popular in everyday use, including any situation in which a non-staining and non-toxic solution is necessary. It is also inexpensive [3] [4].

2.3.2 Stainless steel:

Stainless steel is an alloy of Iron with a minimum of 10.5% Chromium. Chromium produces a thin layer of oxide on the surface of the steel known as the 'passive layer'. This prevents any further corrosion of the surface. Increasing the amount of Chromium gives an increased resistance to corrosion. Stainless steel also contains varying amounts of Carbon, Silicon and Manganese. Other elements such as Nickel and Molybdenum may be added to impart other useful properties such as enhanced formability and increased corrosion resistance.

- Does stainless steel corrode?

Although stainless steel is much more resistant to corrosion than ordinary carbon or alloy steels, in some circumstances it can corrode. It is 'stain-less' not 'stain-impossible'. In normal atmospheric or water based environments, stainless steel will not corrode as demonstrated by domestic sink units, cutlery, saucepans and work-surfaces. In more aggressive conditions, the basic types of stainless steel may corrode and a more highly alloyed stainless steel can be used [5].

2.3.3 Fiberglass:

Manufacturing With Fiberglass: Different resins may then be added to fiberglass once it is woven together to give it added strength, as well as allow it to be molded into various shapes. Common items made of fiberglass include swimming pools and spas, doors, surfboards, sporting equipment, boat hulls and a wide array of exterior automobile parts.

The light yet durable nature of fiberglass also makes it ideal for more delicate applications, such as in circuit boards. Fiberglass may be mass-produced in mats or sheets or custom-made for a specific purpose. A new bumper or fender on an automobile, for example, may need to be custom-made to replace a damaged area, or for the production of a new model. For this, one would create a form in the desired shape out of foam or some other material, then layer a fiberglass coated in resin over it. The fiberglass will harden, then can be reinforced with more layers, or reinforced from within. But, for items like shingles, a massive sheet of a fiberglass and resin compound may be manufactured and cut by machine. It should be noted that fiberglass is not carbon fiber, nor is it glass-reinforced plastic, although it is similar to both. Carbon fiber, which is made of strands of carbon, cannot be extruded into strands as long as fiberglass, as it will break. This, among other reasons, makes fiberglass cheaper to manufacture, although it is not as strong. Glass-reinforced plastic is what it sounds like – plastic with fiberglass embedded into it to increase strength. The similarities to fiberglass are apparent, but a defining characteristic of fiberglass is that the glass strands are the main component [6] [7].

2.4 Water properties:

water is fluid medium that exert force on bodies moving through them. Some of these forces slow the progress of a moving body; others provide support or propulsion. A general understanding of the actions of fluid forces on human movement activities is an important component of the study of the biomechanics of human movement [1].

2.4.1 Buoyancy:

Buoyancy is a fluid force that always acts vertically upward. The factors that determine the magnitude of the buoyant force were originally explained by the ancient Greek mathematician Archimedes. Archimedes' principle states that the magnitude of the buoyant force acting on a given body is equal to the weight of the fluid displaced by the body. The latter factor is calculated by multiplying the specific weight of the fluid by the volume of the portion of the body that is surrounded by the fluid. Buoyancy (Fb) is calculated as the product of the displaced volume (Vd) and the fluid's specific weight (γ): [1]

$$F_b = V_d \ \gamma$$

2.4.2 Flotation:

The ability of a body to float in a fluid medium depends on the relationship between the body's buoyancy and its weight. When weight and the buoyant force are the only two forces acting on a body and their magnitudes are equal, the body floats in a motionless state, in accordance with the principles of static equilibrium. If the magnitude of the weight is greater than that of the buoyant force, the body sinks, moving downward in the direction of the net force. Most objects float statically in a partially submerged position. The volume of a freely floating object needed to generate a buoyant force equal to the object's weight is the volume that is submerged [1].

2.4.3 Drag:

Drag is a force caused by the dynamic action of a fluid that acts in the direction of the free-stream fluid flow. Generally, a drag is a resistance force: a force that slows the motion of a body moving through a fluid. The drag force acting on a body in relative motion with respect to a fluid is defined by the following formula:

$$F_D = 1/2 C_D \, \rho \, A_P \, V^2$$

In this formula, FD is drag force, CD is the coefficient of drag, ρ is the fluid density, Ap is the projected area of the body or the surface area of the body oriented perpendicular to the fluid flow, and v is the relative velocity

The coefficient of drag is a unit less number that serves as an index of the amount of drag an object can generate. Its size depends on the shape and orientation of a body relative to the fluid flow, with long, streamlined bodies generally having lower coefficients of drag than blunt or irregularly shaped objects. Approximate coefficients of drag for the human body in positions commonly assumed during participation in several sports. The formula for the total drag force demonstrates the exact way in which each of the identified factors affects drag. If the coefficient of drag, the fluid density, and the projected area of the body remain constant, drag increases with the square of the relative velocity of motion. This relationship is referred to as the theoretical square law. According to this law. In swimming, the drag on a moving body is 500–600 times higher than it would be in the air, with the magnitude of drag varying with the anthropometric characteristics of the individual swimmer, as well as with the stroke used. Researchers distinguish between passive drag, which is generated by the swimmer's body size, shape, and position in the water, and active drag, which is associated with the swimming motion. Passive drag is inversely related to a swimmer's buoyancy, which has been found

to have a small but important influence on sprint swimming performance. Passive drag on male swimmers is also significantly reduced with shoulder-to-knee and shoulder-to-ankle swimsuits as compared to briefs. Three forms of resistance contribute to the total drag force. The component of resistance that predominates depends on the nature of the fluid flow immediately adjacent to the body [1].

2.4.4 Lift Force:

While drag forces act in the direction of the free-stream fluid flow, another force, known as lift, is generated perpendicular to the fluid flow. Although the name lift suggests that this force is directed vertically upward, it may assume any direction, as determined by the direction of the fluid flow and the orientation of the body. The factors affecting the magnitude of lift are basically the same factors that affect the magnitude of drag:

$$F_L = 1/2 C_L \, \rho \, A_P \, V^2$$

In this equation, FL represents lift force, CL is the coefficient of lift, ρ is the fluid density, Ap is the surface area against which lift is generated, and v is the relative velocity of a body with respect to a fluid[1].

Chapter Three
Experimental Work

3.1 Introduction:

This chapter include description of experimental work in laboratory for rehabilitation by prosthetic I made.

3.2 Brief review about rehabilitation:

Rehabilitation describes specialized healthcare dedicated to improving, maintaining or restoring physical strength, cognition and mobility with maximized results. Typically, rehabilitation helps people gain greater independence after illness, injury or surgery. Rehabilitation can also be explained as the process of helping an individual achieve the highest level of function, independence, and quality of life possible. Rehabilitation does not reverse or undo the damage caused by disease or trauma, but rather helps restore the individual to optimal health, functioning, and well-being.

3.3 Design of prosthetic:

The prosthetic consist of socket, shaft, foot and flipper also I used a tank fill with water as a part of procedure of rehabilitation.

3.3.1 Socket:

the main part of prosthetic used to place patient's amputation leg and the material used to make it "polypropylene" as I discussed in chapter 2

Figure (3-1) socket of prosthetic

3.3.2 Shaft:

The second part of prosthetic used to connect socket and foot and the material used to make it "stainless steel" as I discussed previously in chapter 2

The reason of using stainless steel as material of shaft because it has high resistance to corrosion as the all treatment procedure happening in the water.

Figure (3-2) shaft of prosthetic

3.3.3 Foot:

The third component of the prosthetic, the material used to make it "polypropylene" also I discussed previously at chapter 2 and the main feature of fabricated foot it has motion as long as like ankle joint motion that make this prosthetic more functional than the normal prosthetic.

Figure (3-3) foot and ankle joint of prosthetic

ISSN 2224-5804 (Paper) ISSN 2225-0522 (Online)
Vol.6, No.9, 2016

3.3.4 Flipper:

Accessories used to fit the foot to increase surface area that exposed to water thus force need to move the prosthetic is large and the effort of thigh's muscle increase and it's so good for patient during rehabilitation. Material used to make it "fiber glass" because it's light material and flexible.

Figure (3-4) flipper

3.3.5 Trousers:

Prosthetic wear the trousers to prevent the prosthetic from slipping during exercises and for stability. And also I added a zipper to the trousers for control the straps which used to change the diameter of prosthetic.

Figure (3-5) trousers

3.4 Apparatus of laboratory:

3.4.1Tank:

It used for rehabilitation by filled it at specific level of water and it have to stairs one out of tank and the other inside to facilitate entrance and out of patient.

Figure (3-6) Tank with their stairs

3.5 kinovia:

Kinovea is a video player for all sport enthusiasts. Slow down, study and comment the technique of your athletes or of yourself.

1.Observe and show:

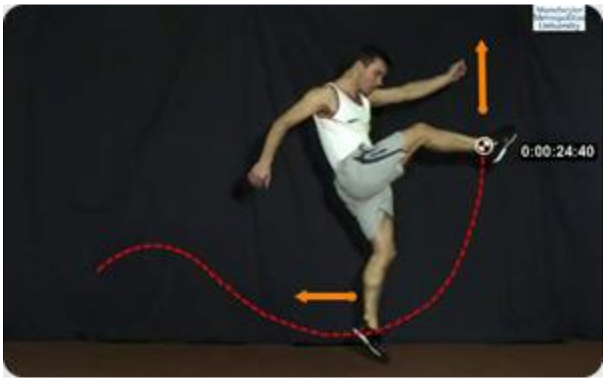

Figure (3-7) Enrich the video by adding arrows, descriptions and other content to key positions.

2.Compare:

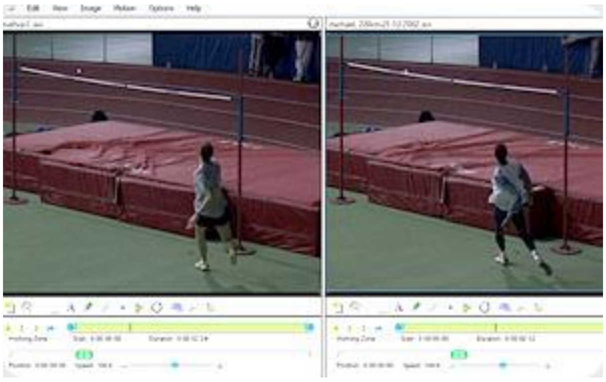

Figure (3-8) Enrich the video by adding arrows, descriptions and other content to key positions.

3. Measure

Figure (3-9) Measure distances and times manually or use semi-automated tracking to follow points and check live values or trajectories.

4. Extend:

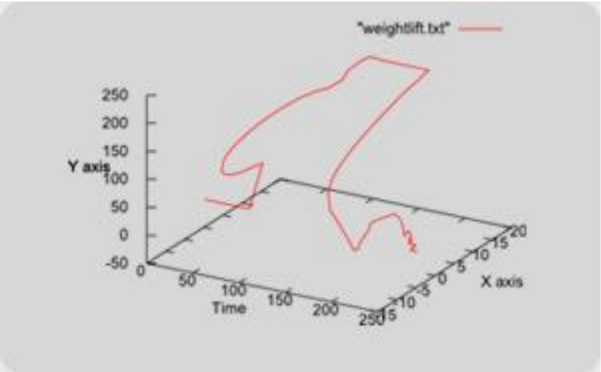

Figure (3-10) Export your analysis to spreadsheet formats for scientific study and further processing.

Chapter Four
Results, Discussions, and Calculations

4.1 Rehabilitation:

Rehabilitation describes specialized healthcare dedicated to improving, maintaining or restoring physical strength, cognition and mobility with maximized results. Typically, rehabilitation helps people gain greater independence after illness, injury or surgery. Rehabilitation can also be explained as the process of helping an individual achieve the highest level of function, independence, and quality of life possible. Rehabilitation does not reverse or undo the damage caused by disease or trauma, but rather helps restore the individual to optimal health, functioning, and well-being.

4.2 Procedure:

1. Laboratory was prepared by providing all equipment of experimental work (tank, source of water, camera).
2. Tank was filled with water until reach to desired level.
3. Patient was ready to enter to the tank to do exercise by taking 2 position (on back and on abdomen) to take more readings.
4. Camera should be available to record movements of patient in the tank.
5. At final, kinovia should be used to analysis movement of patient.

4.3 Results and Discussion:

The all result was calculated by kinovia can be found in table (4-1)

Table (4-1) Results of joints angles and angular velocity.

Performing exercise in the water can be beneficial for a variety of individuals with neuromuscular or musculoskeletal disorders. Aquatic therapy differs from

Movement	Knee joint		Ankle joint	
	Normal	Prosthetic	Normal	Prosthetic
Extension/on back	160 °	152 °	115 °	136 °
Angular velocity		18.03	10.73	18.79

land therapy due to the specific properties of water. These unique properties decrease joint compression forces, may reduce inflammation and provide feedback for improving posture. The resistance of the water during exercise provides a safe environment for addressing balance, strength, and postural deficits. For those patients who may have difficulty exercising on land, aquatic therapy provides a comfortable and therapeutic medium in which to gain strength and endurance.

Most patients find that aquatic therapy provides a safe way to regain their strength, balance, range of motion and flexibility while at the same time manage pain and swelling. Treatment sessions vary from two weeks to four weeks on average. Understanding **angular motion** is particularly important for the student of human movement, because most volitional human movement involves rotation of one or more body segments around the joints at which they articulate. Translation of the body as a whole during gait occurs by virtue of rotational motions taking place at the hip, knee, and ankle around imaginary mediolateral axes of rotation. During the performance of jumping jacks, both the arms and the legs rotate around imaginary anteroposterior axes passing through the shoulder and hip joints. The angular motion of sport implements such as golf clubs, baseball bats, and hockey sticks, as well as household and garden tools, is also often of interest. clinicians, coaches, and teachers of physical activities routinely analyze human movement based on visual observation. What is actually observed in such situations is the angular kinematics of human movement. Based on observation of the timing and range of motion (ROM) of joint actions, the experienced analyst can make inferences about the coordination of muscle activity producing the joint actions and the forces resulting from those joint actions.

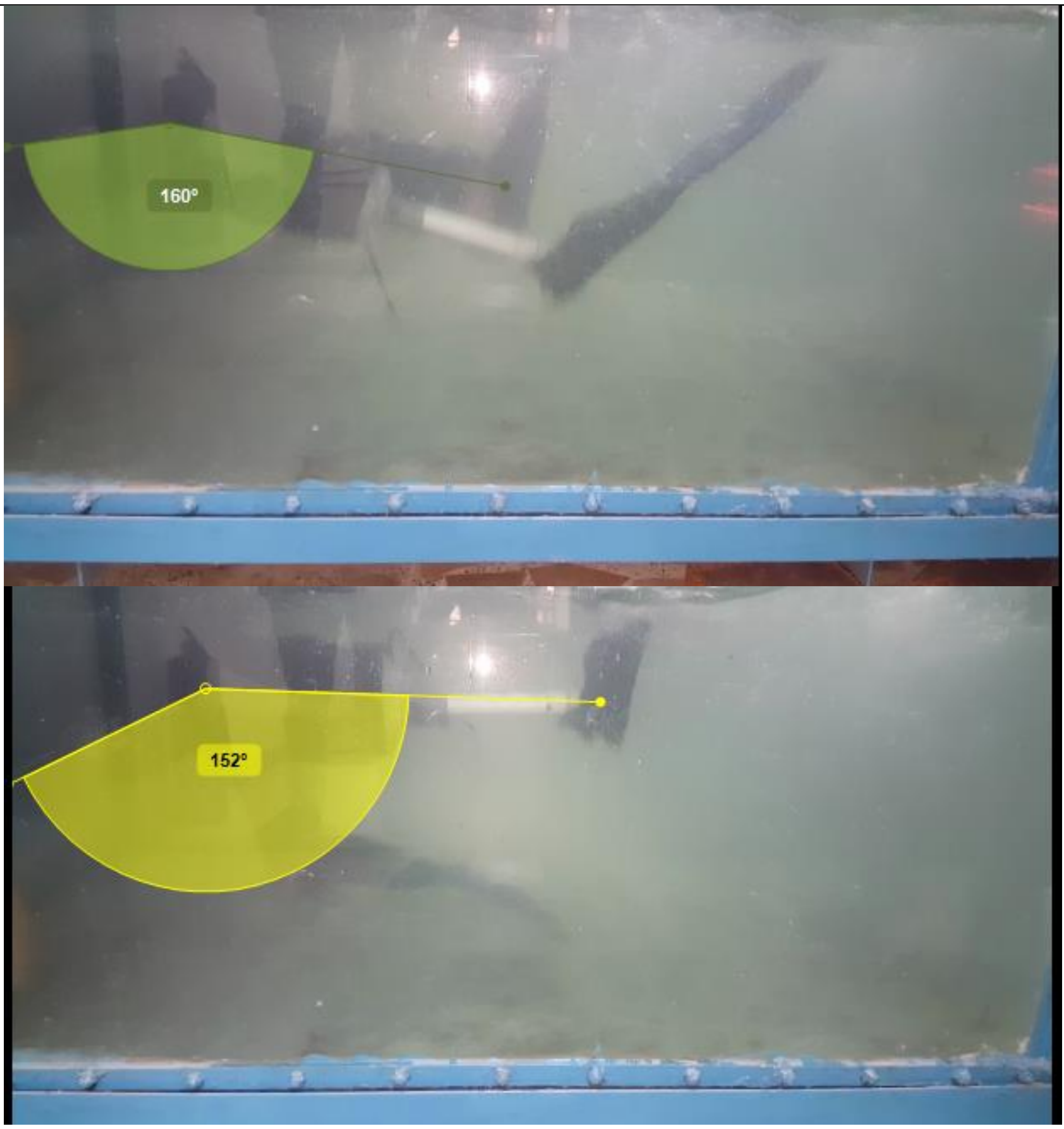

Figure (4.1) Extension of prosthetic and normal leg

At figure (4.1) above there's different between the angle of prosthetic and normal leg, The reason is due to several factor:

1.Water resistant, which is one of the external resistor, in other words, the prosthetic is exposed to more resistance due to large surface area of the flipper prone to water.

2.The weight of prosthetic which is limited in the movement.

3.The normal leg have three joints (Hip, Knee and Ankle) connected to each other by muscles, ligaments and tendons and kinetic transport of the joints be equal, as well, the integrity of muscle strength that binds joints while the amputation leg have two joints (hip, knee) that leads to kinetic transport to movement of prosthetic is not equal, as well, atrophy of thigh muscle.

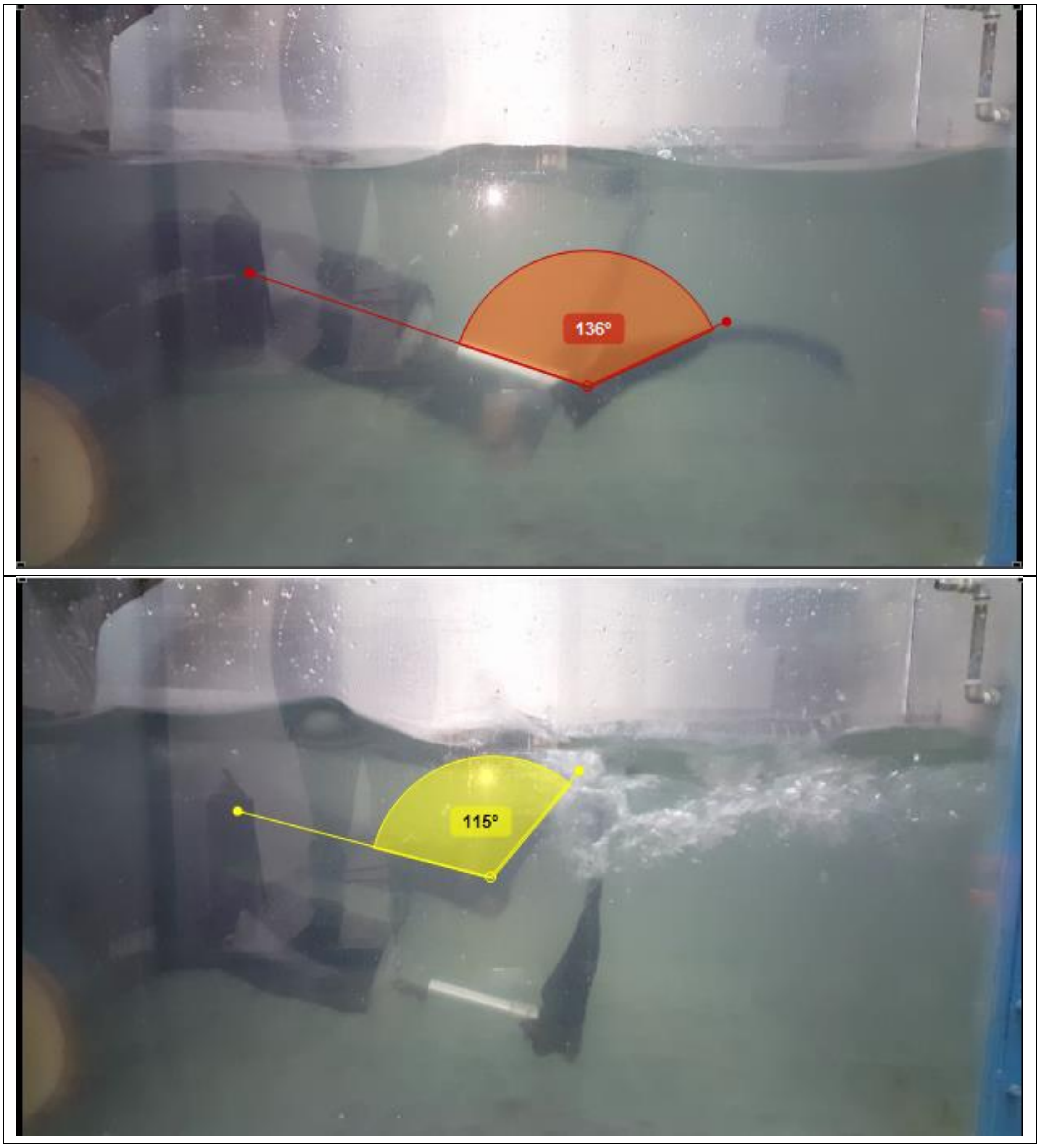

Figure (4.2) extension of normal and prosthetic foot.

At figure (4.2) above there's different between the angle of prosthetic and normal foot, The reason is due to several factor:

1.Water resistant, which is one of the external resistor, in other words, the prosthetic is exposed to more resistance due to large surface area of the flipper prone to water.

2. The normal leg have three joints (Hip, Knee and Ankle) connected to each other by muscles, ligaments and tendons and kinetic transport of the joints be equal, as well, the integrity of muscle strength that binds joints that allow the

patient control of extension of normal foot while the amputation leg have two joints (hip, knee) and there's no ankle joint so the ankle joint of prosthetic have limited range of motion according it the joint will deflect or extent and also kinetic transport to movement of prosthetic is not equal, as well, atrophy of thigh muscle.

4.3 Conclusion:

1. Through the analysis of angles and time found that the angles of prosthetic approach to normal leg.
2. Motion of ankle joint of the prosthetic in the water have flexibility almost similar to the normal ankle joint,
3. Though photography found that the patient has freedom of movement in the water as a lower limb with the help of water properties.
4. Rehabilitation process in the water is designed as a one of using of hydrotherapy.
5. The patient's response to the prosthetic helps him to continuity and ease of movement in the water.
6. This prosthetic helps to rehabilitate the muscle strength of the thigh region.

References:

1) Basic biomechanics sixth edition Susan J. Hall, Ph.D. College of Health Sciences University of Delaware.
2) Locomotor System Anatomy by Finn Bojsen Moller.
3) Market Study: Polypropylene (3rd edition)". Ceresana.
4) Kaiser, Wolfgang (2011). Kunststoffchemie für Ingenieure von der Synthese bis zur Anwendung (3. ed.). München: Hanser.
5) Engineering Materials 2 by David R. H. Jones (1992) [1986].
6) Design with Reinforced Plastics: A Guide for Engineers and Designers by Rayner M. Mayer.
7) The New Science of Strong Materials or Why You Don't Fall Through the Floor by J E Gordon.
8) Foot pressure measurement: a review of methodology by Lord M.
9) Jain A.; Hong L.; Pankanti S. Communications of the ACM.
10) Amputation: Surgical Practice and Patient Management by G Murdoch, A Bennett-Wilson.
11) Limb Amputation: From aetiology to rehabilitation by R. Ham L. T. Cotton.
12) Physical Medicine and Rehabilitation: Principles and Practice by Joel A. DeLisa، Bruce M. Gans، Nicholas E. Walsh.