THE BIOMECHANICAL STUDY ON FORCES AND MOMENTUM THAT ACT ON ANKLE JOINT WHEN STAMPING IN ATTACK AT VOLLEYBALL

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Key words: ankle joint, biomechanics, attack at volleyball
Resumme: Modern research has shown that not only the mechanic factor by itself can influence the structural modifications but it must also be assisted by the tissual biochemical factor which creates the conditions for the disappearance of some structures and the appearance of others.

Introduction

Till ancient times the animal body, human, respectively has been considered as a living machine, and biomechanics, a subject that has appeared -we can say it- quite "recently" (from the Greek words bios=life and mehane=machine), deals with the study of motions from the point of view of mechanics' laws. The human or animal body or its segments are considered mobile, therefore moving.

According to some authors [1, 2, 9, 10], biomechanics is a natural science which studies the objective laws of equilibrium and movement of living material bodies.

One can say that biomechanics deals with the study of the moving forms, of the forces that produce the motion, of the interaction between these forces and those which oppose to the motion. Due to these assertions one can conclude the fact that biomechanics is a method of analysing the motions anatomically and functionally in mechanical terms.

A definition of biomechanics which renders the connection between mechanics and anatomy is given by. [8] The latter asserts that: "biomechanics is the science that studies the repercussions of mechanic forces on functional structure of man, concerning his bone architecture, joints and muscles as factors that determine the motion.

As the above lines highlight, biomechanics deals not only with the mechanical analysis of motions but also with their effects on the structure of organs that make the movement.

As I have already outlined, biomechanics has various definitions in the reference books such as:

- the science that deals with the study of mechanical motion in animal bodies (human, respectively), its causes and manifestations. [6]

- the science that studies the connections and laws of mechanical and biological movement forms. [7]

- the science that studies the action and effect of internal and external forces on biological systems. [8]

- the science that studies how living creatures move, develop in relation with the mechanics principles. [9]

- an application of mechanics laws on living organisms, for example the locomotory system. [5]

- the science that studies the human body's movements as well as those of different segments together with the orthostatic activity of the body or its parts. [4]

Material-method:

The evolution of the motions study

Modern research has shown that not only the mechanic factor by itself can influence the structural modifications but it must also be assisted by the tissual biochemical factor which creates the conditions for the disappearance of some structures and the appearance of others.

As for the study of motions methodology, it has also evolved at the same time with the progresses achieved by science and technique following mainly the same three stages:

a) The stage of using the mechanical installations. During these periods, dynagraphs, pneumographical recordings of the pressure of different segments have been used.
b) The photochemical stage. The chromophotography [11] and cyclogrammetry. [10] Later on the cinematography develops fact which gives the possibility of reproducing the movements on a screen; the use of slow motion to reproduce the images offers the possibility of studying attentively the different biomechanical characteristics of movement
c) The electrotechnical and electronic stage. Tension converters start to be used which are fixed on sports apparatus (platforms, oars, skis, dynagraphical skates) or on the sportsman's equipment and through tension systems they transmit the information to some oscilloscopes which record the different followed parameters giving the possibility of having an electrical, biomechanical analysis of the sports moment. Therefore, electrographical and stereophotoelectronic devices. The electronic calculators make the minute mathematical transformation. [9]

Results:

The creation of the analytical model

If one makes a simple analysis –from a mechanical point of view- one can say that the ankle joint forms according to the movements that it affords a rotating kinematic coupling (cylindrical joint). The kinematic coupling can be defined as a mechanism formed of two elements in direct contact through a link that permits the mobility of at least one of them (figure 1).

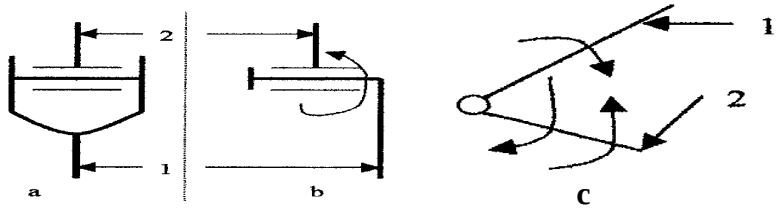


Figure 1. Kinematic coupling. a), b) lateral plane, c) sagital frontal plane. 1 and 2 elements of the coupling

In order to create a reliable analytical model of the ankle joint I have started my judgment having in mind the fact that the joint is a cylindrical one. The cylindrical joint is a type of joint, as we have seen, (figure 1) that allows only the relative rotating movement round its longitudinal axis. The cylindrical joints can be as follows:

- trochlear joints (such as: the humeral-cubital-radial joint that allows only the flex-extend movement of the forearm on the arm) or the joint articulation;
- the trochoid joints which allow only the pivoting motion. (such as the superior radial-cubital joint).

In the case of volleyball (the one taken into consideration) the time before jumping to attack can be sequenced in three phases:

- touching the court with both heels
- moving from the heel to the whole sole
- detaching from the court which means moving the sole by pushing energetically the toes and the metatarsus.

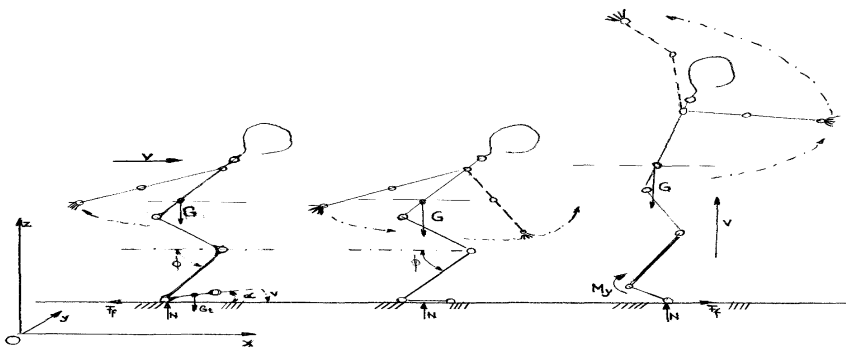
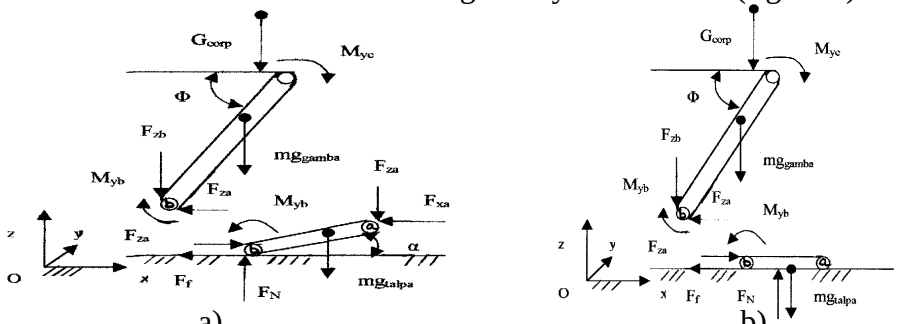


Figure 3. The three phases of stamping for the attack at volleyball.

The present study focuses on the analysis of the first two phases of the time before jumping to attack that is: touching the court with the heel and touching it with the whole sole.

First I have designed the ankle joint as a system of two articulated bars and I have related it to a triorthogonal system of axes (figure 4).



a) b)

Figure 4. Mechanical decompose of ankle joint in the two articulated bars for the first phase and the second.

As one can see in the figure, there is a series of forces that act on the heel which we can decompose according to the three axes: Ox, Oy, Oz, Ox being in a horizontal plane**.**

If we decomposed the joint in the two articulated bars and placed the joint's forces on these two and then we wrote the equation of the forces in relation with the three axes we would get the following results:

Ox: $$F_x = F_{xa} - F_f + m_s a_{xs} \quad (1)$$

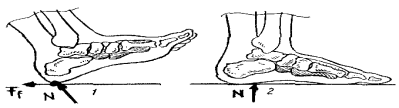
while: $$F_f = \mu mg \; ; \quad (2)$$

results that: $$F_x = F_{xa} - \mu mg + m_s a_{xs} \quad (3)$$

Oz: $$F_z = F_{za} - G_{corp} - m_s g_{zs} - m_t g_{zt} \quad (4)$$

Oy: $$M_y = I_{ys} \cdot \Phi + M_{yb} + F_{xa} \cdot l_s + F_{za} \cdot l_s \quad (5)$$

When first touching the court with the heels the sole forms a third type lever that can be drafted:



a) b)

Figure 5. The level between the sole and the ground contact a), and b) schematic reprezentation of connecting with the ground.

In the 5a, S stands for the support (in our case the contact heel-ground), F is the muscular force of sole flexors that lowers the sole on the court and R is the resistance force represented by the sole's weight..

For this first stage the frictional force that interferes between the heel and the sole is of major importance. Due to this friction between the footwear sole (sports shoe) and the court surface, the sportsman's body, in a translation motion, after the two steps of the impetus is stopped and later on in the third stage, the horizontal transformation of the translation motion turns into a vertical ascending motion.

The above written details underline the idea that the frictional force is of utmost importance as, if the frictional coefficient between the foot sole and ground is not big enough the slide between the two surfaces may come up. This thing is extremely dangerous because it can lead to hurting the sportsman. In the industry of sportswear, footwear respectively, this aspect of friction is thoroughly studied trying to design a more reliable kit in order to get rid of sliding risks and so to avoid the possible traumatisms caused by it.

The anthropometrical parameters specific to every segment were: length, mass, inertness momentum and the gravitational centre.

The length of the shank (l_g) is measured from the lateral malleolus (external) to the femoral epicondyl. The length of the foot sole can be measured from the end of the 5th metatarsus to the lateral malleolus (l_t).

In the other expressions (1, 2, 3, 4, 5) the following notations have been used:

M_{ly} – the inertness momentum

M_{yb} – the rotating momentum in point b (in the ankle joint)

Fx_a, Fx_b, Fz_a, Fz_b – the forces that appear in the ankle joint decomposed after the axes Ox and Oz.

Discussions:

It is very important to know precisely the forces and momentum that act at the level of ankle joint as the latter takes 95-97% of the body weight, therefore it is intensively used.

By knowing the forces and momentum that act at the level of ankle joint one can determine the direction of maximum efforts and use in the trainings exercises which do nor overwork the joint.

The study emphasizes the importance and the role of the frictional force when doing the attack jump.

By knowing the data about the joint forces and momentum one can determine the best weight a sportsman can have in keeping with the sports he/she practices. (the study will be carried out for the volleyball player). In this particular case (volleyball) the maximum tasks are at the level of ankle joint and knee because it is a sport where the jumps are the predominant actions.

From a sporting point of view this paper is of interest as far as the following reasons are concerned :

- the modification and optimization of the training technique. Of a great importance can be considered the trainings with weights (workout trainings)
- the improvement of sportsmen' technique
- the improvement of the materials used in the sports training

As for the industrial mechanics importance one can stress out:

- the creation of measuring apparatus for all the sports fields
- the creation of new materials to replace the bones in case of fractures
- the production of new materials and techniques for the joint and bone prostheses

By continuing this study in the medical field the result can lead to the reduction of days in hospital and the improvement of the surgical technique for this segment.

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Titlu: Studiu biomecanic asupra forţelor şi momentelor ce acţionează la nivelul articulaţiei gleznei în cazul bătăii pentru atac la volei
Cuvinte cheie: articulaţia genunchiului, biomecanica, atacul în volei
Rezumat: Se poate spune, că biomecanica se ocupă, cu studierea formelor de mişcare, a forţelor care produc mişcarea, a interacţiunii dintre aceste forţe şi forţele care se opun mişcării. În urma acestor afirmaţii, se poate concluziona faptul că biomecanica este o metodă de analiză anatomo-funcţională a mişcărilor, în termeni mecanici.

După cum reiese, din rândurile de mai sus, biomecanica se ocupă nu numai de analiza mecanică a mişcărilor, ci şi de efectele lor asupra structurii organelor ce realizează mişcarea.

Prin cunoaşterea datelor legate de forţe şi momente în articulaţie se poate determina şi greutatea optimă a sportivilor în funcţie de ramura de sport practicată (studiul se va efectua pentru modelul de voleibalist). În cazul cestui sport (volei), sarcinile maximale sunt la nivelul articulaţiei gleznei şi genunchiului deoarece este un sport în care acţiunile preponderente sunt săriturile

Titre: Etude biomecanique de les forces et les moments de articulation agissant a la cheville dans le cas de trac pour l'attaque en volley-ball
Mots cle: articulation genou, biomecanique, attac voleiball
Resume: On peut affirmer que la biomecanique etude les formes de mouvement, les forces qui produisent la mouvement et les interactions entre ces forces et les forces qui s'opposent. On peut concluir en thermes mecaniques que la biomecanique este une methode d'analise anatomo-functionelle des mouvements. Meme, la biomecanique etude et les effets sur la structure des organs qui faits le mouvement. Par la connaissence des aspects liees des forces et moments dans l'articulations, on peut etablir la masse optimale pour les sportifs en function de leur specialite (on va etudie le model de voleiball). En ce cas les forces maximalles sont

a niveau de genou parce que s’est un sport ou presque tous les actions ont a la base les sauts.