An integrative diagnostic parameter used for variables of somatic-, cardio-respiratory- and physical performance

PhD Thesis

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Budapest
2007

Introduction

The physical and mental state or their changes caused by physical activity in children, adolescents and adults with different physical activity can be conventionally characterised with the variables described by the measured values in every field of specialty. The development of children, changes in body size and associated physical performance, the somatic-, metabolic- or physical effects of competitive sport, health promoting activity, or hypo-activity can be estimated in many ways but the comprehensive overview warrants the close co-operation of the different specialties. An integrative parameter is needed to describe the joint opinion which integrates all of the measured parameters and outlines how the system works.

To define the functions of biological systems, entropy was found to be appropriate, which originates from thermodynamics and is traditional in informational theory, because nowadays it is suitable for judging all levels of biological systems (Singh, 1998). It has been proved that high level of orderliness or complexity are characterised by low entropy and this is true for populations, individuals and for their very precise molecular structures as well (Udgaonkar, 2001). The open and dissipative systems reduce their entropy and re-configure their structure (Bertalanffy, 1940; McArdle et al., 1985), thus we feel that using parameters that describe the structure and function together is validated.

One of the various entropy calculating methods (Land and Elias, 2005) was used to evaluate the cardio-respiratory (Cardilora et al., 2004; Cysarz et al., 2000; 2007; Pincus and Viscarello, 1992) another for the hormonal system (Pincus et al., 2000; Tuckow et al., 2006; Veldhius et al., 2001) although the entropy was calculated from the time series of one variable. For describing physical performance, for quantifying difference depending on previous practice and for highlighting the link between orderliness and effectiveness in sports entropy was calculated from the shift of the body's centre of gravity or pivot points (Boschker and Bakker, 2002; Cordier et al., 1994; Costa et al., 2003; Csende et al., 2005).

The aim of the study

We analysed the somatic development and the changes in cardio-respiratory and physical performance caused by physical activity among boys and girls with different levels of physical activity and described these states and their changes with an integrative parameter: statistical entropy, which is the indicator of orderliness and randomness, and also involves the level of regulation.

The questions were:

1. Is there a difference in cardio-respiratory performance between the regularly active 11-15 year old athletic boys and the non-athletes, and can we describe the difference with our integrative parameter?
2. Are the parameters of somatic development and physical performance modified by the level of physical activity in 7-14 year old children, and are the morphological and functional differences revealed in the values of entropy?
3. With the integrative parameter used by us, is there demonstrable difference in somatic development and changes in physical performance of 7-11 year old girls and boys attending normal or elevated level PE classes?

Subjects

To answer our questions we looked at the settings of three analysis groups considering the WMA (1966) instructions during this process. Volunteer children and adolescent (Table 1) participated in the study.

Table 1. Distribution of studied subjects by age and physical activity

Activity/Age	**11**	**12**	**13**	**14**	**15**	**7-14**	**7-11**
Athletes	67	48	52	56	52		
Non Athletes	43	39	43	37	41		
Active						20	
Non active						19	
Elevated PE							113
Normal PE							148
Total	**110**	**87**	**95**	**93**	**93**	**39**	**261**

Methods

The entropy characterising the performance of the cardio-respiratory system of athletes and non-athletes was calculated from the values measured every half minute during spiroergometric exercise. The somatic development of 7-14-year-old children was described by the entropy calculated from variables suggested by the relevant literature. The entropy of the development of the cardio-respiratory system was calculated from the four basic gas exchange data, resting heart rate, respiratory exchange ratio and from variables of physical performance. The usual variables were used to evaluate the somatic development of 7-11-year-old pre-pubertal children. To describe the development of physical performance we used the results of four motor tests and the entropy was calculated from the above. The time series consisted of the data taken yearly or six monthly during the longitudinal studies.

Statistical entropy was calculated by the time series of all the measured variables by the method known from thermodynamics (Boltzmann, 1877) and information theory (Shannon, 1948), because our goal was to describe the children and adolescents as a complex system.

We have found

1. The cardio-respiratory system of the athletes was working more orderly in all age groups in the whole measured period compared to the non-athletes. These differences were significant only in the three older age groups. The two oldest age groups were significantly more orderly in both subgroups than the younger ones. The performance during exercise was again more orderly among the athletes and there were significant differences between the youngest and the two eldest groups. The changes in the subgroups were different, among the athletes the 14 and 15-year-old differ significantly from the younger ones. Among the non-athletes although the randomness seems to increase at 11 years, but the changes after 12 years were not significant. The cardio-respiratory system of the non-athletic subjects was working significantly more orderly in the restitution in three age groups. Among the athletes the 14-15-year-old ones differ significantly from the younger subjects. The tendency changes of subgroups can indicate that the entropy is age-related. The significant increase with age in orderliness can be understood as the consequence of improving level of regulation. Significant differences of the regression functions proved the effect of sport. This was also supported by the hypothetical stagnation found in the non-athletic group in early post-pubertal years. The possible explanations are: the higher performance level of the athletes, the effects of regulation sourced from larger cardiac output, the known high inter-individual variability during the restitution and the short period of data collection. The lower entropy of the athletes during the whole data collection as well as during exercise and the tendency of age dependency perfectly showed that the cardio-respiratory system of the athletes worked more orderly, proving the effect of intensive and regular physical activity on orderliness (Boschker and Bakker, 2002; Cordier et al., 1994; Csende et al., 2005; Pijpers et al., 2001; 2003).

Our hypothesis can be accepted.

2. Comparing the orderliness of somatic development and the changes of cardio-respiratory function arise from physical activity in physically active and non-active children has proved the positive effect of physical activity. Unlike the alteration of the morphological constitution, the metabolism and the development of the "complex system" was significantly more orderly in the active group. At the beginning of the –eight data collections– study, the discriminant function analysis (DA) showed no differences between the groups. There were no differences in the majority of between-groups comparisons, but the active group had significantly higher physiological performance from 12 years of age and higher physical performance except the time of the first observation. At the end of the study the DA revealed significant difference in their metabolic system, where the physical performance was only the discriminator variable. Our results are similar to Baxter-Jones and Mundt (2007), Dridi et al. (2005), Rowland (2005) and others data that showed the training resulted in a slight metabolic adaptation during pre-pubertal years, but the motor performance indicates the positive effects of training. The relation of entropy and the results of DA have proved that entropy describes the development with a different quality than the comparison of the variables and is suitable for demonstrating the positive effects of physical activity.

Our hypothesis can be accepted.

3. The study of morphological development and physiccal performance in pre-pubertal children participating in elevated and normal level of PE did not confirm our initial hypothesis. The entropy showed that the development of the hypoactive groups were more orderly in both sexes. Unlike the physical performance, somatic development and the development characterising the whole system was significantly more orderly in the normal PE girls. In boys all the three entropies were sig-

nificantly lower in the normal PE class. Since our results contradicted in part to some published data, this linear developmental period was also analysed by variables. We have done this procedure, despite the fact that entropy can reveal such characteristics which the conventional variable analysis did not show and entropy gives a more reliable characterization of data than that we can have with analysing just one parameter (Lai et al., 2005; Verklan et al., 1999). The analysis by variables resulted in more significant changes during six months among the normal PE pupils which suits the age-related development more. In variables describing the somatic development only in relative body fat had one more significant change among the normal PE girls, which was not acceptable, but in all the other cases we thought that the difference between frequencies was an acceptable cause of the entropy-relation. As one of the further explanations we did the logical analysis the fitted model. We think that the entropy which was calculated from the basic anthropometric data and from the results of motor tests consisting of natural movements is suitable characterising the development in one way. We found significant relationship between age and our variables which proved the linearity of this developmental stage and the rightful use of entropy (Land and Elias, 2005). With one exception, there was no difference between the slopes of regressions describing the variables used in our model characterising the groups, the difference originated from the initial selection that remained constant during the study. This means that the five physical activity sessions in a week for four years had no measurable training effect! This is the true explanation for the entropy relation, because there was nothing to be revealed. The comparison of the entropy showed a different view than the variable and variations analysis. Within-group changes differed by the variable analysis. Comparing the data of each data collections to DA showed a conesquent difference between "somatic" and "physical" factors as well. The entropy found no difference between the developments of the groups at the same level of physical activity.

In summary: all the three different studies proved that entropy is suitable for the description the training-adaptation caused by different levels of physical activity and for characterisation the somatic and the attached physical development in children and adolescents, if the frequency and the intensity of physical activity can cause a detectable training effect!

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