# Synergistic issues of motor learning sequences as an outcome of its internal refactoring

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***Abstract* -** The current study is mostly addressed to athletics coaches who deal with the selection and training of athletes for hurdle events. The research aims to develop few certain aspects of beginner and advanced athletes, training for professional athletics, within the orientation stage to short hurdle races. Our brief presentation intends to develop several particular aspects, less approached in the literature of motor learning and on selection field for children and juniors. In motor learning process, approached as a synergetic and inferential procedure, certain internal reconfigurations of learning units can be defined as effective refactoring steps, aimed on forming high level and very stable motor skills. Some of them may describe aspects of a narrow field of investigation, consisting in supportive arguments based on good practice experiences.

***Keywords*** – Body centre mass, Clustering of algorithms, Inferential learning process, Mnemonics, Procedural refactoring, Refactoring principles, Synergistic process.

## I. Introduction

In the input stage of such a learning unit (**LU**) as a part of learning acting microsystem (**LAM**), an initial model is configured by a designer, as a pattern that is to be achieved by the algorithmic organization of the motor learning process, under the independent variable intervention (i.e. an inferential method of motor learning and assessing the individual technique of sprint hurdling). In most cases of motor learning and assessing a new motor skill, the athletes do not have in their own *motor portfolio* the appropriate structure that is to be tested.

Therefore, we cannot apply a pre-test based on this trial. Hence we could develop later on, a series of other assessment tests which could be applied, that are correlative to the skill that is to be learnt. In fact, the form of the movement performed at maximal morphokinetic parameters should lead to the execution of other parameters, these being also maximal, but topokinetic.

As we refer to high performance sport, we cannot dissociate the two characteristics of the motor operation to be taught and assessed. Obviously this association is mandatory and compulsory in the cases of sports in which the assessment of movement is mixed (morpho-topokinetic type), as in the case of sprint hurdling [11].

## II. Theoretical Background

### A. *Purpose of the study*

The development of this study conducts to an emphasized of the reconfiguration effects and also, restructuring of the original operational model of motor learning on the characteristics of the constituent inferential sequences. Refactoring may eventually lead, even to a redesign of the entire learning process, if the post-sequential results (the sequential outputs) are not the expected ones. During the motor learning process, each learning sequence (learning unit – **LU**) will be completed through a demo of the stage-level of the motor structure learnt at the time, accompanied by a so-called application-level test (test level) or sub-sequential test, to check the characteristics of fairness (the incremental-driven), or, where appropriate, correction of errors of execution (type decremented) as learning outcomes in that sequence, reported to the original pattern.

Along with this process, another mini-project is following-up, with ameliorative effect on the topokinetic component (refers to the development of motor skills involved - particularly the speed and explosive strength), leading to an amplification effect on the level of motor aptitudes, a compulsory incremental condition, in order to achieve the final motor pattern, both in terms of morphokinetic (acting system - *learning-consolidation-training* **[LCT]**, individual running technique over hurdles) and topokinetic (higher parameters of individual running speed, speed-reaction and execution), such as those of the explosive strength, mostly the impulse force of the lower limbs etc.

### B. *Relationship between human motor genotype and phenotype on refactoring procedure of motor learning process*

In fact, this is one of the main features of motor learning in high performance sport. Motor learning process cannot replace motor-aptitudes development, which must accompany by complementarity the motor skills acquisition. Thus, we stress the idea of the phenomenon to be deliberately induced, at the *mutual potentiation* between the two interventions upon the motor aptitudes and skills [12]. (Fig.1).

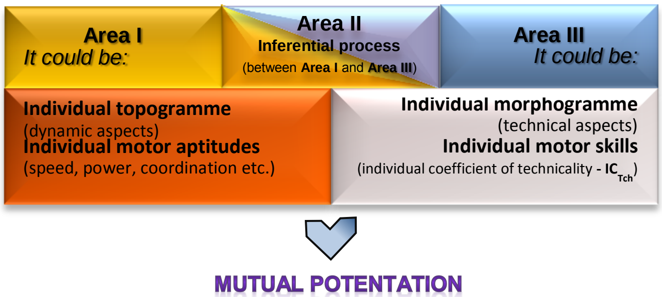


Fig. 1. Several aspects of *mutual potentiation* in motor learning process

Particularly important will be the following rule: the acquisition of a particular motor skill should be mandatory, as well as the proper development of motor aptitude-support. Developing positive effects of the means and methods used in motor learning, without action upon the motor aptitudes involved are not sufficient to produce general and specific quality performance bounds.

More specifically, a perfect individual running technique over hurdles, extremely refine as execution will not automatically lead to a final course of the hurdles race at the identical level with that of speed race on the same distance [5]. The final course of hurdles race **(CHR)** will be achieved by the cumulative course performed by that athlete on the speed race **(CSR)** with no hurdles. On this result is to be added the lost course over passing each hurdle, multiplied by the number of hurdles (defined as individual coefficient of technicality - **IC$_{Th}$**) [12]. The sum of the two timing components will result the individual performance, which will be measured. Otherwise, without the high individual speed rate, without a proper individual rate of speed reaction, without a high level of individual acceleration and in the absence of a higher index of explosive leg strength, the result will be a modest one [4]. See below two potential situations, in this presented context (Fig. 2 and 3).

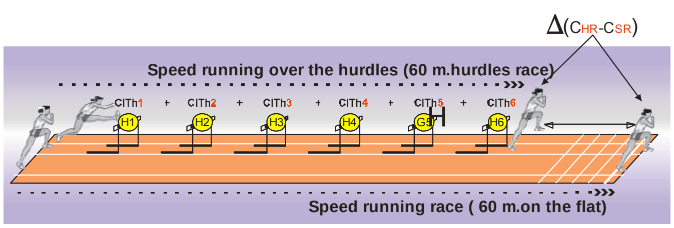


Fig. 2 Low level of individual coefficient of technicality **(IC$_{Th}$)** [12]

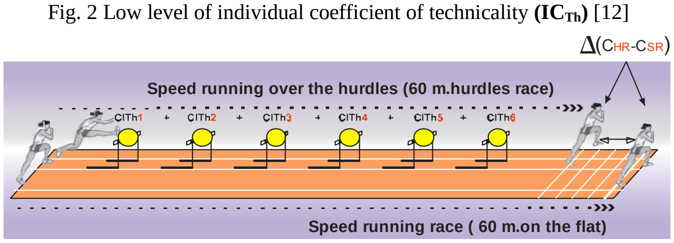


Fig. 3 High level of individual coefficient of technicality **(IC$_{Th}$)** [12]

The aim of applying all these methods is to reduce, as much as possible, the risk of building the procedural sequences named motor decrements (labile or unstable motor skills, wrong or partially correct executed), from both morpho and topokinetical view. This could be a new paradigm of analysis, in the context of our applied research. (Fig. 4).

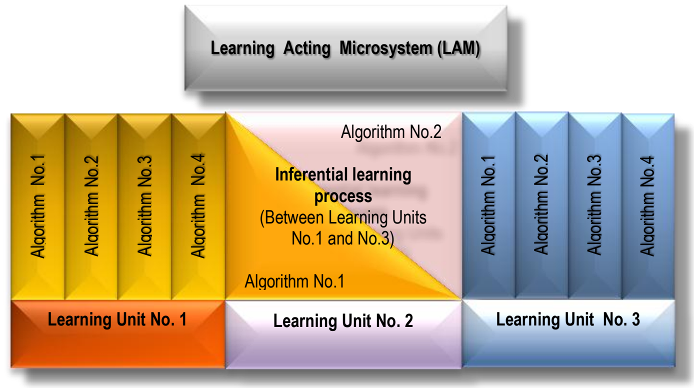


Fig. 4 A notional pattern of structural and chronological organization of the algorithms before refactoring intervention in motor learning process [12]

Otherwise, the inference sought by us, could be transformed into a repetitive linear process on its longitudinal conduct, described sometimes by the presence of interference phenomena (with disrupter effects) between the operationalized sequences of the motor learning units, and beyond. Instead of inference learning process, it will be developed an interfering modular process in stagnation or even decremented, with many unnecessary consumption of resources [1]. This loss will induce effects which will disturb the psychomotor behavior with pedagogical and time-consuming failures alike [11].

Negative learning becomes a significant risk when this process forwards towards motor morphogrames and topogrames with increasingly detailed and at a complex level, more refined and difficult to be executed in the target of qualitative and quantitative parameters that were initially configured for the final pattern to be. As they reach the terminal stages of learning, with repeated and continuously improved (iterative) executions, such as: **execution → error → correction → partial error → correction → correct execution → practicing proper execution** - these degenerates, in unnecessary and time consuming repetitions, demotivating alike. From some estimates, we can appreciate that their duration could reach a weight of approx. 50% of the planned duration of a learning unit.

In the elaboration process of learning algorithms, as each one reaches its final stage, sequential tests should be introduced, as inferential elements in designing a systemic-serial motor unit, with double assessment features:

•**feed-back regulator** of the sequence already performed and
•**feed-forward proactive and anticipatory-corrective**,

for the next sequence, and thus, predictive assessment on future behavior and athletic performances.

The failure of designed intermediate parameters should mandatory lead to a return at the sequence that has not produced the expected results, until it fulfils the implementation of restructuring, according to the pattern and pre-established motor task. The very concept of sequential test development must be a rigorously grounded test battery type, so that applied tests to become tools that highlight in a significant ,correlative and adequate manner the inference of the motor learning process. A crucial element in designing tests is to anticipate possible errors and obvious, their relevance in the assessment and then correction of the monitored parameters. Unit-tests and system- tests will thus become the most important instruments in the psychological and pedagogical portfolio of the trainer related to the motor learning process. Trainer then acquires the status of a project and psycho-pedagogical process developer. Developers of such tests are also becoming some of the most important actors in the learning process. We do not exaggerate thinking that they should be organized into external evaluation experts that can be mixed (including besides coaches, psychologists, statisticians, physicians etc.), with a black-box type vision, particularly specialized in identifying and locating errors, and in subsidiary to immediately configure corrective solutions.

Inferential process feature of motor learning can be achieved only by drawing other features, such as the systemic incremental construction of learning sequences [12]. We believe that motor learning will gain the inferential attribute only with an incremental iterative [10]. The reconfigured post-writing of a new learning sequence performed once the corrective evaluation of a sequence is accomplished, becomes another feature of the proposed type of learning. Iteration, somehow linear and potential excursus of the learning process, emerges to a progressive inference [11] that gives to the series of consecutive executions an upward trend, from a high quality level to another, both in terms of accuracy and execution technicality and in terms of its dynamic features: speed, acceleration, explosive force, magnitude, distance, trajectory etc.

From the foregoing, it can be clearly gathered the complexity of approaching motor learning in this respect. We can even predict a gradual dissolution, a functional devaluation or decomposition controlled and mediated by the trainer of the original algorithms. Their mission, once completed, converts them automatically in steps consumed which were initially triggers, conditional, some of them even mandatory, with original binding effects on motor learning process. Along the development process, they become *redundant components* of motor learning, with disruptive effects and even with *process deceleration*. From the already accomplished algorithms decomposition, we can take their unbundled elements which could be useful to subsequent interventions, some of them with corrective or regulator function.

## III. Problem Solution

### A. *Inferential motor learning and its refactoring*

DISMANTLING or gradual decomposition algorithms already accomplished is generated by evolution itself of the motor learning process, due to increasing its complexity. Once added a new learning sequence, with new tasks and functions, it is actually built on the existing *pattern*, sometimes unprepared to bear it. At that time, the whole model will be systemically re-configured, so that it could take in an inferential-systemic way.

We could define the restructuring operation of the initially operational model, a *refactoring* of the motor learning process, with strong inferential effects of the constitutive sequences. Restructuring, namely *refactoring* [7], will lead eventually, even to redesigning the entire learning process, whether the post-sequence results would not be the predicted ones. Although much more demanding, short-term effort and creativity consuming, the redesign will produce extremely positive and beneficial medium and long term effects. Refactoring action does not change the actual functionality of the learning process. Refactoring intervention only leads to a change of the internal structure of learning, in order to achieve inter-sequential inference, leading thus to an acceleration and optimization of the process, whose final results are preserved.

In our view, *refactoring* process has to be done gradually and in a flexible manner. Restructuring one of the algorithms may be a first step. Then it will be possible even a structural algorithmic unit translation to another position, in the chronology of motor executions, within the same learning sequence, defined by us as *intramodal translation*, or moving it to another learning sequence (motor learning unit) defined by us as *intermodal translation* [3]. Refactoring could mean coupling or uncoupling, bringing together or sub-sequential fragmentation some components of two learning sequences. As it can be seen, the possibilities of reconfiguring or structural reorganization are extremely varied. (Fig. 5).

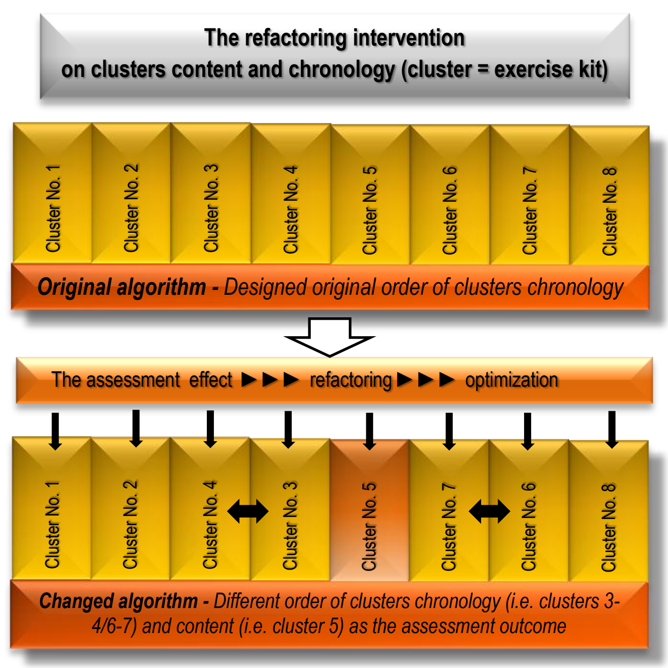


Fig. 5 The translation of cluster positions after refactoring intervention

We can develop and implement several principles [12] of refactoring as follows:

- *Principle of maintaining the process functionality and finalities.*
- *Principle of optimization and procedural efficiency.*
- *Principle of ensuring feed-back and feed-forward mechanisms.*

- *Subordination the refactoring to the general and specific teaching principles.*
- *Principle of comprehensiveness of internal procedural mechanisms.*
- *Principle of joint assessment validation of refactoring procedural effects.*
- *Principle of systemic approach of refactoring action and influence of the site.*

### *B. An approach related to the mnemonic method and refactoring procedure on motor learning process*

MNEMONICS is regarded as one of learning methods which helps in creating memory associations between certain concepts. It generates a replacement where a series of abstract concepts are replaced sequentially in memory with emotionally loaded representative words which are stored and relatively stabilized, the latter being in turn, replaced by representative images. It seems that this method activates the visual cortex and then the associative one, which transforms abstract concepts into images that become more efficient in relation with other active learning methods. It is obviously not enough only to look at a heuristic map, therefore we will have to achieve an internal reconstruction, a *refactoring* of the entire process of storing private information, which will constitute a regulating mechanism [9].

This technique is often used in areas that require memory storage of considerable quantities of information. Concepts turn into objects, subjective images, with positive effect in the area of mnemonic processes, which become memory items and interacting with each other, turning into a systemic whole to be forfeited and no longer forgettable. Sometimes, this type of information aggregation contributes to the random of mnemonic process and reduces the arbitrary nature of memorizing logic. It is therefore necessary to group information (especially abstract) to decrypt items that have common characteristics, from *abstract* to *concrete imagery*, generating so-called information pickets or *clusters* - as human brain can store only a limited number of separated information. Grouping (clustering) in associative items allows an individual to store a substantially increased number of information (abstract or images), by favouring the logical memory contexts (understanding the logical relations, rational of information, the (inter) networking, the (inter) determinations, the causality of inter-causality, legalities etc.), so a logical learning, even a creative one.

However, this assembly process is not chaotically done. It must be based on a particular internal language [8], an operational code (an *opcode*) [3]. Extrapolating this process, specific to the computer programming, in the intimate human association cortex - requested by specific information storage and association learning, we believe that the efficiency (speed and accuracy) of the execution of a motor structure is inversely proportional to the number and complexity of assembly process and refactoring of the underlying operational information.

We believe that such an approach of motor learning process can lead, through a deeper and refined analysis, to render to the efficiency of algorithmic exercise structures, especially for those difficult and complex structures, starting from the concepts appropriate to IT and cybernetics framework. Thus, witnessing to another type of refund to proto-concepts that generates a cyclic ascending trial, both in terms of time, and from that evolution itself. Return one form thereof reinforced, for the initial stage, from which they were generated, could provide a comprehensive platform and deep analysis, to develop new phylosophies of motor learning processuality (motor skills, in our case). We find such a link between the concepts of verbal or declarative knowledge, procedural or eupraxis [12] knowledge involved, approached by a number of specialists in the field we are reviewing this paper and the mnemonic type of memorizing processuality, which originally starts from abstract concepts (words, notions), which evolves to operate with objects and images as a basis for subsequent storage processes and then reproducing them, either as declarative or an eupraxis forms (motor behavior).

### *C. The evolution of the body centre mass **(BCM)** related to body height - possible criterion of orientation of beginner and advanced athletes towards the hurdles event*

ONE of the most important issues in the process of screening future athletes is to anticipate physical constitution of tomorrow’s teenager by looking at today’s child. Yet, this anticipative image has no precise instruments of prediction. We often speak about the “eye” of the coach that mentally accelerates the evolution of the child in front of him. Some of the trainers are really able to predict that, based on a heavy professional experience, as well as on a specialised documentation within this field.

Large numbers of studies reveal the fact that there are no correlations that could demonstrate that an athlete with remarkable results at an early age will definitely perform as a senior athlete. As a trainer, I have often come up against situations when young athletes, mostly girls of 10-12 years old had won national championships at *children level I and II* categories. As they grew older, those tiny girls, powerful, very fast, robust, resistant and coordinated, became more and more heavy and massive, no longer able to catch up with the training exigencies. So called athletic “champions-to be” were disappearing from the running tracks, without even reaching the *junior II level* of age category (15-16 years old).

“Why is that happening?”- was the question we have asked ourselves over many years. Often, we thought training was not appropriate. The answer came out finally from the way of setting out *screening criteria* in the process of initial selection.

Each branch of sport has its own ideal constitutional morphotype which is strongly related to a particular sportive field requirement. Athletics, for example requires motor criteria within the initial selection (screening stage). The most posturographists related the relationship between the position of the centre of pressure and the position of the centre of gravity. [2,4,13,14] pointed out that the position of the centre of mass of the body makes the difference in speed records (e.g. athletes with longer legs and a higher centre of mass are advantaged). These criteria point out the current motor qualities through a series of control tests of individuals, with the result of an individual score that enables ranking. The following motor qualities are assessed:

- Speed, i.e., running speed measured over 50 metres starting from standing position;
- High jump (explosive force) of the lower limbs, measured with la long jump without impetus;
- Arm strength and coordination elements of this level, measured with a shot put, without impetus; also, another test would be that of maintaining a suspended position with arms bent over at 90 degrees;
- Abdominal strength: timed pull-ups (30 seconds);
- General skill: a timed relay race;
- General endurance, measured by a 600 metres running test.

Up to a point, everything seems to work out well. But only up to a point which then becomes a “critical point”, from which the assessment of the constitutional morphotype starts, as well as of the psycho type, then of the somatic type, physiotype, etc. For this new set of criteria, called “complex-factor” (with a determinative significant power, up to that of contributing factor), there is no “control testing” or standardised marks of ranking. We must underline that girls are mostly discussed here. Most of them, apparently thin, get higher results than boys of the same age group. This is the so called “trap” in which most of the coaches usually fall. Because of their short experience, they tend not to consider much of the important evidence, such as the following ones, called by us “screening tips”[12]:

- *Somatometric and anthropometric screening* – somatometric assessment (height, weight, length of the limbs, length of the bust, perimeters, diameters, dynamometrics, the body centre mass position, etc. as well as the correlations between them);
- *Somatoscopic screening* – somatoscopic assessment (vicious spine positions or lower limbs – *valgum* or *varrus* knee, flat foot, etc);
- *Genotypic screening* – constitutional genotypic assessment (morphotype) of the genitors;
- *Puberty / sexual screening* – the level of sexual development: evolution tendency of the secondary sexual characteristics at the pre-puberty and puberty age (the ratio between biological and chronological age);
- *Anamnetic screening* – investigation and assessment of clinical anamnesis;
- *Functional screening* – investigation of certain body functions, followed by minor medical evaluations (an ECG is compulsory), allergy tests, etc.;
- *Muscular screening* – evaluation of the muscular fibres typology;
- *Psychological screening* – standardised tests are used here, such as for:
    - The level of attention (concentrated, distributed, discriminatory, etc.)
    - The level of multiple intelligences – mostly those with a certain significance on high performance sports: spatial-visual intelligence, musical-rhythmic intelligence, corporal-kinaesthetic intelligence, interpersonal and intrapersonal intelligence;
    - The level of emotional intelligence;
    - A certain temperamental typology;
    - The affective-emotional typology;
    - The moral-volitional typology.
- *Psychomotor screening* such as for:
    - The level of psychomotor development (corporal scheme, laterality, coordinative capacity);
    - The sensorial perceptive and motor level;
    - The corporal and its segments kinaesthesia.
- *Suggestional screening* – investigation of the level of motor suggestibility.

We have therefore found that underlining the complexity of all aspects connected to the high performance sports selection is well based on facts. Obviously, there are certain steps to be followed, depending then on the trainer, who has to set priorities in a right chronological order. We also emphasise here the importance of this set of criteria, compulsory to be fully or partially assessed by the professional athletes-to be.

Related to the above mentioned criteria, we refer now to a personal longitudinal research study that I have elaborated and experimented during my professional activity. The starting point was the idea that hurdles runners should have an optimal constitutional shape, connected to the technical requirements of this certain athletic event.

Briefly, it is about designing somatic evaluation grids, so called somatic patterns, in which the hurdles runner should fit perfectly. We have experienced this study for over 15 years. As a result of this research, Table 1 shows the evaluation grids on certain stages. In relation to the hurdles techniques assimilation, we have considered the following parameters as suitable for the designed patterns:

- Body height **(BH)**;
- Body weight **(W);**
- Length of the lower limb **(LLL);**
- Position and evolution of the height of the body centre mass **(BCM).**

Within the permanent selection, approximately 200 girls were investigated. Based on individual somatometric files we have observed them over 5-6 years. We have chosen the above parameters, due to the fact that the first signs of puberty lowered the sportive efficiency of the girls. Very few of them moved on without negative influences on their achievements. Because, at present, the possibilities of a biomechanical study are utterly limited, oftentimes the appreciation of a technical execution has a deep objective characteristic, but obviously a limited one. In the case of hurdles, the constitutional particularities of the sportsperson, in correlation with the space and time particularities and the technicality of their movements, will constitute an assembly of factors that influence performance.

Among these particularities can be found those connected to the height of the body centre mass **(BCM),** the point where the sum of all moments equals zero, [15]. A part of the relationships that can be established between **BCM** and the other elements which take part in the achievement of high level performance:

- the position of **BCM** in connection with the height of the sportsperson;
- the position of **BCM** opposed to the height of the hurdle;
- the length of the lower limb **(LLL)** and its ratio with the height of the body;

- the amplitude of the trajectory of the vertical oscillations of **BCM** while jumping over the hurdle in relation to their amplitude while running in between the hurdles;
- the interrelationship in the context of dynamic features of the execution: speed and acceleration, rhythm and tempo, technicality.

The study of the segmentary lengths of the body and the relationships between them, correlated with the interactions that arise during the hurdles run, becomes a necessity if we intend to shape authentic performers for this sport event. If we only focus on partial guide marks (for example: focusing on the evolution of the height and weight), we will only obtain partial results throughout the training process. That is why an objective approach of the distribution of segmentary partial weights is utterly important (hindquarters/backquarters) through the evolution of the position of the **BCM** (over the process of growth and ontogenetic development of the sportswomen). If we ignore the interdependence between these factors in the somato-functional development of the body, some early promising results will not necessarily have the expected results and we will have to realise where we failed with the training process, whereas the cause lies in the ignorance of some aspects of somatic evolution.

Gravity acts upon the body in the way of cumulated forces, on a vertical plane, having the running track as direction. The vector resulting from their cumulative acts upon a point of the body, called the body centre mass, which is generally found at the intersection of frontal, sagittal and transversal planes (medial positions).

The body centre mass **(BCM)** can be defined as the point upon which a resultant of the lines of gravity acts. This is a conducted and oriented force, so it is a vector and can be described mathematically. Since gravity is defined according to acceleration "g" (9.81 m/s$^2$) and results from the action of the gravitational forces "F" on the mass of the body "M", it means that $g = \frac{F}{M}$ thus $M = \frac{F}{G}$ and F = Mg. For symmetrical bodies that have a uniform density, the gravitational centre superposes upon its geometrical centre. Since the human body is asymmetrical and the different segments have various densities, **BCM** will not coincide with the geometrical centre.

The different positions the human body can take, in our case the one of the hurdles runner, supposes the continuous modification of the position of the point in which the resultant of the lines of gravitational forces is applied. Thus, the **BCM** of the body does not have a fixed position, but it varies from person to person, from one body posture to another, from one sequence of movement to another. **BCM** moves in the same direction as the movements of the body. It can go upwards, whenever we lift the upper or lower limbs, and it goes down whenever the limbs come back to the normal position. Due to these multiple variations of **BCM** its localisation cannot be established but for one determined position of the body: standing, sitting, hanging, supine position etc.

In the case of hurdles, when the body of the athlete is in motion, the trajectory of **BCM** defines or does not define the efficiency of the movements the athlete performs. The totality of these movements leads to a movement of the **BCM** on the optimal trajectory which facilitates the obtaining of the best sporting achievements. The trajectory of **BCM** gives us data on particularities of the body (implicitly and the technicality of the movements) as a whole, as well as on the movement of its segments (lower limbs, upper limbs, etc.).

Meanwhile, the vertical oscillations of **BCM** while running hurdles are more accentuated in the moment of the jump across the hurdle, and are higher, respectively. One of the objectives that have to be followed in the process of motor learning of the jump across the hurdle, is that, through its technical execution of this motor structure, the vertical oscillation is as low and precise as possible, it is close to the oscillations of the **BCM** while running in between the hurdles.

The lone interior forces cannot modify the position and movement in space of the **BCM**, but only the centres of weight of the segments of the body (limbs, trunk). The movement of the **BCM** is possible only when external forces act upon it, for instance the forces of reaction to the completion of impulsive movements of the legs while running or while jumping across the hurdle.

If the resultant vector of these forces is directed towards the body centre mass, it will imprint on the whole body a movement of translation towards a direction and way, opposed to the action of the impulse of the legs, towards the finishing line, respectively. If the resultant force does not go precisely through the centre of weight, but through its vicinity (higher or lower), it imprints the body (the entire morphodynamic system) a movements of rotation or overturning.

The direction or sense of overturning will be ahead and downwards, if the resultant acts above the **BCM**, and ahead and upwards if it acts under the **BCM**, respectively. There can be other situations, especially during the offsetting body, the jump over the hurdle, when the cumulated external forces act laterally from the point of **BCM**, imprinting over the body of the runner movements of torsion towards the right or the left, or in directions combined with those described above. All these will have negative effects on the final result. This matter will be closely examined later. But our aim was to describe the importance of biomechanical approaches in the analysis of the technicality of the hurdles event, with reference to the ideal constitutional morphotype for this complex event, starting from the premise that a higher position of the **BCM** constitutes a favouring factor in the hurdles event.

Consequently, we measured the position of the **BCM** in different moments, over several years. The technique of measurement was the indirect method, using the following equipment (Figure 6 ):

- balance: wooden rack with a length of 2 metres and a weight of 10 kilograms; centimetre measuring band.

We used the following formula for determining the position of the **BCM**:

$$\mathbf{H_{(CMC)} = \frac{GP\text{–}GT}{G} \times 2}$$

where:

**H (BCM) =** the height of the body centre mass
**$G_P$** = the partial weight of the body of the sportsperson, lying on the rack with the soles placed on the distal end of the stretcher
**G** = the weight of the sportsperson,
**$C_T$** = the weight of the rack.

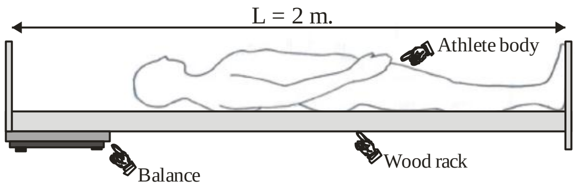

Fig. 6 The indirect determining of BCM position

We used this method because we found the most widely used that the level of **BCM** is positioned invariably at approximately 56.5% of the height, regardless of the constitutional particularities of the sportsperson, which introduces an invariable coefficient (0.057) in the formula, thus:

**BCM = height x 0.057 + 1.4 (measurement in centimetres)**

This seems to be a limited interpretation, because it does not take into account the distribution partial weights and the relationship between the lengths of the segments. Each athlete constitutes an individuality, that is why a global approach is inefficient, if not mistaken.

Thus, we started from some premises – hypotheses:

a) we have no objective reason to state that the curve of the evolution of body height is necessarily parallel to the BCM, during the growth and development of the body.
b) the development of the body does not necessarily happen on the basis of proportional evolution of the partial weights and the length of its segments;
c) the distribution of muscular mass and of the adipose tissue is not uniform and identical for several individuals.

These premises allowed us to reason that there can be at least three different situations of the evolution of these ratios:

a) an evolution proportional to the parameters involved;
b) a stagnation or regress of the position of the body centre mass **(BCM),** paralleled with the growth of body height **(BH)** and the length of the lower limb **(LLL)** on the basis of accentuated accumulation of muscular and adipose mass (especially to girls), on the level of the pelvis and hips;
c) an accentuated growth of the height of **BCM**, on the basis of the growth of body height **(BH),** due to the growth in length of the hindquarters or to accentuated accumulation of muscular or adipose mass in the area of backquarters.

During the research, new elements have come to light, elements that had not been in our focus initially. By this we mean the surveillance of the percentage ratio between weight and height, recorded at different moments:

a) before the beginning of the menstrual cycle;
b) at the beginning of the menstrual cycle;
c) after approximately one year from the beginning of the menstrual cycle;
d) after two years;
e) after more than two years from the beginning of the menstrual cycle.

The measurements and the correlations between the parameters allowed us to establish some approximate (constitutional morphotypes) stages somatic models, that we considered optimal for the hurdles event, with the aid of which we can thus compare the comprising (or not) into a chart, of a future hurdles athlete, starting from pre-puberty or puberty age. Thus we can foresee the constitutional profile of the future hurdles runner, adequately directing the selection and training, having a reliable reference and more consistent elements regarding the evolution of the athlete. Knowing in due time the differences in regard to these models, we are able to predict the age of maximum efficiency or the age of risk.

We applied it and noticed that it is a useful tool in the selection process, but also in the prevention of some unreal predictions in the constitutional evolution of the hurdles runner. We started from the hypothesis that a higher position of the **BCM** constitutes a favouring element in the hurdles event, because it determines a diminution of the amplitude of the vertical oscillations of the **BCM** while jumping across the hurdle and its bringing closer to the level of vertical oscillations of the **BCM** during a sprint event on a plane level, and also of the running in between the hurdles. The positioning of the **BCM** at an optimal level of 56-57%, or even at 57-58% from the body height determines the above mentioned details (Fig. 7 and 8)

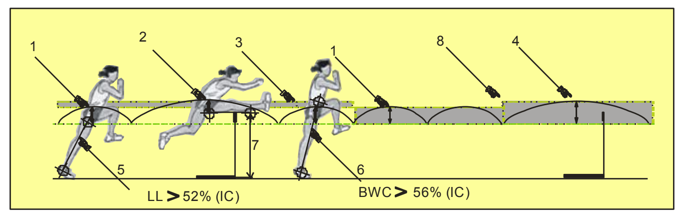

Fig. 7 The low level of vertical oscillations of the BCM

**1.** vertical oscillations of the **BCM** while running between the hurdles; **2.** vertical oscillations of the **BCM** while jumping across the hurdle; **3.** the difference in amplitude between the two moments; **4.** the amplitude of the oscillation of BCM over the hurdle; **5.** the length of the lower limb (LLL); **6**. the height of the position of the **BCM**; **7.** the height of the hurdle (HH); **8.** the difference between the amplitudes of the oscillations of **BCM** during the running between the hurdles and the jump over the hurdle.

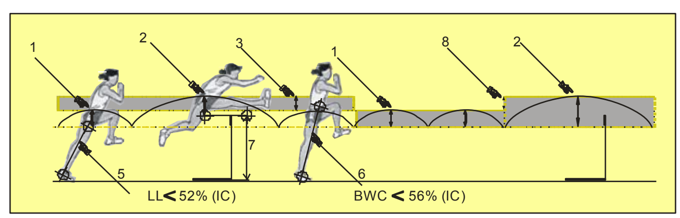

Fig. 8 The high level of vertical oscillations of the BCM

**1.** vertical oscillations of the **BCM** while running between the hurdles; **2.** vertical oscillations of the **BCM** while jumping across the hurdle; **3.** the difference in amplitude between the two moments; **4.** the amplitude of the oscillation of **BCM** over the hurdle; **5.** the length of the lower limb (LLL); **6**. the height of the position of the **BCM**; **7.** the height of the hurdle (HH); **8.** the high difference between the amplitudes of the oscillations of **BCM** during the running between the hurdles and the jump over the hurdle.

Below is the description of a tool, still in the stage of prototype, which will allow precise measurements of the **BCM** in supine position which is in its final stage of development. We intend to register this tool with O.S.I.M. Romania (State Office for Inventions and Trademarks) being an own invention in the field. Fig. 9.

Fig. 9 Apparthus for the measurement of BCM in supine position

## IV. DISCUSSION

BASED on the recorded result and their analysis we can notice the following:

a) the evolution of the height of **BCM** shows particular differences for each individual, exemplifications in two different typical cases, presented in Figures 5 and 6;

b) the middle level we found for **BCM** is of approximately 57% of the height, confirmed by [6];

c) the middle level of the **LLL/H** ratio is about 53-54%;

d) the middle level of the **W/H** percentage is:

- I – pre-puberty stage, 24% 1-1.5%
- II - puberty stage, 26% + 1-1.5%
- III - stage at the beginning of the menstrual cycle, 28 %+1-1.5%
- IV - stage after 1 year from the beginning of the menstrual cycle 31 % + 1-1.5%
- V - stage after two years and after more than two years from the beginning of the menstrual cycle + 34 % + 1-1.5%

According to the results we can come to a number of conclusions and recommendations:

a) the hypothesis is confirmed also through the point of view of the results of the athletes in time;

b) a distorted evolution of the recorded parameters is correlates with the lowering of the sporting efficiency and vice-versa;

c) the non-framing in stage models leads, in time, to a stagnation of the results and even to their regress;

d) the keeping and training of the girls who fit into these models, even if the initial results are not very satisfactory;

e) the individual somatometric file is useful in predicting the somatic evolution;

f) even within exceptional results in the categories children I or juniors III, the girls who overcome these models, in time become overweight, regressing in time;

g) the guide mark for the appreciation of biological age is the beginning of the menstrual cycle and not the chronological age and the level of manifestation of secondary sexual characteristics.

After analysing the results, the resulting conclusions, we suggest the following:

a) the usage of the stage models as guide reference values in the prediction and constitutional evolution of the selected athletes;

b) we suggest the using of these referential models, both in the initial selection process as well as during the training stage.

As exemplifications of the present study, we include below the somatometric files of the two cases described above. Based on the graphic representation of the recordings over several years, the differences of evolution between the two distinct situations becomes evident, framing in the model and non-framing in the model.

## V. CONCLUSION

AS a conclusion, the *reconfigured post-writing* of new learning sequences achieved after the corrective assessment of a sequence already done, becomes another distinctive element for this type of learning. The process will be a phasic one, synchronic and diachronic alike: from simple to complex, from unstable to stable, from incorrect or partially correct, to correct, from right to refined and ultimately, to a high-performance one.

Finally, between motor learning - linked to skills training, skills and driving habits (including mnemonic processes) and smart learning - acquisition related to notions and concepts, there is a relationship of functional complementarity. Altogether, they provide a comprehensive learning in different sports disciplines and practical learning situations, provided the athlete to use their motor behavior by harnessing the synergy of the three types of knowledge and by linking actions and driving with intellectual schemes.

The body centre mass (**BCM**) is just one component of the factors that influence achievement, the framing in the above described models not being functional, isolated from the level of motor qualities or the necessary set of motor skills, a premise fulfilled by us through the selection of the most valuable athletes of our club.

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