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Identification of Biomotor Structures as a Precondition for Programming Kinesiologic Education in Children Aged Seven to Nine Years

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A B S T R A C T

A sample consisting of 487 children (249 male and 236 female) aged 7–9 years (± 2 months) underwent programmed kinesiologic transformation procedures for 18 months. The morphological and motor development was followed up by use of 14 morphological and 12 motor variables at 9-month intervals. Three taxonomic analyses for each measurement time point were calculated for either sex in order to determine the initial and transitive position for each individual study subject, and to identify most homogeneous groups within the sample as a whole. Three taxonomic variables were isolated on each measurement for either sex. Study results revealed female children to undergo faster development with earlier formation of the three morphological-motor structures ranked according to their predominance: mass, i.e. ectomesomorphy, motor, and endomorphy. Entity projections upon taxonomic variables at particular measurement points clearly identified the morphological-motor variables to be addressed by general and differentiated programs of kinesiologic education in order to achieve optimal effects during the development of the child's body as a whole.

***Key words:** children, morphological-motor structures, development*

Introduction

It is generally known that man is an integrative being whose characteristics tend to incorporate in a harmonious integrated system. This also applies to the energy resources obtained from the environment as well as to the knowledge and concepts acquired in lifetime. As all the characteristics and abilities are inter-related, their mutual effects and interactions are inevitable[1–4].

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There are numerous and vast opportunities and modes to influence the health and fitness of youngest children, however, development of abilities in these age groups shows great variation. Therefore, systematic and controlled kinesiologic activities for proper reinforcement of all body functions are of paramount importance[5–11].

Assessment of the relevant dimensions of the anthropologic status is the main starting point of any programmed training process in the kinesiologic educational activities, whereby the initial and transitive position of the anthropologic status are defined by the height and relations among the dimensions thus assessed. Quantitative determination of the students' anthropologic status relative to the standardized school standards appears to be acceptable but far from optimal due to the lack of information on the relationships among the characteristics assessed, which can only be obtained by use of multivariate analysis[12–15].

The efficacy of kinesiologic and health education increases proportionally to the opportunity of individual student approach. The formation of homogeneous groups according to the morphological -motor structures using the technique of taxonomic analysis is directed towards this goal[12,13]. Thus, quality activities in kinesiology cannot be realized without quality differential programs that tend to satisfy at least homogeneous groups if not individuals. Of course, this is primarily the matter of correct initial and subsequent taxonomization as a basis precondition for appropriate programming and reprogramming of kinesiologic education. The problems of data taxonomization in any scientific discipline including kinesiology are related to the two basic, mostly confronting logical standpoints. In the former, the typing within a population sample comes down to classifying the subjects into exclusive groups, i.e. into a limited number of strictly defined subgroups. Such an approach provides classification, selection and follow-up of objects in a process of transformation. In the latter approach, the subjects are assumed to be divided into groups determined by a model allowing for a particular subject to take a relatively stable position at more than one taxon. In spite of useful information obtained by these models, however, some problems persist that just cannot be avoided. For example, it is quite difficult to precisely answer the question of the exact contribution of particular variables to defining homogeneous group within an integral sample, what is the real number of taxons, i.e. what is the optimal number of subject groups with similar and recognizable anthropologic characteristics, etc.[16–18]. For these reasons, an algorithm integrating the basic tenets of distinct and composite taxonomic procedures was used in the present study[19].

The aim of the study was to demonstrate the need of determination of the initial and transitive position of each individual and to properly identify the groups existing in a sample in order to allow for appropriate programming of transformation processes in kinesiologic education. Along with this objective, stability of the biomotor structures of boys and girls aged 7–9 years while influenced by systematic kinesiologic treatment was assessed.

Subjects and Methods

Study sample included 487 children of both sexes (249 boys and 238 girls), first -graders from Split elementary schools, mean age on entering the study of 7 years (±2 months). All study children underwent programmed kinesiologic transformation procedures over 18 months and measurements at three control time points at 9-month (±10 day) intervals (see photos on Figures 1a-d). The purpose of the transformation process was to provide support to the biological growth and development, and especially to the broad -spectrum motor abilities.

Twenty-six variables were chosen so as to evaluate the morphological and motor status of the study subjects. The following 14 morphological variables were included: stature (mm), leg length (mm), total arm length (mm), wrist width (mm), bicondylar femur diameter (mm), biacromial diameter (mm), biiliocristal diameter (mm), body mass (dkg), forearm circumference (mm), lower leg circumference (mm), chest circumference (mm), triceps skinfold (1/10 mm), subscapular skinfold (1/10 mm), and abdomen skinfold (1/10 mm). The measures were taken according to the international biological program.

The following 12 variables were used in motor status assessment: sidesteps (s), polygon backward (s), bench standing (s), forward bow (cm), hand tapping (taps/min), foot tapping (taps/min), standing jump (cm), ball throw (dm), 20-m run (s), sit-ups (*per* min), bent arm hang (s), and 3-min run (m)[11]. The measurements were taken by qualified and trained professionals with rich experience in collecting these initial data. Entity relocation on taxonomic dimensions is one of the best indicators of characteristic restructuring. For this reason, taxonomic analyses of the first, second and third points of measurement were compared in separate for boys and girls (i.e. six taxonomic analyses).

Fig. 1. Programmed kinesiologic education in children aged 7–9 years.

The algorithm used in the study determines initial position by distinct taxons based on the entity Euclidean distance. Centroids of the variables for thus formed entity groups in a standardized space are determined, treated as coordinates of the taxonomic variables. The vectors are drawn into the position of unit length, and then by orthonormal transformation to optimal orthogonal position. Nontrivial vectors are retained and drawn to the parsimonial nonorthogonal position by nonconditional transformation, where after entity projections upon taxons are calculated[16,19].

Results

In the boy sample (Table 1), taxons were identified in nonorthogonal solution on initial measurement as motor (average projections of coordination variables, movement frequency and all strength factors), body mass based on ectomesomorphy, and adipose tissue, i.e. endomorphy. The entities were easy to identify, and so was their number for each distinct group (G1, G2 and G3). In G1, the entities were described as good motor fitness, average body mass, and no excess adipose tissue. The entities in G2 were described as low motor ability, high body mass, and pronounced adiposity. In G3, the entities were described as poor motor ability, extremely low body mass, and no excess adipose tissue, i.e. considerably underdeveloped considering the sample as a whole.

On second measurement, taxons were identified as motor (all projections were negative), mass taxon, i.e. ectomesomorphy (primarily defined by skeleton longitudinality, then by skeleton transversality, body volume and body weight), and adipose tissue taxon (quite high projections of all skinfolds). G1 entities were described as average motor fitness. The entities were characterized by low mass with negligible adipose tissue, i.e. as morphologically underdeveloped in the sample as a whole. G2 obviously had good motor abilities. The entities showed a more pronounced voluminosity, indicating appropriate development. G3 showed the entities of markedly low motor ability, high body mass, and pronounced adiposity.

On third measurement, taxons were identified as body mass taxon (skeleton and muscle mass, i.e. ectomesomorphy), general motor taxon (defined by all strength factors in separate, coordination and aerobic endurance), and adipose tissue taxon. G1 entities were characterized by low body mass, average motor ability, and minimal adipose tissue. G2 entities indicated high body mass (ectomesomorphy), good motor abilities, and slightly elevated adipose tissue. G3 entities also showed high body mass but very poor motor abilities and pronounced adiposity.

Correlations revealed a strong and expected association of morphological taxons at all points of measurement.

In the girl sample (Table 2) taxons were on initial measurement identified as morphological (MS, mostly defined by ectomesomorphy and to a lower extent by adipose tissue), motor 1 (MT1) with power predominance, and motor 2 (MT2) with direction predominance. The entities and their number for each distinct group were identified. In G1, the entities were described as markedly ecto-meso-endomorphic with all motor abilities being very poor, i.e. both those predominated by power and those predominated by direction mechanisms. The entities in G2 were described as good motor abilities, especially those power predominated, with above-average morphological characteristics. G3 entities were morphologically underdeveloped with average motor abilities.

On second measurement, taxons were identified as body mass based on ecto-

TABLE 1
TAXONS (TX), TAXON CORRELATIONS (R) AND TAXON CENTROIDS (CT) FOR GROUPS OF ENTITIES (G) ACCORDING TO MEASUREMENT POINTS (M) – BOYS (N=249)

Variable				M1			M2			M3		
				TX1	TX2	TX3	TX1	TX2	TX3	TX1	TX2	TX3
Stature				0.01	0.60	–0.12	0.10	0.59	–0.12	0.54	–0.06	–0.08
Leg length				0.04	0.48	–0.02	0.06	0.56	–0.11	0.50	–0.07	–0.09
Total arm length				0.00	0.56	–0.14	0.00	0.50	–0.12	0.51	–0.03	–0.12
Wrist width				0.03	0.52	–0.04	–0.05	0.46	0.02	0.49	0.00	–0.02
Bicondylar femur d.				–0.05	0.51	–0.02	0.06	0.41	0.06	0.45	–0.07	0.01
Biacromial diameter				–0.02	0.45	0.02	–0.08	0.40	0.11	0.37	0.02	0.09
Biiliocristal diameter				0.12	0.29	0.18	–0.04	0.32	0.22	0.34	0.04	0.21
Body mass				–0.03	0.50	0.22	–0.01	0.45	0.25	0.42	–0.04	0.24
Forearm circumf.				–0.02	0.46	0.09	–0.04	0.37	0.18	0.36	0.12	0.23
Lower leg circumf.				–0.02	0.48	0.18	–0.08	0.38	0.22	0.32	0.06	0.26
Chest circumference				0.01	0.41	0.23	–0.09	0.36	0.31	0.29	0.16	0.36
Triceps skinfold				–0.04	0.12	0.45	0.07	0.14	0.42	0.07	–0.09	0.48
Subscapular skinfold				0.03	–0.05	0.58	0.05	0.00	0.61	–0.06	–0.09	0.63
Abdomen skinfold				0.01	0.10	0.50	0.01	0.05	0.59	–0.04	–0.01	0.68
Sidesteps				–0.40	–0.01	–0.01	0.40	–0.06	0.12	0.00	–0.36	0.09
Polygon backward				–0.37	–0.07	0.19	0.52	0.02	0.06	0.04	–0.39	0.07
Bench standing				0.39	0.01	0.00	–0.31	–0.07	0.02	0.05	0.18	0.00
Forward bow				–0.05	0.15	–0.02	–0.17	0.07	0.03	0.17	0.03	0.06
Hand tapping				0.39	–0.07	0.11	–0.33	–0.02	0.10	0.00	0.24	0.05
Foot tapping				0.41	–0.09	0.11	–0.49	–0.04	0.13	–0.07	0.31	0.08
Standing jump				0.58	–0.06	–0.01	–0.51	–0.02	–0.11	–0.01	0.58	–0.09
Ball throw				0.38	0.12	–0.03	–0.26	0.10	–0.03	0.09	0.39	0.04
20-m run				–0.43	–0.03	0.02	0.37	–0.02	0.08	0.02	–0.54	–0.01
Sit-ups				0.35	0.05	0.03	–0.47	0.06	–0.01	0.04	0.49	0.03
Bent arm hang				0.33	–0.01	–0.18	–0.24	–0.08	–0.13	–0.05	0.38	–0.12
3-min run				0.21	–0.05	0.00	–0.33	–0.01	0.01	–0.03	0.38	0.01
				MT	MS	FT	MT–	MS	FT	MS	MT	FT
				R1	R2	R3	R1	R2	R3	R1	R2	R3
R1				1.00	–0.01	–0.29	1.00	–0.05	0.11	1.00	0.00	0.53
R2				–0.01	1.00	0.50	–0.05	1.00	0.56	0.00	1.00	–0.22
R3				–0.29	0.50	1.00	0.11	0.56	1.00	0.53	–0.22	1.00
	M1	M2	M3	CT1	CT2	CT3	CT1	CT2	CT3	CT1	CT2	CT3
G1	67	144	171	0.78	–0.06	–0.43	–0.01	–0.65	–0.55	–0.50	0.03	–0.44
G2	93	78	47	–0.24	0.97	0.81	–0.35	0.80	0.31	1.19	0.51	0.32
G3	89	27	31	–0.33	–0.96	–0.53	1.05	1.15	2.02	0.94	–0.94	1.96

MT = motor taxon; MS = body mass taxon; FT = adipose tissue taxon

TABLE 2
TAXONS (TX), TAXON CORRELATIONS (R) AND TAXON CENTROIDS (CT) FOR GROUPS OF ENTITIES (G) ACCORDING TO MEASUREMENT POINTS (M) – GIRLS (N=238)

Variable	M1			M2			M3		
	TX1	TX2	TX3	TX1	TX2	TX3	TX1	TX2	TX3
Stature	0.45	–0.13	–0.06	0.59	–0.04	–0.09	0.61	0.08	–0.12
Leg length	0.38	–0.05	0.00	0.60	–0.03	–0.11	0.54	0.01	–0.05
Total arm length	0.38	–0.11	0.02	0.53	–0.02	–0.13	0.50	0.00	–0.05
Wrist width	0.37	–0.03	–0.31	0.46	–0.02	0.10	0.55	0.11	–0.09
Bicondylar femur d.	0.39	–0.03	–0.10	0.35	0.08	0.26	0.42	0.01	0.07
Biacromial diameter	0.31	–0.14	0.07	0.47	0.02	0.04	0.37	–0.05	0.12
Biiliocristal diameter	0.30	0.12	–0.21	0.41	–0.04	0.17	0.40	0.05	0.14
Body mass	0.47	0.03	0.01	0.43	–0.04	0.27	0.43	0.03	0.24
Forearm circumf.	0.40	0.02	0.01	0.31	0.10	0.30	0.28	–0.14	0.38
Lower leg circumf.	0.45	–0.05	0.12	0.32	0.06	0.33	0.28	–0.06	0.32
Chest circumference	0.42	0.07	0.01	0.33	0.04	0.29	0.27	–0.14	0.42
Triceps skinfold	0.28	0.14	0.18	0.11	–0.10	0.43	0.05	0.13	0.48
Subscapular skinfold	0.28	0.21	0.12	0.03	–0.07	0.47	–0.04	0.07	0.58
Abdomen skinfold	0.29	0.19	0.17	0.04	–0.10	0.52	–0.06	0.10	0.63
Sidesteps	0.11	–0.06	0.49	0.03	–0.15	0.20	0.05	0.23	0.05
Polygon backward	0.04	0.14	0.27	0.05	–0.38	0.11	0.04	0.31	0.11
Bench standing	0.05	–0.06	–0.37	0.07	0.24	–0.07	0.02	–0.24	0.05
Forward bow	0.20	–0.10	0.13	0.26	0.26	–0.01	0.14	–0.34	0.13
Hand tapping	0.04	–0.01	–0.43	0.03	0.30	–0.06	–0.02	–0.37	0.00
Foot tapping	–0.02	0.01	–0.25	–0.03	0.33	–0.06	–0.10	–0.41	0.08
Standing jump	0.03	–0.24	–0.19	0.08	0.39	–0.17	0.11	–0.42	–0.23
Ball throw	0.07	–0.14	–0.27	0.07	0.45	0.00	0.09	–0.42	–0.05
20-m run	–0.12	0.32	0.06	–0.01	–0.42	–0.03	0.04	0.44	–0.08
Sit-ups	0.05	–0.08	–0.20	0.00	0.39	0.14	0.04	–0.35	–0.09
Bent arm hang	–0.02	–0.18	–0.34	–0.11	0.50	–0.02	–0.09	–0.40	–0.16
3-min run	–0.03	0.09	–0.47	–0.06	0.34	0.02	–0.03	–0.35	–0.07
	MS	MT1–	MT2–	MS	MT	FT	MS	MT–	FT
	R1	R2	R3	R1	R2	R3	R1	R2	R3
R1	1.00	0.15	0.17	1.00	0.12	0.51	1.00	–0.23	0.46
R2	0.15	1.00	0.20	0.12	1.00	–0.29	–0.23	1.00	0.17
R3	0.17	0.20	1.00	0.51	–0.29	1.00	0.46	0.17	1.00

	M1	M2	M3	CT1	CT2	CT3	CT1	CT2	CT3	CT1	CT2	CT3
G1	40	75	74	1.53	1.06	0.68	0.88	–0.61	10.09	0.71	–0.72	0.04
G2	104	61	137	0.22	–0.43	–0.14	0.35	0.90	–0.23	–0.59	0.20	–0.45
G3	94	102	27	–0.89	0.03	–0.13	–0.86	–0.09	–0.66	1.05	0.96	2.16

MS = body mass taxon; MT = motor taxon; FT = adipose tissue taxon mesomorphy, motor (best defined by the factors of strength), and adipose tissue. The entities identified in G1 were characterized by high body mass, poor motor abilities, and marked adiposity. G3 entities showed pretty good motor abilities, above-average ectomesomorphy, and no adipose tissue excess. G3 entities were characterized by low body mass, negligible adipose tissue, and slightly under-average motor abilities.

On third measurement, taxons were identified similarly to the second measurement: body mass, i.e. ectomesomorphy, motor taxon, and adipose tissue. G1 entities were described as ectomesomorphic and good motor abilities. G2 entities were characterized by low body mass, no adipose tissue, and poor motor abilities, i.e. markedly underdeveloped in the sample as a whole. G3 entities were high body mass, extremely poor motor abilities, and pronounced adiposity.

Discussion

Determination of the initial and transitive position of each individual is highly relevant in terms of both volume programming, modality defining, and selection of performance content. For these reasons, it appears crucial to properly identify the existing groups in a sample, and then to submit them to a treatment leading to convergence, i.e. to the achievement of overall goals.

In children of both sexes, morphological taxons describe two opposite facets of development: ectomesomorphy as a positive and endomorphy as a negative side of development. Ectomesomorphy is in positive correlation, and endomorphy in negative correlation with motor abilities.

Obviously, systematic treatments and development *per se* resulted in substantial variation between particular points of measurement, indicating restructuring of the morphological-motor characteristics in the children of both sexes.

In the boy sample, the number of average motor entities of low body mass and low adipose tissue values increased from one measurement to another. On initial measurement, the boys had good motor abilities combined with moderate body mass and negligible adipose tissue, or had poor motor abilities combined with high body mass and pronounced adiposity, or with low body mass and no adiposity.

From one point of measurement to another, the muscle mass increase with adipose tissue reduction led to the formation of a group of entities with good motor abilities, while the number of entities with poor motor abilities, high body mass and pronounced adiposity declined. Skeletal constitution showed better stability and slower rate of changing, so that ectomesomorphy became the major feature in boys only on the third point of measurement. This provides evidence for the effects achieved to have allocated the entities exactly according to their abilities and ecosensitivity to the stimuli.

In girls, the morphological development obviously occurred at a faster rate, because on initial measurement the morphological taxon defining overall morphological development ranked first. During the study period, the systematic kinesiologic treatment and development *per se* led to the formation of morphological taxons, first as ectomesomorphy and third as endomorphy. As early as the next measurement, the motor taxons 1 and 2 from initial measurement integrated into a unique motor taxon responsible for overall motor efficiency. In addition, a group (around 30% of the total sample) of girls with extremely good motor abilities, marked ectomesomorphic constitution and under-average endomorphy was formed on the second measurement. Counter posed to this group was a group of girls with very poor motor abilities due to high body mass and pronounced adiposity. The rest of 40% of the study girls were morphologically underdeveloped and with slightly under-average motor abilities in the group as whole.

On third measurement, the number of girls with very good motor abilities, pronounced ectomesomorphy and moderate adiposity increased. However, the proportion of girls (>50%) with under-average motor abilities due to inadequate body mass also increased, along with a low proportion of girls with extremely poor motor abilities due to high body mass and pronounced adiposity.

Kinesiologic education provided for 3x 45 minutes *per* week is obviously inadequate to achieve any substantial stimulation of the morphological-motor development for the next period in girls. This is clearly shown by taxon centroids in the third point of measurement.

By use of taxonomic analysis, two groups of entities were formed in the samples of both male and female children, for which general and partial programs of kinesiologic education should be designed. Such programs would meet the children's requirements in this segment of education, thus supporting and upgrading their overall psychosomatic development.

Many determinants of the man's development have remained integrated in his anthropologic structure and represent the persistent basis of man as a being. In their study, Katić et al.[20] recognized the basic motor abilities related to the phylogenetic development of man. Morphological structure as a subsegment of the anthropologic system allows for the motor manifestations to realize. By acting upon the development of motor abilities, the development of the body as a whole, i.e. its composition and structure, are also being influenced. So, changes in the morphological structure occur, which at the same allow for higher motor efficiency and further development of motor abilities. The morphological-motor development thus leads to ever more intense integration of motor abilities in the morphological system, as clearly evident also in the present study through entity projections onto taxons. Obviously, the morphological-motor development should be observed through interactions of the morphological and motor systems, thereby employing targeted kinesiologic treatments to bring the structures of these systems into optimal inter-relationships. In order to properly design the general and partial programs of kinesiologic education, a multivariate discriminative analysis for complete taxon description can now be performed on each measurement according to groups of entities. The general programs of kinesiologic education should thereby maintain the already attained development and support further development of the relevant motor abilities and desirable morphological features. Accordingly, partial programs should tend to eliminating developmental deficits in the children's overall morphological-motor status. In this way, the minimum state in the morphological and motor characteristics of development that should be achieved by every normal child during a particular stage of development is also determined.

Determination of the entity position on the taxonomic variables obtained (body mass, i.e. ectomesomorphy, motor abilities, and adipose tissue, i.e. endomorphy) is a key precondition for quality programming of the kinesiologic education performance. Kinesiologic education should follow the basic determinants of the man's development (described in Katić et al.[20]). Therefore, it should tend to achieve the following: minimum of characteristic persistence (evaluated by the variables used), minimum of movement routine, minimum of movement skills, minimum of movement knowledge, and acting on the development of creation on movement. These terms are developmental components of the integral maturation of the movement concepts in man, which do not disappear on attaining the minimum, but their development should be permanently influenced upon and upgraded.

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IDENTIFIKACIJA BIOMOTORIČKIH SKLOPOVA KAO PREDUVJET PROGRAMIRANJA KINEZIOLOŠKE EDUKACIJE DJECE OD 7. DO 9. GODINE ŽIVOTA

SAŽETAK

Na uzorku od 487 djece (249 dječaka i 236 djevojčica) starosne dobi od 7 godina (+/– 2 mjeseca) primijenjeni su programirani kineziološki transformacijski postupci u trajanju od 18 mjeseci. Morfološko-motorički razvoj djece praćen je s 14 varijabli iz morfološkog i 12 varijabli iz motoričkog prostora mjerenih svakih 9 mjeseci. U cilju utvrđivanja inicijalne i tranzitivne pozicije svakog pojedinca, kao i što homogenijih grupa unutar uzorka, izračunate su za svaki spol po 3 taksonomske analize, tj. za svaku točku mjerenja. Za oba spola u svakom mjerenju izolirane su po 3 taksonomske varijable.

Kod ženskog se spola razvoj odvija brže te se prije formiraju 3 morfološko-motoričke strukture poredane po dominantnosti i to: masa tj. ektomezomorfija, motorička i endomorfija. Projekcije entiteta na taksonomske varijable u točkama mjerenja jasno su pokazale na koja morfološko-motorička obilježja treba djelovati općim i diferencijalnim programima kineziološke edukacije kako da bi se postigli optimalni efekti razvoja dječjeg organizma kao cjeline.