Body Mass Index - a referential parameter of the female selection in hurdling

Indicele de masă corporală - parametru de referință în selecția permanentă la alergările de garduri - fete

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Abstract

Background. It is well known that children are not exact copies of their adulthood, disparities occurring in their build, even substantially, from one age to another, in the ontogenetic development. The modelling and reshuffling processes are ubiquitous throughout the auxological evolution of an individual, until the age of approx. 25 years. The physical growth and development processes are not always linear or synchronous and harmonious throughout this evolution. Sometimes this process suffers a sinuous route, even unpredictable with remarkable leaps during puberty, with the occurrence of some intersegmental temporary asymmetries and disproportions. In sports these aspects can positively or negatively influence the individual performance.

Aims. Our study aimed at critically analyzing the manner in which the Body Mass Index (BMI) should be worked out, during the ”tumultuous” period (around puberty), during the ontogenetic evolution of selected female athletes in the hurdles event. Thus, we are aiming to avoid the misinterpretation of the Body Mass Index at ages up to 18 years, frequently known as improper terms such as “undermuscled” or “underweight”.

Methods. Based on a personal analysis following several longitudinal studies, we have developed five ideal somatic scales being categorized into five stages: before the onset of menarche (stage 1), at the onset of menarche (stage 2), one year after the onset of menarche (stage 3), two years after the onset of menarche (stage 4) and over two years after the onset of menarche (stage 5). The followed parameters were: body height, body weight, lower limb length, body gravity center and body mass index.

Results. We set several interrelations among these indicators to anticipate an ideal somatic profile or pattern in high performance hurdling at an adult age (over 18 years old). Mainly, we followed the relationship between body weight, body height, body gravity center, all together related to the body mass index. Consecutively by use of a factorial analysis, we found that the reduced nominal value of the body mass index apparently places an athlete at pubertal age into an underweight category, subsequently presenting an ideal somatic pattern of a female athlete hurdler.

Conclusions. We propose to use our stadial pattern-scales during the initial and continuous selection process, in terms of favoring the future high performance indicators along with other motor parameters - morphokinetic (form, structure, technicality and fairness) and topokinetic (strength, vectors, velocity, amplitude and stamina). Thus, we hope to prevent a possible athletic career's failure due to a disturbing overweight pattern of the athlete somatotype profile by failure to comply with our proposed pattern-scales.

Keywords: allometric pattern, auxology, undermuscled, underweight, somatotype.

Rezumat

Premize. Aşa cum este arhicunoscut, copilul nu este o copie fidelă a adultului, între segmentele și organele sale apărând disparități, uneori substanțiale, de la o vârstă la alta, în evoluția sa onotogenetică. Procesele de modelare și remaniere corporală sunt omniprezente pe tot parcursul auxologic al evoluției unui individ, proces care se încheie la vârsta de cca. 25 de ani. Creşterea și dezvoltarea fizică nu sunt întotdeauna procese lineare, sincrone și armonioase, pe parcursul acestei evoluții. Acest proces suferă uneori un parcurs sinuos, chiar imprevizibil, cu momente caracterizate prin salturi remarcabile – specifice vârstei pubertare, chiar cu apariția unor asimetrii și disproporții intersegmentare temporare. În sport, aceste aspecte pot influența pozitiv sau negativ performanțele individuale.

Obiective. Studiul de față își propune să analizeze critic modul în care Indicele de Masă Corporală (IMC) ar trebui interpretat, pe parcursul unei perioade mai agitate (peripubertară) în evoluția onotogenetică a unor fete, selectate pentru atletism în probele de garduri. Dorim, astfel, să evităm interpretarea greșită a Indicelui de Masă Corporală, la vârste sub 18 ani, regăsită sub termeni de genul „submusculos" sau „subponderal".

Metode. Pe baza unor analize personale, rezultate din studii longitudinale, am elaborat cinci grile somatice, considerate ideale, grupate în cinci stadii: înaintea instalării menarhei (stadiul 1), la instalarea menarhei (stadiul 2), după un an de la instalare, (stadiul 3), după doi ani (stadiul 4), și la peste doi ani de la instalare (stadiul 5). Parametrii urmăriți au fost: înălțimea corporală, greutatea corporală, lungimea membrului inferior, centrul de gravitație al corpului și indicele de masă corporală.

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Rezultate. Între aceşti indicatori am stabilit interelații care să anticipeze un profil sau pattern somatic ideal al alergătoarei de garduri, la nivel de performanță, la vârstă adultă - peste 18 ani. Am urmărit, în principal, relațiile dintre greutate, înălțime şi centrul de gravitație a corpului, toate raportate şi la idicele de masă corporală. În urma unei analize factoriale, am constatat că valoarea nominală redusă a indicelui de masă corporală încadrează, în mod aparent, o atletă la vârstă pubertară, în categoria de subponderalitate, ulterior, la vârstă adultă, acesta prezentând un profil somatic ideal pentru proba de garduri.

Concluzii. Propunem utilizarea grilelor stadiale, realizate de noi, în procesul de selecție inițială şi de parcurs, ca indicatori factoriali favorizanți ai performanțelor ulterioare, alături de cei de natură motrică - morfocinetici (formă, structură, tehnicitate şi corectitudine) şi topocinetici (forță, vectori, viteză, amplitudine, rezistență). Se elimină astfel eşecul în cariera sportivă, datorată unei supraponderalități perturbatoare, prin neîncadrarea în grilele pattern propuse de noi.

Cuvinte cheie: pattern alometric, auxologie, submusculos, subponderal, somatotip.

Background

The physical growth and development of individuals, in terms of their physio-morphogenetic evolution, is not always a synchronous and harmonious ascending linear process. Between the regions and segments of an individual's body, certain disparities may occur during ontogenetic evolution. Body growth, modeling or remodeling and proportioning processes are present throughout the auxological evolution of an individual, a diachronic process that ends around the age of 25 years old. Sometimes, this evolutionary process takes a sinuous, even unpredictable course, with several moments characterized by remarkable saltatory steps, specific to pubertal age, or with the occurrence of some temporary intersegmental asymmetries and disproportions. Studies regarding these aspects have been performed by many authors (Rolland-Cachera et al., 1991; Rolland-Cachera et al., 2002; Cameron, 2007; Lemaire et al., 2014; Nummia et al., 2014).

Therefore, we cannot discuss about a general pattern or "allometric pattern" of ontogenetic evolution (Zelditch et al., 2003), valid for all individuals. The laws of physical growth and development are clearly fundamental in terms of diversity of evolution but also related to the variability and specificity of human ontogeny, under a multifactorial genotypic (internal) and phenotypic (external) influence. The functional echoes of these morphological and structural developments are ubiquitous, sometimes exceeding the normal limits, with more or less obvious dysfunctions, even pathological in nature, or on the contrary, with outstanding performance surpluses (Ribeiro et al., 2006; Pappai et al., 2012).

Sports selection was one of my personal concerns in my teaching and coaching career, one of the interesting running races being female hurdling on short distances (60 m and 100 m).

Based on observations as well as on my experience of over 25 years of high performance athletic activity, I found that a difficult problem in the selection of young athletes consists of anticipating the somatic constitution of a future teenager or adult female hurdle runner by investigating 9-11-year-old girls anthropometrically and somatoscopically, during the initial selection (Neagu, 2010). Since there are no accurate tools allowing to prefigure this body image, "the coach's eye" (A/N), which can see the future through a mental acceleration of the somatic evolution of these girls, can play a role. There are real limits to the coach's "eye" looking at "tomorrow's" adolescent body, based on "today's" somatoscopic assessment of the prepubescent individual (Fig. 1).

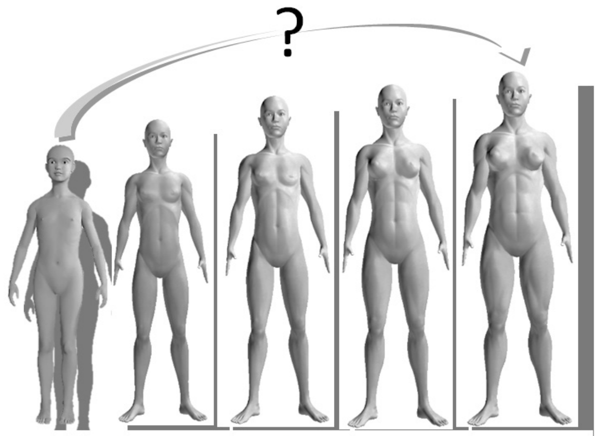

Fig. 1 – The limits in predictability of the future corporal image, based on somatoscopic assessment of a prepubescent individual.

Many specialized studies reveal that there are no certainty correlations proving that a female athlete who achieves outstanding results at a young age will obtain excellent sports performance as a junior or senior (Monsma & Malina, 2005; Tróznai & Pápai, 2008). I often saw in my coaching career young athletes who at the age of 10-12 years were in the top national novice II and I rankings. As they grew older, those girls, usually small in stature, robust, powerful, fast, well-coordinated and resilient, became more and more massive, heavier, and in a short time they no longer coped with the increasingly demanding requirements of high performance sports training. These so-called "athletic hopes" disappeared from the athletics tracks, without even reaching the junior II category (15-16 years) (Fig. 2). For many years I wondered why this happened. It was only after a long time that I found the answer - the reconfiguration and (re)prioritization of the sports selection criteria (Neagu, 2010).

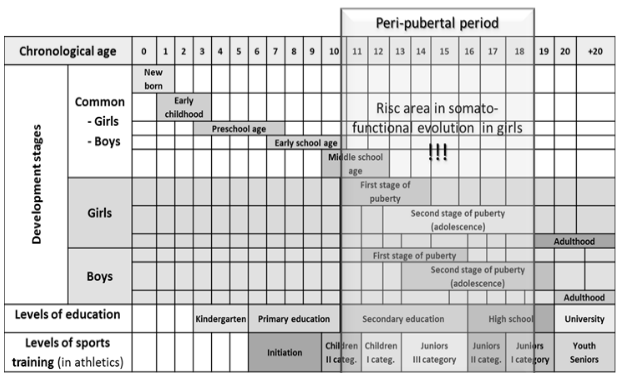

Fig. 2 – Timeline of individuals in the sports training process. Adaptation after (2).

Aims

It is known that for each sport there is an ideal somatotype that strongly correlates with the dynamic requirements and particularities of that sport - motor capacity, functional, energetic and metabolic, psychological parameters, etc. (Tróznai & Pápai, 2008). In athletics, the selection criteria in the initial stage (detection phase) are of motor nature, par excellence. They evidence the current level of the motor skills (motor qualities) of interest through a comprehensive battery of tests, the individual results being converted to scalar points that rank the tested children.

In time, a "critical area" (A/N) takes shape, due to the exclusion from baseline criteria of the ideal individual somatotype, complemented by the psychotype and finally by the physiotype, into which the athlete should fit (Claessens et al., 1999). For these criteria there are no standardized tests, score grids or ranking points. All these indicators form a "multiplex referential factor" (A/N) with different levels of influence: from a determining to a favoring, then a neutral (the so-called "zero factor") and finally, a disturbing factor. The pubertal period represents such a factor (Benedet et al., 2014; Himes et al., 2004).

This "trap", in which many sports teachers and coaches (especially inexperienced) are caught, makes them disregard other relevant criteria, which we subsume to the intension of the term "permanent selection screening " (A/N) in high performance athletics (Fig. 3).

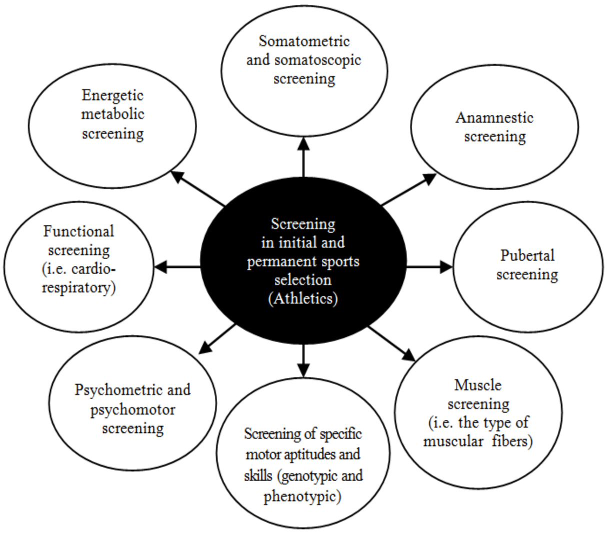

Fig. 3 – Screening in initial and permanent sports selection.

Methods

A critical analysis of how the Body Mass Index (BMI) should be interpreted is particularly necessary in the context of correlative somatic indexes during the peripubertal period of selected girls in hurdling (Garrido-Chamorro et al., 2009). This allows avoiding the misinterpretation of the BMI level (with lower nominal values than those considered normal) at ages under 18, when certain individuals are erroneously classified as "undermuscled" or "underweight". This is why we have developed predictive grids, considered as ideal models in female hurdling, as predictive references for post-puberty age. The early identification of the gaps against these profiles can allow highly effective measures and the avoidance of risks and failures. Failures can be explained by an inadequate management of the training process, eluding the somatic and functional aspects of athletes, as possible disturbing factors (Neagu, 2010).

In a longitudinal study over 15 years, we investigated this aspect, monitoring four quantitative somatic parameters:

Body Height (BH)
Lower Limb Length (LLL)
Body Gravity Center (BGC)
Body Weight (BW)

In terms of somatic qualitative parameters, we calculated the following percentage ratios between the quantitative parameters:

Body Weight per Body Height (BW/BH x 100)
Lower Limb Length per Body Height (LLL/BH x 100)
Body Gravity Center per Body Height (BGC/BH x 100)

Later, we added to these parameters the Body Mass Index (BMI) as an additional element in our analysis and as an important referential parameter, calculated using the formula:

BMI = BW (kg) / **BH²** (m)

in which:

BMI = body mass index
BW = body weight
BH = body height

Finally, we developed, based on several representative samples of subjects, five predictive stadial somatic grids as ideal referential patterns for female hurdles: before the onset of menarche (stage 1), at the onset of menarche (stage 2), one year after the onset of menarche (stage 3), two years after the onset of menarche (stage 4) and over two years after the onset of menarche (stage 5) (Fig. 4).

PREDICTIVE IDEAL SOMATOTYPES AT PUBERTAL AGE
(Hurdles runners - girls)

Body height (cm)	Somatotype 1 (prepubertal age) BW/BH=24%±2%				Somatotype 2 (onset of menarche) BW/BH =26%±2%				Somatotype 3 (one year after the onset of menarche) BW/BH =28%±2%				Somatotype 4 (two years after the onset of menarche) BW/BH=32%±2%				Somatotype 5 (over two years after the onset of menarche) BW/BH =34%±2%			
	BW (kg)	BGC (cm)	LLL (cm)	BMI	BW (kg)	BGC (cm)	LLL (cm)	BMI	BW (kg)	BGC (cm)	LLL (cm)	BMI	BW (kg)	BGC (cm)	LLL (cm)	BMI	BW (kg)	BGC (cm)	LLL (cm)	BMI
	24%	58%	53%	↓	26%	58%	53%	↓	28%	57,5%	52%	↓	32%	57%	52%	↓	34%	56,5%	52%	↓
140	33.60	81.20	74.20	17.14																
142	34.08	82.36	75.26	16.90																
144	34.56	83.52	76.32	16.67																
146	35.04	84.68	77.38	16.44	37.96	84.68	77.38	17.81												
148	35.52	85.84	78.44	16.22	38.48	85.84	78.44	17.57												
150	36.00	87.00	79.50	16.00	39.00	87.00	79.50	17.33	42.00	86.25	78.00	18.67								
152	36.48	88.16	80.56	15.79	39.52	88.16	80.56	17.11	42.56	87.40	79.04	18.42								
154	36.96	89.32	81.62	15.58	40.04	89.32	81.62	16.88	43.12	88.55	80.08	18.18								
156	37.44	90.48	82.68	15.38	40.56	90.48	82.68	16.67	43.68	89.70	81.12	17.95	48.36	88.92	81.12	19.87				
158	37.92	91.64	83.74	15.19	41.08	91.64	83.74	16.46	44.24	90.85	82.16	17.72	48.98	90.06	83.74	19.62				
160	38.40	92.80	84.80	15.00	41.60	92.80	84.80	16.25	44.80	92.00	83.20	17.50	49.60	91.20	84.80	19.38	54.40	90.40	84.80	21.25
162					42.12	93.96	85.86	16.05	45.36	93.15	84.24	17.28	50.22	92.34	85.86	19.14	55.08	91.53	85.86	20.99
164					42.64	95.12	86.92	15.85	45.92	94.30	85.28	17.07	50.84	93.48	86.92	18.90	55.76	92.66	86.92	20.73
166					43.16	96.28	87.98	15.66	46.48	95.45	86.32	16.87	51.46	94.62	87.98	18.67	56.44	93.79	87.98	20.48
168									47.04	96.60	87.36	16.67	52.08	95.76	89.04	18.45	57.12	94.92	89.04	20.24
170									47.60	97.75	88.40	16.47	52.70	96.90	90.10	18.24	57.80	96.05	90.10	20.00
172													53.32	98.04	91.16	18.02	58.48	97.18	91.16	19.77
174													53.94	99.18	92.22	17.82	59.16	98.31	92.22	19.54
176													54.56	100.32	93.28	17.61	59.84	99.44	93.28	19.32
178																	60.52	100.57	94.34	19.10
180																	61.20	101.70	95.40	18.89

Fig. 4 – The five predictive somatotype grids at pubertal age (hurdles runners - girls).

For each stage we set up an ideal pattern with optimal interrelations between the studied parameters: Body Height (BH); Lower Limb Length (LLL); Body Gravity Center (BGC); Body Weight (BW). The graphical representation for each stadial profile is shown in Figs. 5-9.

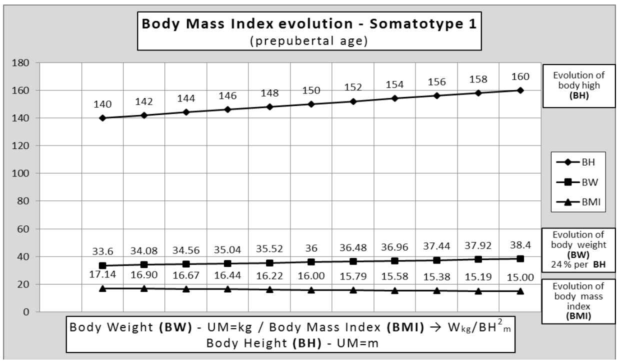

Fig. 5 – The ideal somatotype – stage 1.

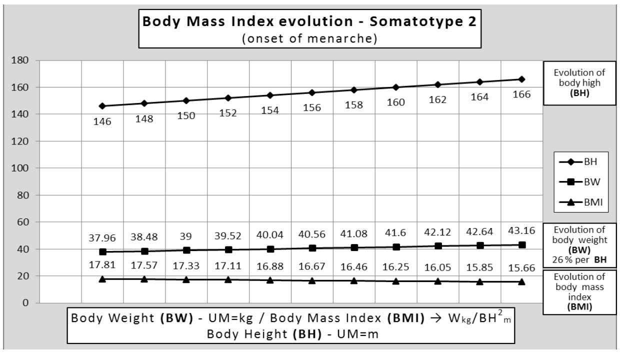

Fig. 6 – The ideal somatotype – stage 2.

Results

The measurements made and the correlations between the monitored parameters allowed us fitting (or not) the future female hurdler' somatotype into the pattern grid, starting with pubertal age. In this way, we could anticipate the future somatic profile, guiding and adjusting the permanent selection and training process, as an important reference in the progression of the hurdler.

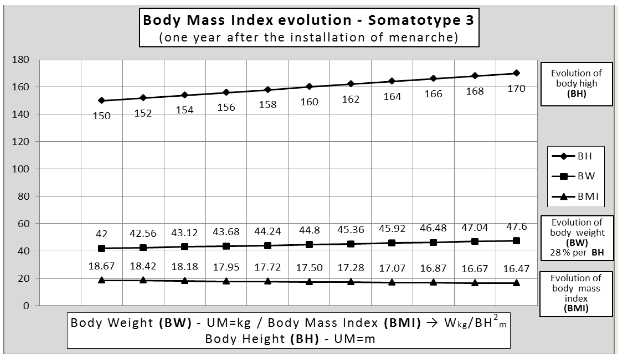

Fig. 7 – The ideal somatotype – stage 3.

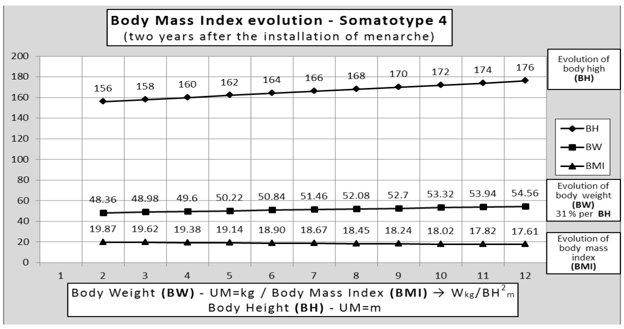

Fig. 8 – The ideal somatotype – stage 4.

Discussions

Having our stadial profiles as a reference, we were able to follow up the progress of our athletes over several years, based on individual records. We used for comparison databases from France, on cohorts of subjects between 1-18 years old (1) (Fig. 12). We present two study cases as examples of the application of the profile grids proposed by us in the practice of training (as ideal patterns). In the case study no. 1, the subject fit into the pattern-grid (Fig. 10). Subsequently, the athlete obtained remarkable results as a junior and senior (national champion and medalist in a number of official competitions). In the study case no. 2, the subject did not fit into the grid (Fig. 11). Subsequently, the athlete did not achieve remarkable results as a junior. After a short period and very modest results, she quit high performance sport.

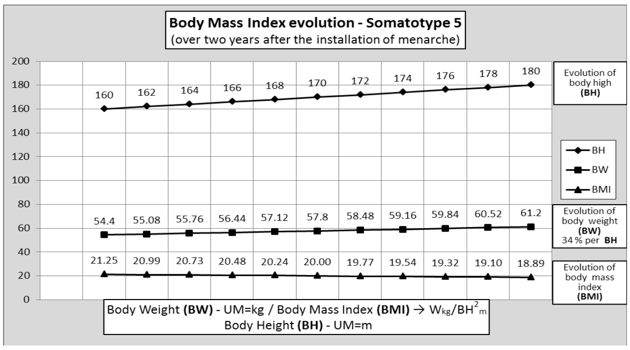

Fig. 9 – The ideal somatotype – stage 5.

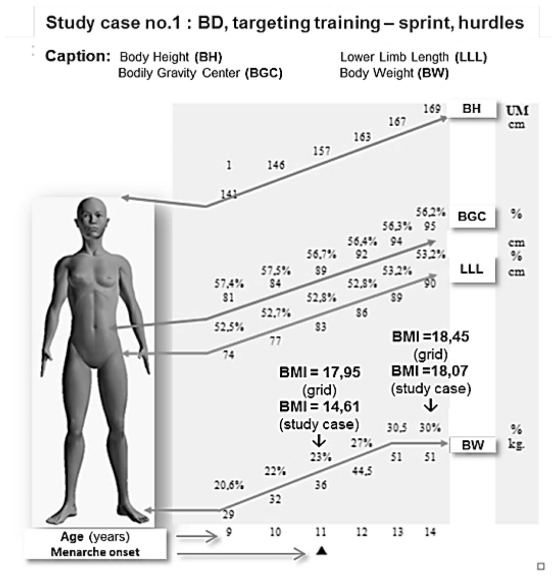

Fig. 10 – Example of a somatotype that fits into the predictive grid.

In both cases, the Body Mass Index (BMI) at the onset of menarche had values of 14.61 (study case no. 1) and 15.40 (study case no. 2). With aging, BMI increased, reaching almost equal values, 18.07 (study case no. 1) and 18.03 (study case no. 2). By analyzing the individual records, we found that a disturbing factor was the increased BMI = 15.40 in study case no. 2 compared to 14.61 in study case no. 1. This was the first sign of inconsistency in the grid. The second disturbing factor for subject no. 2 was the decrease of the Body Gravity Center (BGC) by almost 2%, from 58% at the onset of menarche to 56.5% two years after the onset of menarche. Case no. 2 accumulated adipose body mass in the lower limbs with negative consequences on hurdling biomechanics and technique. The BGC evolution of subject no. 1 remained relatively unchanged, with a value of 56.7% at the onset of menarche and 56.2% approx. two years after the onset of menarche.

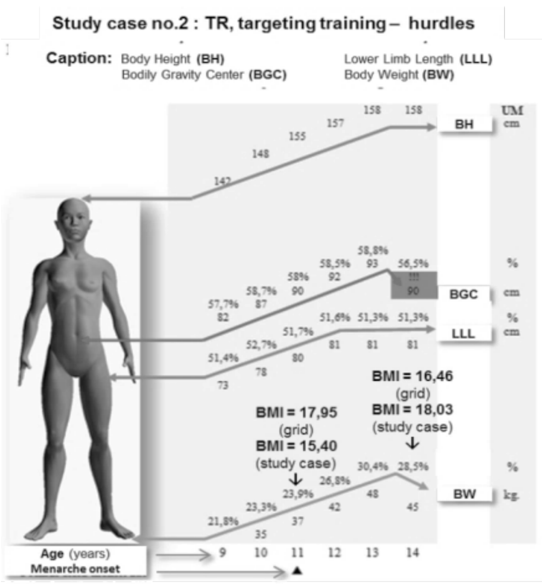

Fig. 11 – Example of a somatotype that does not fit into the predictive grid.

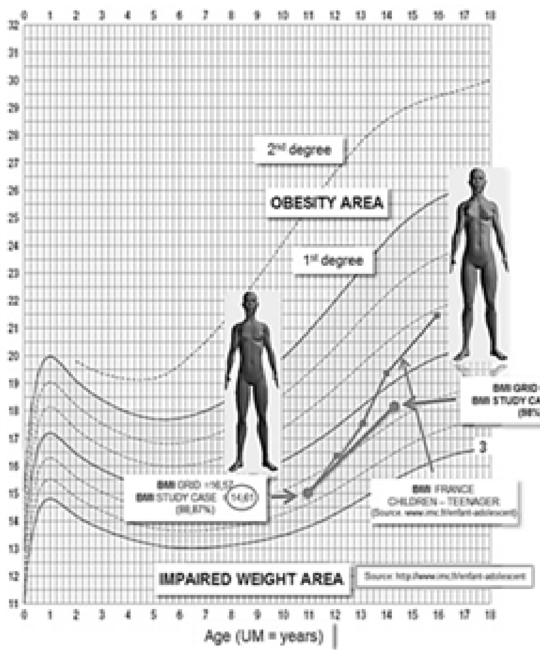

Fig. 12 – Comparison of BMI evolution curves in France (children and teens - girls) and in our predictive models.

Conclusions

1. The sports training of female hurdlers can still be optimized by increasing the degree of predictive and objective parameterization of their somato-functional evolution.

2. Using predictive grids exceeds the discursive framework (sometimes elusive, subjective and limited) of somatic development prediction (e.g. based only on momentary somatoscopic examination). These will provide important objective and complementary references to permanent selection in athletics.

3. The level and the evolution of BMI become important parameters alongside the other somatic indicators (quantitative and qualitative), by comparison with normal values.

4. Our analysis shows that the BMI value should be 88-89% of normal values (reference French database, girls, 11-13 years) in the 1st and 2nd stages (pre-pubertal and pubertal), and 96-98% in the 3rd and 4th stages (post-puberty, 14-16 years). We found that any value exceeding these limits led in time to "overweight" from the perspective of hurdling requirements.

5. The correct interpretation of BMI must be put in the context of dynamic and biomechanical requirements of hurdling. A special emphasis should be placed on optimizing the "ballistic component" (A/N) of hurdling. This is the only way to pass from "contiguity to continuity" (A/N) in the hurdles race.

6. Any isolated interpretation of BMI can generate validation errors if the body composition is not taken into account (e.g. the active/passive body mass ratio). This will be a focus of our future researches.

7. An interdisciplinary approach to our future research is necessary, by complementing our team with other specialists in medical disciplines, as a real support in the validation of the research results. This is another development objective that we pursue.

Conflicts of interests

Nothing to declare

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