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Determination of postural differences between different sports branches

Doctoral Thesis - Summary

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autor Andrei Zoltan Farkaş
scientific superviser Prof.univ.dr.ing. Inocenţiu Maniu

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1. INTRODUCTION

Human adaptation to the bipedal posture was a consequence of the need to go further distances from climate change a few million years ago. The posture is influenced by the relationship with the environment, food, daily activities, occupational activities etc.

We have shown the level of physical activity, this is a way of expressing numerically a person's daily physical activity and is used to estimate total energy expenditure [12]. The physical activity level defined for a non-pregnant adult without lactation relative to the basic metabolic rate defines the total energy expenditure of that person over a 24-hour period or the energy consumption coefficient [31].

There have been two great revolutions in the evolution of human culture. The first was the agricultural revolution that led to an increase in the food source and population, but the number of infectious diseases increased as people began to live in cities where they were surrounded by garbage and other debris. The second one was the industrial revolution and the emergence of modern science, the two being interdependent and leading to a higher increase in the food supply, an explosion of the population, with which the number of diseases decreased again after the invention of the health care system and modern medicine.

We are now in the healthiest stage in human history in terms of malnutrition and infectious diseases such as plague, smallpox, but increased deaths from non-infectious diseases such as cancer, heart disease, diabetes , allergies, osteoporosis, obesity and other diseases whose incidence is increasing such as depression, alzheimer's, myopia, dental degradation, musculoskeletal disorders [6] and others [14].

From the point of view of posture and energy consumption, these revolutions in the evolution of human culture have had great consequences in the development of the modern man's body. From the point of view of the level of physical activity we can identify 3 categories of life styles depending on the energy consumption: sedentary, active and super active.

The third category, the super active, represents the population interest group in this thesis, namely performance athletes.

Modern sport is a real industry in which performance athletes can be easily categorized as full-time employees, in some cases extended, given that their lifestyle is often very well calculated 24 hours a day on long periods of time in terms of nutrition, training, physical, psychological recovery, rest and all aspects of their lives. Considering this aspect and the fact that they exceed the functional limits of the human organism that represent thousands of years of evolution, we can easily assume that a human body engaged in practicing a performance sport is subject to phenotypic changes. Phenotypic plasticity refers to changes in the behavior of an organism, its morphology and physiology due to the need for adaptation to the unique environment [20]. In our case, the unique environment is the land / hall / infrastructure needed to practice a certain sporting branch.

In the case of performance athletes, all these factors are different between different sporting disciplines, of course the diet is controlled for all performance athletes, but the big difference is found in the other factors: the ground / hall / infrastructure needed to practice a certain sporting field, and so on, leading to the specific development of muscle memory and the body of athletes.

The ergonomic posture is ensured by the coherent central integration of the tonic-static and tonic-dynamic reflexes that underlie the balance and the multiple conditions that condition the body's orientation in space, from an integrated and symmetrical morphostructure, a proper coordination, a

balanced tension relationship / length between the antagonist muscle pairs creates an accurate image of the body and a valid kinesthetic perception of its functions.
Practicing performance sports leads to musculoskeletal overload which often has pathological consequences, which is why it is very important to study postural differences between different sports disciplines.
The doctoral thesys aims to determine the postural differences between athletes coming from different sports fields, which aims at:
• anthropometric study of athletes;
• objective determination of the rear geometry with the "Zebris" system;
• postural determination in orthostatic position;
• Determination of muscular symmetries / asymmetries resulting from sports activities specific to the studied branches;
• statistical correlation of specific parameters;
• biomechanical analysis of posture with "Anybody" software.
Determining postural differences between different sporting disciplines aims at:
• monitoring sports activities and performances;
• monitoring the clinical recovery of injured athletes;
• prevention of occupational diseases;
• making sports selection more efficient.
The determination of posture in sport plays an important role in the prevention of chronic occupational diseases and offers solutions in optimizing specific activities, generating superior results of treatments, performance, selection and, implicitly, quality of life at the level of the entire sports performance community, as well as for mating or semi-professionals.

2. THE ACTUAL STAGE IN THE RESEARCH FIELD OF THE THESIS

Postural deviations have been associated with various types of pain and dysfunction. However, posture is not an easy subject to study, mainly because postural assessments are still scientifically imprecise, such as shooting assessments; or costly, such as magnetic resonance imaging (MRI); while others such as X-rays involve irradiation problems for subjects [3; 21; 23].
There is some scientific evidence linking posture and balance problems with orthopedic and rheumatological diseases such as knee osteoarthritis, ankle instability, neck tension, and back pain [25]. Among the most common methods of assessing the posture encountered in the literature are equilibrium force platforms [8] as well as the use of goniometers and inclinometers, flexible curves, measuring tape and posture shooting itself [7; 9] Myers [19] states that posture, standing or sitting motionless is not there because people are never immobile. In other words, people are always on the move, balancing and adapting. The immutability, balance and repeated patterns of the stabilization movement are all considered posture.
Jose Luis Pimentel do Rosario [22] in the twenty-two more relevant articles described 11 types of technologies, namely, force plate, photograph, quenches, inclinometers and tape, 3D X-ray analysis, sensors, electromyography, kinect , magnetic resonance imaging, 4D computed tomography, and infrared samplings.
By reviewing the literature, we found numerous methods of postural determination, some being more rudimentary while others use state-of-the-art technologies. All methods of postural determination presented both advantages and disadvantages, some being invasive, others being expensive, while some non-invasive ones, such as force plates, require coupling with other methods for accuracy.
In order to determine as accurately as possible the positions specific to the groups of athletes studied, we used in combination, as suggested in the literature, several non-invasive methods and technologies, equipped with the Ergonomics Laboratory of the Department of Mechatronics.

3. INSTRUMENTS USED IN SOLUTION OF THESE OBJECTIVES

A correct biomechanics of the foot is responsible for maintaining body posture and symmetrical distribution of planting pressure [28]. Furthermore, it exerts an important effect on static postural control (in terms of orthostatic position) and dynamic [13; 18; 29]. Moreover, according to Bricot [4], postural problems can start at the feet (ascending: walking antalgic or limp) or head (descending: eyes, vestibular system, temporomandibular joint). However, even when the problem comes from the head, legs are affected, and also require treatment [4]. The principle is to map the plant surface pressure, which indirectly indicates significant postural anomalies [11; 17].
Computerized barometric analysis records plantar footprint and soil reaction forces. This analysis allows to determine the percentage of the weight sustained by each leg and the symmetry ratio.
The barometer consists of a detection platform with a length of 160cm and 40cm wide, containing 25600 pressure sensors, along with an optoelectronic system made up of a video camera [30].
In the orthostatic biometric analysis, the subject has to sit on the pressure plate and stay in a relaxed natural position for 5 seconds to determine the static test, expressed as a calculation of the mean of the subject's oscillations.
Baropodometric technology is increasingly used in other specialties such as social sciences, psychology [15; 16], in medical branches such as ophthalmology and neurology, in patients with disabilities, hemiparesis and maxillofacial pathologies [10], where they detect different tension distribution profiles, useful for therapeutic programs and research [1; 2].
Thermography is a non-invasive, non-contact technique that falls within the category of passive diagnostic methods, where the device does not act on the subject at all, but only receives information from it. Thermography involves taking the thermal image of a human object or body and converting the image obtained into frequencies from the visible field, for which the eye exhibits spectral sensitivity. The resulting image is digital and requires information retrieval, processing and storage equipment.
Computerized thermography is a functional imaging diagnostic method in the EKG, EEG, EMG family, which explores the thermogenesis of human cells under health and illness. Infrared imaging has been used for decades to monitor the temperature distribution of the body surface [24; 27].
The thermographic device used is a FLIR B200 and features a technique that senses and records the hot and cold areas of the body through infrared detection methods that react to blood circulation.
The main technical features of this appliance are as follows:

- 200X150 pixel resolution;
- 2X digital zoom;
- Integrated digital camera;
- possibility to make annotations;
- "touch screen" screen;
- Interchangeable infrared lenses of 25 ° and optional 15 ° and 45 ° [33].

The FLIR B200 measures temperatures ranging from -20 ° to + 120 °. The integrated 1.3 megapixel camera allows for faster and easier observation and inspection, plus the "picture in picture" system that allows the infrared layer to overlay the visual image. The areas highlighted in red are the regions where the temperature is higher, that is, the areas of muscular contraction, and the regions represented in cooler colors: blue, green, are regions where body temperature is lower.
The Zebris CMS-HS spine examination system and the Winspine related program [32] determine the spatial coordinates of spinal vertebral processes.
The system consists of:

- lumbar belt that emits ultrasound pulses;
- a tripod consisting of three ultrasonic microphones to check for spinal movements;
- a pointer with two ultrasound emitters;

Transmitters send ultrasound pulses at regular intervals, which are recorded by microphones (measuring frequency is 100 Hz).
The WINSPINE measurement software records and stores the spatial coordinates of the microphones, and the spatial coordinates of the spikes are calculated from them generating a report that provides information on the positioning of the backline on the sagittal, front and horizontal plane.

Other output parameters include chest spine, lumbar lumbar lumbar spine, upper body inclination, sacral angle, pelvic and shoulder obliquities, lateral scoliosis, pelvis and spine mobility; similar parameters to the Cobb method [26].

4. EXPERIMENTAL DETERMINATION OF POSTURAL DIFFERENCES ON SPORTING BRANCHES

The determinations were made on three sports lots (12 basketball players, 13 volleyball players and 9 footballers), representing Timişoara in the first national league.

All athletes examined were physically fit and had the medical visits up to date when the data was collected.

Due to the low number of footballers we eliminated from the subjects of the other two athletes several athletes and some of them who were trained on certain specific positions (pivots in the case of basketball players and libero in the case of volleyball players), to reach an equal number of subjects and all having the handsome member on the right.

The experimental means of postural investigation used were: the electronic baropodometer (force plate), resulting in 29 parameters for each of the 27 athletes analyzed (783 values), the "Zebris" ultrasound system, resulting in 23 parameters for each athlete (621 values) and with the FLIR B200 thermo-thermography we took thermographic seals on athletes after practicing the sport specific training, thermal photos from which we analyzed 28 muscle areas (front and rear) for each of the 27 of athletes for which we analyzed average temperatures (756 values).

For the values of the 49 parameters obtained after postural orthostatic determination with the two devices, we performed a Pearson correlation coefficient (PCC) or statistical binary correlation using the IBM SPSS software to determine which parameters of the two devices of postural determination has a direct correlation.

After the ample statistical analysis we selected those parameters that were within the Pearson coefficient value> 0.05 and compared them graphically and statistically to the three sporting branches.

For the values obtained from the thermal imaging we performed a "T independent" test for the determination of muscle group temperatures with the same software (SPSS).

It is noted that the mean values of:

• the anthropometic parameters obtained (chap.4.1): weight, height (height), shoe size, spine length and lumbar vertebrae length, show upward trending values from soccer players to basketball players. Linear statistical correlation is positive, except for the linearly negative thoracic length compared to the lumbar length;

• pelvic / shoulder rotation, pelvic obliquity and pelvic / shoulder obliquity (ch. 4.2) show differences between the three sports, while soccer and basketball have similar values and volleyball has lower values; Pelvic torsion has the smallest value in basketball and over twice as high in football; the most pronounced positive correlation observed between pelvic and pelvic / shoulder obliquity;

• differences in pelvic height and shoulder height in volleyball and basketball subjects record higher left values; in football the registered values have a slightly dominant weight on the left side; the left-left pelvic height difference has mean positive linear linkage with pelvic / shoulder rotation, left scoliotic deformation, right lateral inclination and sacral angle; the right-hand pelvic height difference has an average positive linear correlation with pelvic / shoulder obliquity and pelvic obliquity, and a very poor correlation with the left foot angle; the height difference in the right shoulder has an average negative linear correlation with the pelvic obliquity and the left shoulder for all sports branches;

• the smallest mean shoulder blade distances from the front plan were recorded at volleyball with higher values for the right shoulder blade; in soccer and basketball the average distances were higher in the left shoulder; there was a direct linear positive positive correlation left / right; for the right side, weak correlations were observed with pelvic / shoulder obliquity and pelvic obliquity; the mean differences in the distances between the shoulders are again lower in volleyball and have a mean negative linear correlation with the right scoliotic deformity; parameters related to the position of the shoulders have no correlation with the size of the athletes;

• the toracic kyphosis reads in normal range for all sports with the observation that volleyball is at the upper limit; lumbar lordosis is at the lower normal limit for soccer and basketball; the volleyball players have exceeded the range of normal values by 3 degrees, the curve having a slight tendency toward "flat" lordosis; the sacral angle to basketball players and volleyball players are in the normal anthropometric range, with footballers exceeding the 4 ° to "flat" range; thoracic chest is linearly positive in line with lumbar and thoracic lobes, and linearly negative to total column length and right scoliotic deformity; lumbar lordosis from the sacral angle and the lumbar region have positive linear values and negative values for the length of the spine and the thoracic length; cyphos and lordosis have correlations with the lengths of their respective areas; the sacral angle appears to be linearly negative with the length of the spine, linearly positive with lumbar lordosis, and has no correlation with the thoracic chest; the sacral angle is higher for footballers, its value decreasing as the average anthropometric size of the athletes grow; all angular values of the spine are correlated with the length of the spine in all sportive branches;

• total trunk inclination is towards the front of all sports, volleyball registering the maximum value and having a poor correlation only with the angle of the legs; in the case of lateral inclinations we have higher average values on the left than on the right in all the groups of athletes, the smallest being observed for the footballers; it exhibits positive linear linkages with pelvic / shoulder rotation and a strong linear positive correlation of the right slope with the left pelvic height difference;

• left / right scoliosis is similar to football and volleyball; in basketball the weight is on the left side with a significantly higher value; the right scoliotic deformation has a mean negative correlation with the thoracic chest and the difference in the distance between the shoulders; left scoliotic deformity has an average positive correlation with the left pelvic height difference and a poor correlation with the right lateral inclination;

• plantar area (cap.4.3) increase in relation to anthropometric sizes, the ratio being higher between basketball and volleyball than between volleyball and football;

• the maximum pressures do not correlate with the anthropometric dimensions, the highest being in basketball and volleyball having very close values; Planetary surface correlations are negative averages with mean, maximum planting pressures and right scoliotic deformation; compared to chest clover has a positive positive linear correlation; the maximum and average pressure correlates poorly with the sacral angle and the length of the column, with lumbar lordosis correlating the negative environment.

• the CoF angle for all three sporting branches is positive in the normal reference range, with no correlation with the angular values given by the Zebris system; the leg angle slightly correlates negatively with the left shoulder height difference and total trunk inclination and shows a linear negative correlation with the right and positive foot angle with the left and right foot axis;

• plantar areas and pressures are distributed more quantitatively on the back of all three sports; the surfaces have a greater share

• high right on all branches, and higher volley pressures as well as a weight on the left side of the surface; the frontal planar surface of the right leg correlates linearly negatively with the right scoliotic deformity, the posterior line correlates positively linearly with thoracic chest; the total left / right leg surfaces correlate with lumbar lordosis, the left one with a mean negative linear value and the right one with the same positive value; the same correlation is also observed with the sacred angle; the absolute, posterior posterior plantar pressure correlates with the mean positive linear pelvic torsion; the total relative planting pressures correlate with the pelvic torsion and the planar surface with lumbar lordosis and the sacral angle;

• the foot angle is considerably higher for footballers for both legs than for the other two sporting branches; all sporting branches have higher values at the dominant leg; the axis of the legs is higher for all footbal sports, especially for volleyball; the left leg angle relative to that of the right foot has a positive average direct correlation; all left leg correlates with pelvic torsion and moderate with sacral angle, both correlations being positive; the left and right leg angle correlates with the waist height, linearly above the mean; the angle of the right leg has an average positive correlation with lumbar lumbar and linear negative with the posterior plantar pressure and the angle of the right foot axis; for the angles of the legs on the left, we found a strong negative correlation with its frontal surface and a positive average correlation with its total surface and pelvic / shoulder obliquity; in the right leg we have a mean positive linear correlation with the thoracic length and mean negative linear correlations with the lumbar length and the lumbar lordosis level.

As a result of the analysis of the asymmetry / symmetry through thermography (ch.4.4), we found that

at the level of all the analyzed muscle groups we have left as well as right muscular asymmetries in all sports. For many groups, we also recorded subjects with symmetric values. Among the sporting branches, we recorded a different weight in all muscle groups except in the group of extensors where all branches had the same weight left / right and in the legs where volleyball and basketball players had a predominant identical weight on the left side.
As a whole, footballers recorded predominantly left-handed asymmetry. Volleyball instead dominated the right side. Basketball players have the highest asymmetry towards the left side of the three branches.

5. BIOMECANICAL ANALYSIS OF THE POST

In the first part of the 5th chapter we presented general notions of static and dynamic biomechanics.
In the biomechanical analysis we can see that the center of mass (chapter.5.7) in all three subjects is on the left side of the body in the sagittal plane, which moved with the increase of their waist to the axis. Also closely related to the height, the center of gravity climbs along the Y axis, this increase not directly at the height of the athletes. Soccer players recorded a ratio between the height of the center of gravity and the lower height than the other sports.
The majority weight on the left of the coordinates obtained from the determination of the center of mass of a representative of height and average weight for each sporting branch validates the data obtained in the previous chapters.
After performing the inverse dynamic simulation (ch.5.5), it can be observed that in the quadratus lumborum muscle the AnyBody reference model has similar left / right values, slightly higher on the left. All athletes recorded significantly higher values on the left side of the muscle group, gradually higher from football to basketball. For the "multifidi", the model has equal left / right values, athletes having higher values on the right again gradually higher from football to basketball. The group "erector spinae" has the same tendencies as the "multifidi" group with the observation that all sports record values under the reference model.
At arm group level, biceps and extensor have the same tendencies. The benchmark model has similar left / right values, while all sports have higher values on the right, increasing gradually from football to bout. Similar to the group of arms, the femur biceps group behaves with the observation that besides basketball the other sports have values under the reference model.
The reference calf muscles of the reference model have higher values than any sport, slightly larger on the right. Football and volleyball have slightly higher values on the right side, whereas in the case of basketball, identical left / right values were recorded.
At quadriceps we recorded both left and right foot values for all athletes and the AnyBody. However, in the case of basketball players and AnyBody, both values are insignificant compared to the values obtained for the right foot of football and volleyball players. These are very high compared to their left foot or any of the basketball player and benchmark legs, the other values being extremely low.
The modeling / simulation revealed the theory of cross-strain muscle chains that during the course of the cycle and for the maintenance of the postural balance, the distribution of loads goes through a cycle from the upper muscle groups on the right side of the trunk to the lower left and vice versa.

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