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RELATIONSHIP BETWEEN THE HIP ANATOMY AND SPORTING PERFORMANCE

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Abstract:
The hip anatomy has an important role in delivering high-level performance in all branches of sports. It is among the prominent performance determiners for athletes in outclassing each other and delivering maximum performance. The lower extremity anatomic structure is known to have effect on all branches. This study seeks to emphasize the relationship between the hip anatomy and sporting performance.

Keywords: anatomy, hip anatomy, sport

1. Introduction

Anatomy is the branch of science concerned with and organs that form the bodily shape and structure of humans and the systems that are formed by the organs and their relationships. The term anatomy is a Greek word in origin in which ana means "up" and tome means "cutting" (Çimen 2003).

Furthermore, it is considered one of the criteria of selection during the special talent tests of branches to determine whether the physical structure is compatible with the characteristics of the branch (Karakuş and Kılınç 2006).

Hip movements have close relationship with movements done in joints between hip joint and spines and in joints between the bottom of the spine and sacrum. In other words, movements of the hip are determined by the movements done in hip joint by the thigh or movements done between the spines and the sacrum of the spines (Demirel and Koşar 2002).

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This study seeks to examine the relationship between the hip anatomy and sporting performance. There are different research methods in this area. Correspondingly, these researches are essential to be discussed in order for other training methods, which support the hip anatomy and sporting performance, to have positive effects on the performance.

2. Literature Information

2.1. Human Anatomy

All organs and formations discussed by the anatomy belongs to a person who is positioned opposite, standing upright with head held high eyes facing forward, top faced to the side of body and palms facing forward (Zeren 1971).

Types of anatomy are:

- Systematic anatomy which mentions systems,
- Topographic anatomy which examines the human body with separated regions,
- Surface anatomy which examines formations on the living in terms of hand, eye, radiology or endoscopy.
- Comparative anatomy,
- Developmental anatomy which refers to the development of the anatomy or embryology,
- Microscopic anatomy which examines tissues and organs microscopically,
- Pathologic anatomy examines tissue and organs of patients,
- Surgical anatomy which refers to surgical applications of the anatomy,
- Applied anatomy,
- Descriptive anatomy,
- General anatomy,
- Physiological anatomy as the functional anatomy,
- Aesthetic (artistic) anatomy which examines changes in appearances in human body during the resting or movement,
- Gross anatomy which refers to macro examination of large parts,
- Clinic anatomy which examines application of normal anatomic knowledge on the living during the clinic (Çimen 2003).

2.2. General Information about bones

The science concerned with bones is called osteology. Bones form the skeleton in a body. Upper and lower limbs are called skeleton apendiculare while the part from the head to the lower part of the pelvis is called axial skeleton (Arıncı and Elhan 2001).

Bones form the skeleton in a body. A new born skeleton consists of about 270 bones while it is 206 for and adult skeleton. The skeleton has plenty of functions as follows:

a. it supports, protects the body and provides movements with muscles,
b. it protects the vitals with formations such as cage (i.e. the skull, rib cage, heart and lungs)
c. bone marrows of some bones produce red blood cell.
d. bones store minerals such as calcium and phosphorus (Süzen 2006).

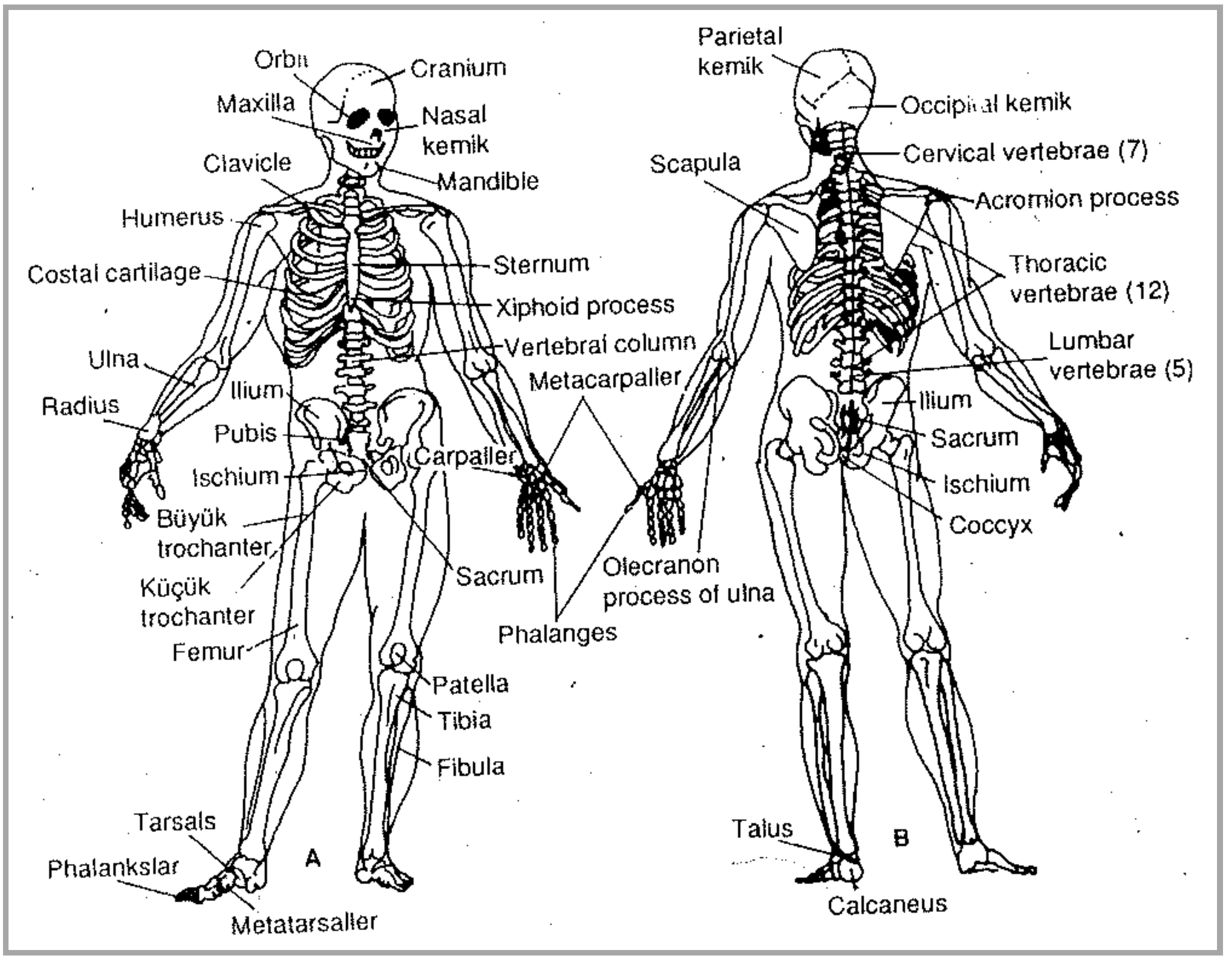

Figure 1: Bones that form the human skeleton (Demirel and Koşar 2002)

2.2.1. The structure and angle of the bone

33% of the bone tissue is comprised of organic materials while the rest is comprised of inorganic materials. Among these inorganic materials are calcium phosphate, calcium carbonate, magnesium phosphate, alkali salts etc. which provide the yellowness of the bone; whereas organic ones provide the elasticity of the bone (Demirel and Koşar 2002).

The bone tissue is generally comprised of substantia ossea and medulla ossea in the internal part. The bone tissue is the main material that shapes the bone and its parts except for those of joints is covered with periosteum (Arıncı and Elhan 2001).

In addition to these, they store Ca and P and blood is formed in bone marrow. The membrane that covers the bones is called periost (Çimen 2003).

2.2.2. Lower Limb Bones

The region which is positioned from art.sacroiliaca at the back and symphsis pubis in front to the tiptoes is called lower extremity (regio membri inferioris).

Lower Extremity is examined as separated into four regions:

- Regio glutea is the region from sacroiliac joint at the back and symphsis pubis in front to hip joint (art.coxae).
- Thigh (femur) region (regio femoralis) is the region from the hip joint to the knee joint (art.genu).
- Leg (regio cruralis) is the region from the knee joint to the ankle joint (art. Talocruralis).
- Foot (regio pedis) is the region from the ankle joint to the tiptoes (Süzen 2006).

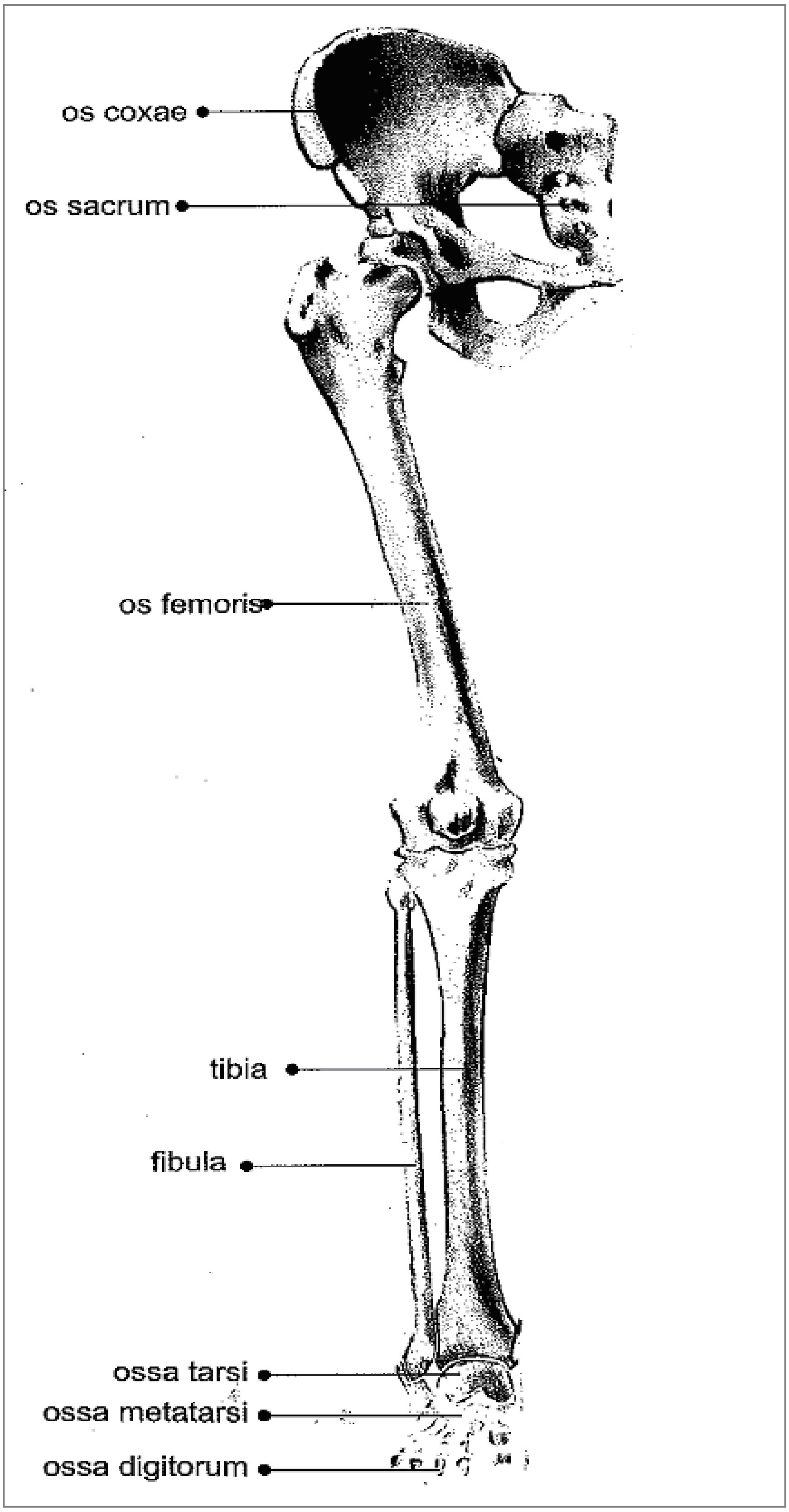

Figure 2: Lower Extremity Bones (Süzen 2006)

2.2.3. Thigh Bone (Femur/Os coxae)

It is among the paired bones and a wide and flat bone. It is formed with convergence of ilium, ischium and pubis. At the joint of the three bones is the head of the thigh bone (caput femoris), and acetabulum (asetabulum) which forms the joint (Süzen 2006).

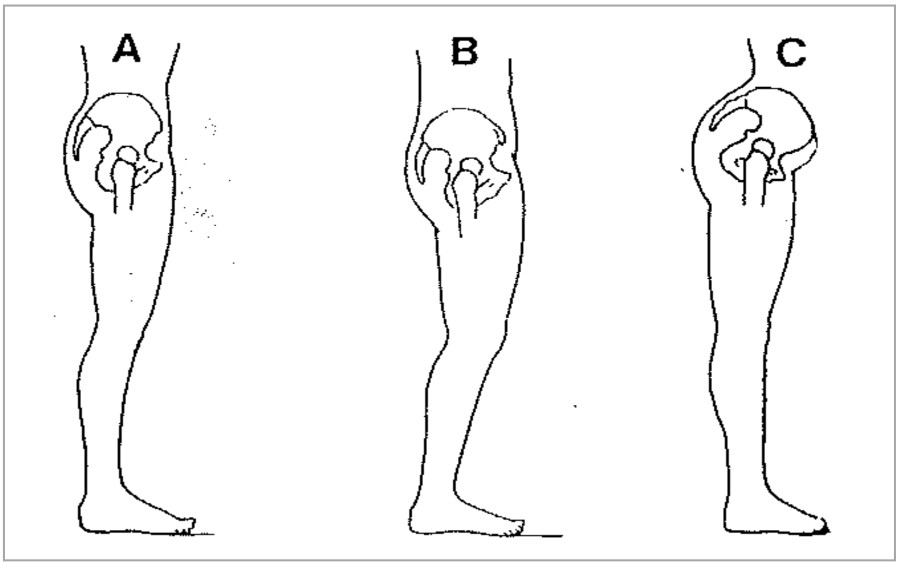

Figure 3: a) middle position b) back bending c) front bending (Demirel ve Koşar 2002)

Seen only in children, these three parts come out as a single part through symphysis at the ages of 14 and 16. The cartilage that separates these three parts from each other is seen in the shape of Y line from the radiography obtained from the acetabulum of the children. Therefore, this cartilage is called as Y cartilage in the clinic (Arıncı and Elhan 2001).

As a flat bone the thigh bone is articulated with the same opposite bone in front and on the middle line and with sacrum at the back (Zeren 1971).

2.3. General Information about Joints

The functional attachment between different bones of the skeleton is called as joint (articulatio). In some joints bones are immovably attached to each other. Suturas between all bones of the skull base but especially the mandibula are of this type of bones (Arınca and Elhan 2001).

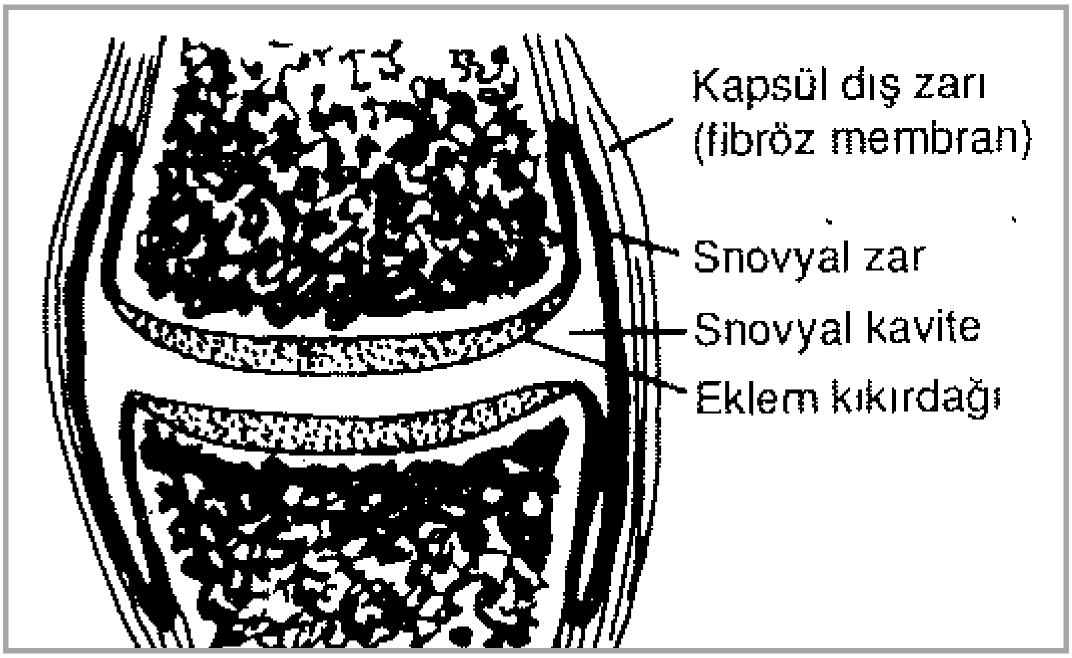

Figure 4: Frontal Part of the Cavitary Joint (Demirel and Koşar 2002)

Joints are passive components of our movement system along with bones. In order for the force produced by muscles to mobilise the bone attached to the muscle, this bone should pass through one or a couple of joints, that is to say, the muscle should certainly pass over one or a couple of joints positioned between the beginning point and the point of attachment (Demirel and Koşar 2002).

Joints are examined in three groups depending on their structures and movement capabilities:

1. Articulationes fibrosae
   Synarthroses
2. Articulationes cartilaginea
   Ampharthroses
3. Articulationes synoviales
   Diarthroses (Süzen 2006).

2.3.1. Joint Structure and Angle

Normally 120–130° flexion and 10– 15° extension movements can be performed in the sagittal plane (Hamill J ve Knutzen KM 2009). The hip flexion movement can be limited by capsuloligamentous structures, muscles and bones. Due to the hamstring muscles passing through the hip and knee joints, hip flexion decreases when the knee joint is in extension (Nordin 2001). Iliofemoral ligament, frontal capsule and hip flexor muscles reduce the extension. When the hip is in flexion, the internal rotation movement is between 0–70° while external rotation varies between 0 and 90° (Turgut A 2015).

There is a strong relation between the structures and functions of the joints. The position of the adjacent bones that form the joint, the shape of joint surface and feature of all tissues participating in the joint structure have been adjusted depending on the functions of joint (Demirel and Koşar 2002).

Joints are rich in terms of nerve terminations. Neural networks spread all over the joint. The fibrous membrane which protects the joint from external factors is richer than tendons which have sensation of pain (Süzen 2006).

In full motion joints, joint surfaces are totally separated. To facilitate the reciprocal convergence, joint surfaces of bones forming the joint have totally separated from each other and extended as well as have been covered with cartilage and a capsule made up of fibrous tissue from the outer (Arıncı and Elhan 2001).

2.3.2. Joints of the Lower Limb

Body-weight bearing and movement of whole body is provided by lower parts of the body in humans as livings walking on their feet. Lower limbs are comprised of hip girdle, thigh, calf and feet.

These joints allow us to carry out frequent daily motions such as using muscles, walking, crouching and standing as well as to run and do other motions in many sports branches. Moves done in the hip girdle are produced by muscles in the lumbosacral region of the spine and by muscles which pass over the hip joint and end in thigh (Demirel and Koşar 2002).

The success lies particularly behind the force, flexibility and bouncing technique of the lower extremity and spinal muscles (Letzelter 1986). Thus, determination of the lower extremity force and preparation of training programs of the athletes accordingly play a crucial role in enhancing the performance (Kashihora et. al 2005).

Lower Extremity Joints (Juncturae membri inferioris): Art. Coxae – Art. Genu – Art. Tibiofibularis – Art. Talocrusralis – Artt. Pedis – Art. Subtalaris – Art. Talocalcaneiformes–Art. Cuneocuboidea–Artt. Intertarseae – Artt. Tersometatarsales – Artt. Intermetatarsales – Artt. Metatarsophalangeales – Artt. Interphalangeales pedis (Arıncı and Elhan 2001).

2.3.3. Hip Joint

Hip joint motions are comprised of flexion, extension, abduction and rotation along with special physiological limitations of soft tissues. Flexion is limited by Hamstring muscle group while extension is limited by capsular ligament thickening. Abduction is limited by abductor muscle group, adduction, abductors, and tensor fasciae latae muscles while rotation is limited by fibrous capsular tendons. Ranges of motions of the hip joint are as follows: (Turgut A 2015).

Range of motion of the hip joint:

1. Flexion 135°
2. Extension 10-30°
3. Abduction 40-45°
4. Adduction 20-30°
5. Internal rotation 35-40°
6. External rotation 45°
7. Internal rotation (90° in flexion) 45°
8. Internal rotation (90° in flexion) 40°
9. Abduction (90° in flexion) 65-90°
10. Adduction (90° in flexion) 40°

Acetabular coverage is an important factor for proper hip bio-mechanic. The degree of the acetabular coverage is measured with Wiberg angle and measured normally as 26±6 degree. Insufficient coverage of the femoral edge results in abnormal direction of the acetabulum and insufficient weight-bearing (Ekşioğlu et. al 2001).

The hip joint is in shape of a concave-sphere and helps execution of flexion, extension, hyperextension, abduction, adduction, internal and external rotation, horizontal flexion, horizontal abduction and circumduction movements.

The joint is positioned between ligaments - lig. Illiofemorale, lig. Pubofemorale and capitis femoris de acetabulum- which reach out into the thigh from the three bones that form the femur and femoral head and curbs the abduction and external rotation movements (Demirel and Koşar 2002).

Type 1: is the normal hip whose Beta angle is smaller than 55 degrees and whose alpha angle is bigger than 60 degree. The alpha angle decreases while the Beta angle increases in a hip dysplasia. Acetabulum is mature.

Type 2: there is a delayed acetabular ossification. It is an intermediate type of or physiologically immature hip and a “critical” hip. It can occur at any age and has high risks for half-dislocation or dislocation. Alpha: 43-59 degree, beta: 55-77 degree.

Type 3: is an eccentric hip whose femoral head is half-dislocated or dislocated. The alpha angle is below 42 degree.

Type 4: has a serious dysplasia along with inversion in labrum. Femoral head is dislocated. (Verim and Sarı 2013).

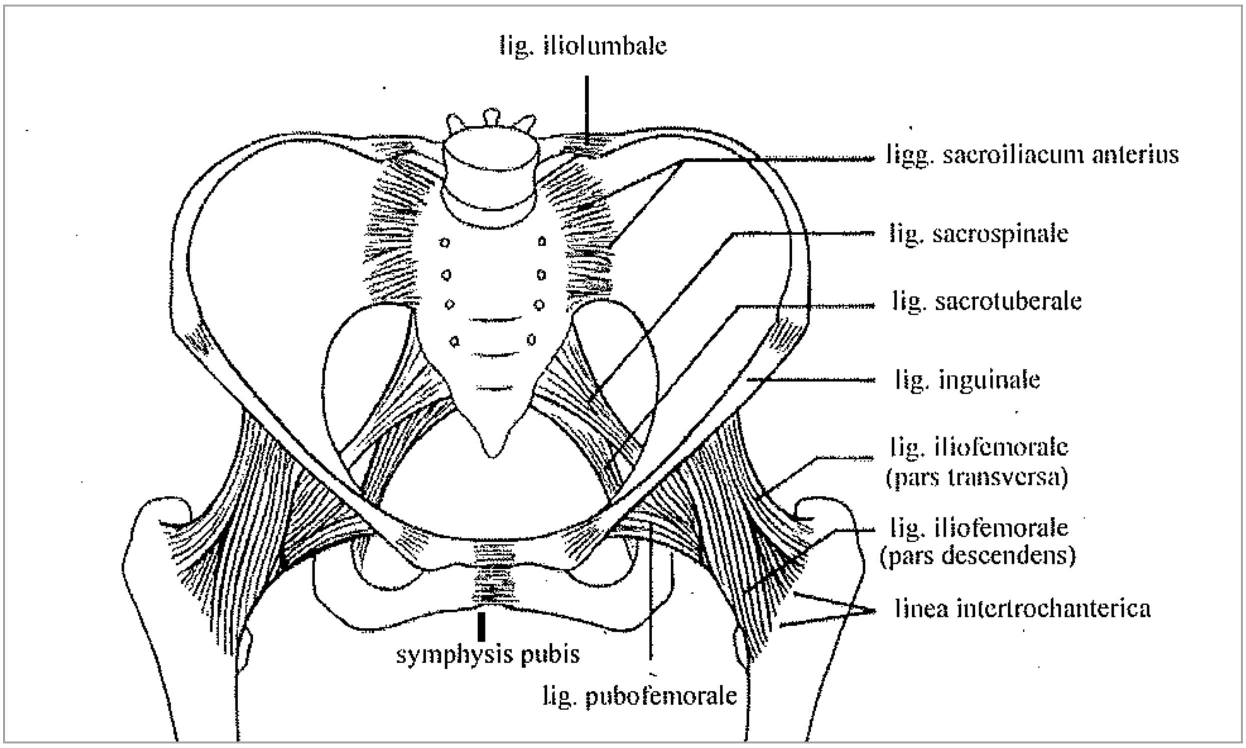

Figure 5: Frontal View of Hip and Hip joint centre (Çimen 2003)

It is a joint of art. spheroidea group formed between Caput ossis femoris and acetabulum. Caput ossis femoris, the convex joint surface, is in shape of a sphere and is covered with joint cartilage all over except for fovea capitis femoris to which lig. Capitis femoris holds on (Arıncı and Elhan 2001). This joint which attaches the lower limb to the pelvis is of the enarthrosis group and connects the thigh bone to the femur (Zeren 1971).

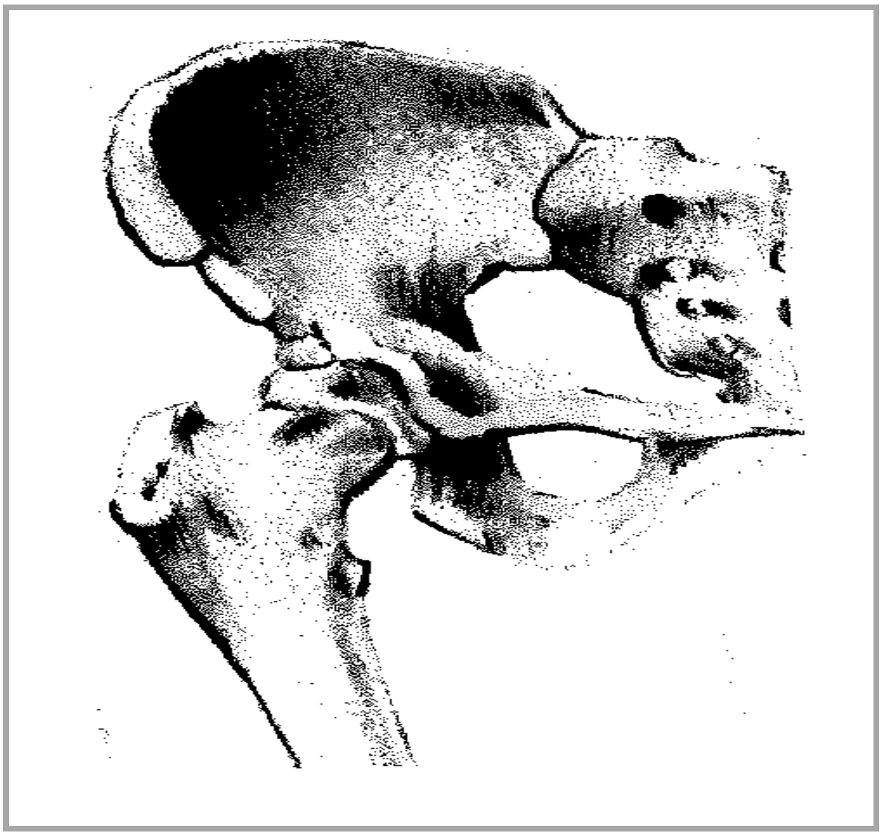

Figure 6: art. Coxae (Süzen 2006)

The hip joint is a synovial joint in shape of nest or round. It has a perfect structure for standing and walking. A major part of the hip joint stability is provided by the joint capsule (Ekşioğlu et. al 2001).

2.3.4. Hip Muscle

Awareness of anatomic features of hip region muscles ensures that exercise is carried out towards muscles groups targeted during the exercise. For instance, while both rectus femoris and iliopsas muscles are stretched by holding the knee in flexion during hip flexor stretching in a standing position, extension of the hip while the knee is extension produces a strain in only iliopsoas muscle (Atalay et. al 2014; Oatis CA 2009).

Muscles of the Gluteal region can be discussed within 2 different groups as superficial and deep ones. Superficial muscles are gluteus Maximus, gluteus medius and minimus and TFL muscles. This group is responsible for the extension, abduction and medial rotation of the hip in which only the gluteus Maximus produces lateral rotation. Abductors and extensors of the hip are crucial in terms of pelvic stability (Atalay et. al 2014; Houglum PA 2009). It is a critical factor in relation to execution of the stability movement in hip joint and supporting of forces during daily activities (Atalay et. al 2014; Bowman at. al 2010). While Gluteus medius shows the highest activity in particularly compression phase of the walking, it produces much more force than expected considering its size (Atalay et. al 2014; Ward SR et. al 2010).

A. Quadratus femoris muscle

When the pelvis is in a stationary position, it takes the thigh into the external rotation. When the femur is in a stationary position, where it is contracted in both sides it helps the extension of pelvis. In case of one-sided contraction, it contributes to the internal rotation of pelvis. (Turgut A 2015; Calais-Germain B. 2007).

B. Gluteus minimus muscle

It is main function is to enforce the frontal side of the gluteus medius. Besides enabling abduction for the thigh, it helps flexion and internal rotation. When the femur is in a stationary position, where the gluteus minimus is contracted in both sides it helps flexion and external rotation of the pelvis and where it is contracted in one side it helps lateral flexion or external rotation of the pelvis (Turgut A 2015; Calais-Germain B. 2007).

C. Gluteus medius muscle

When the hip is in a stationary position, its main function is abduction. However, it helps flexion with frontal tendons and extension with back tendons. When the femur is in a stationary position, where both sides are contracted, gluteus medius plays a role in both flexion and extension of the pelvis depending on the contraction of the frontal or back tendons (Turgut A 2015; Calais-Germain B. 2007).

D. Gluteus Maximus muscle

Deep layer pulls the femur back in soft abduction and external rotation when femurs are in a stationary position (hip extension). When the femur is in a stationary position, where both sides are contracted, gluteus maximus plays a role in extension of the pelvis and when one side is contracted, it plays a role in extension, internal rotation and medial flexion (Turgut A 2015).

2.4. Importance of Hip Structure in Sport

As the hip joint is of art. Spheroidea group, it has three main axes as transverse, sagittal and vertical and many secondary axes. Among these main axes, abduction and adduction are executed around transverse axis, internal and external rotation around vertical axis and circumduction movements by using all axes. These axes pass through the centre of the femoral (Arıncı and Elhan 2001).

Movement expansion of the hip joint is at a high level. When the knee joint is in flexion, what limits the hip flexion movement is the femoral region holding on the abdomen. When the knee is in extension, strain of hamstring muscles limits the hip flexion. Considering the muscles in hip region, it is observed that external rotation muscles are stronger than those of internal (Ekşioğlu et. al 2001).

It is known that hip movements have close relationship with movements executed in joints between hip joint and lumbar spines and in joints between bottom lumbar spines and sacrum. In other words, movements executed by the thigh in hip joint or movements executed by the body in joints between lumbar spines and sacrum determine the hip movements (Demirel and Koşar 2002).

The femoral head is in size of 3/5 of a sphere and faces medial side-up and a bit forward. In the middle of the head is a concavity called fovea capitis femoris formed as the round ligament is attached into it. Each side of the head is covered with cartilage. The head is attached to the bone shaft via neck and the neck produces a bending angle of 130 degrees through the shaft axis (Zeren 1971).

The hip flexion is one of the strongest movements of the body. In addition to basic movements such as walking and running, we use the hip flexion almost in every single movement. The hip flexion is needed during acts such as swimming, jumping, high jumping, pole-vaulting, kicking, some sorts of gymnastics, tower jumping, etc. (Demirel and Koşar 2002).

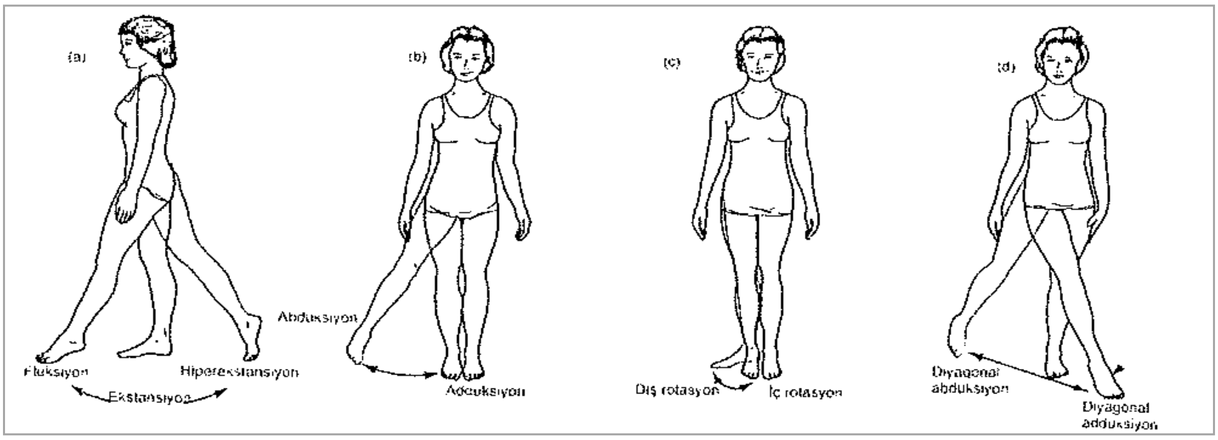

Figure 7: Basic movements in hip joint (Demirel and Koşar 2002)

The force effective on the hip during walking is between 3.5 and 5 times more than the body weight. When a single-limb stance, there is 6 times more force on the hip than the body weight. Overloading on the hip during running is 10 times more than the body weight (Canale and Beaty 2008).

2.4.1. Advantages of Hip Structure on Sport

The degree of abduction and adduction executed around the sagittal axis of the hip joint depends on bilateral stances of the femur and pelvis. When in standing position, we can execute abduction of 40 degrees and adduction of 10 degrees in average.

When we force to do more movements, joint (sutural) ligaments interfere. However, by bringing the thigh into flexion a bit, we can ease these ligaments, thus can execute abduction up to 90 degrees (Arıncı and Elhan 2001).

When in upright posture, the hip joint is in extension. It occurs when we are engaged in many hip extension locomotors like walking and running just like in hip flexion. We need hip extension during sports branches such as swimming, long and high jumping, weight lifting and in some gymnastic figures (Demirel and Koşar 2002).

Leg and iliac muscles (hip muscles) play a key role in a forceful kick, but in doing so we need a help from the body muscles. During throw-in, all muscles including glutes, body, pectorals and arm muscles work co-ordinately. In the fight to win the ball, particularly glutes, leg and body muscles are used (Karatosun 1991).

Hip abductors are needed to equilibrate during falls following an athlete's leaping up as in tossing branches such as javelin throws and shot-puts though they are not often used and are weak movements, in gymnastic and sports such as ice dancing, etc. (Demirel and Koşar 2002).

It is a movement we encounter during leg strokes in breaststroke swimming, inside cuts in football and in skiing. We encounter it in walking, running, forehands and backhands and rotations in tennis. When feet are in a stationary position on the ground, there is an external rotation in left hip joint during a right-turn of the hip (Demirel and Koşar 2002).

2.5. Methods to Develop the Hip Structure

It was shown by Borms et. al (1987) who studied 10 - 20 - 30 seconds of static stretching exercises on flexibility of hip flexors (2 days a week for a period of 10 weeks), that static stretching exercises developed the flexibility at the same level and therefore 10 seconds of static stretching exercises were enough to develop the flexibility.

As Bullock-Saxton (1994) put forward that hip-muscle functions have relation with severe sprains, strengthening of hip region muscles at this time is highly important. Therefore, thera-band and resistant exercises may be practised and lateral walking or back walking is suggested.

Active motions towards other joints of the lower extremity such as hip and knee during physical injuries are applications that make the recovery as fast as possible and provide a quick return to the functions (Can and İkiz 2013).

Spinning at home works the leg, thigh and hip muscles. Spin bikes which show the mileage and pulse rate are the most suitable ones for exercising at home (Sağlam et. al 2008).

2.6. Hip Anatomy in Sport

We encounter it in walking, running, forehands and backhands and rotations in tennis. When feet are in a stationary position on the ground and the hip turns right and left, internal and external rotations are seen in right and left hip joint (Demirel and Koşar 2002).

It is seen in gymnastics and in some kicks in football. It is executed by adductor longus and brevis, graclis, iliopsoas, pectineus, rectus femoris, sartorius and tensor facia lata and through loosening of external rotators (Demirel and Koşar 2002).

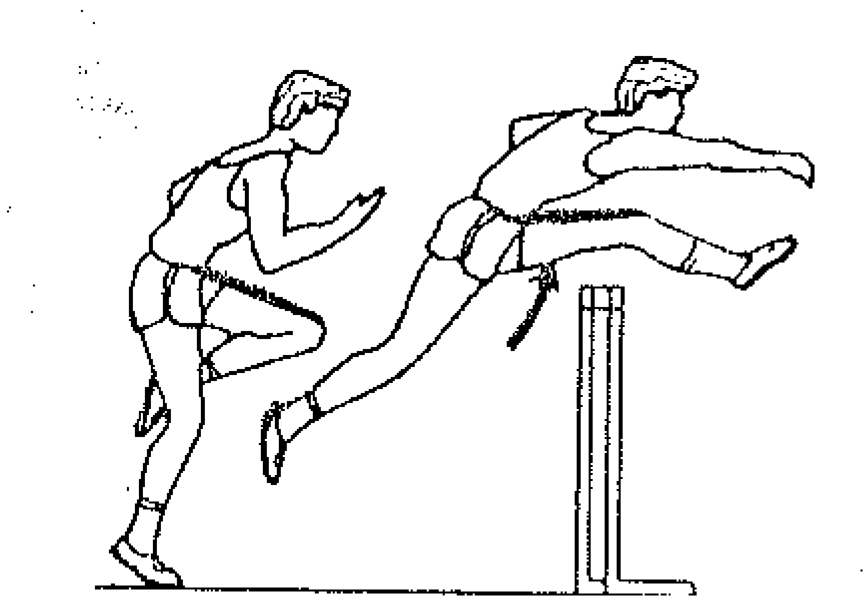

Figure 7: There is flexion in hip spinning leg and extension in the other during jumping (Demirel and Koşar 2002)

Balance movements contain movements of ankle, knee and hip joint as well as movements coordinated with kinetic chain. This process has a crucial place in revealing "effluent" movements related to the sport (Harringe et. al 2008).

To balance the centres of gravity on their feet, female sprinters move their pelvises more. As bigger muscle groups step in during sprinters' running, mechanical effectiveness of the running decreases. This situation is theoretically considered as a limitation for the running ability in women. However, according to research in this field it has been observe that hip width does not affect the performance (Medved 1996).

3. Conclusion

It has been seen from the literature review that there is not any direct research on the impact of the hip structure on sporting performance. This research provides clues for trainers to enhance the performance of their athletes. The hip anatomy has an important place in forehands and backhands in tennis, in rotary motions in some techniques in football, in gymnastics, walking and running and in many sport branches alike. It is observed that joint structures that form the hip anatomy and muscle groups are effective when practising daily activities and sportive motions and triggering the motion. In many sportive branches and technique applications, researches related to the hip anatomy are required. We suggest that hip anatomic structure be determined and that its impact on sporting performance parameters be studied and examined.

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