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original article

Sport context and the motor development of children

O contexto esportivo no desenvolvimento motor de crianças

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Abstract – Over the last 30 years there has been a considerable increase of research in the field of motor development. Although the first reports were based on biological factors, current discussions include the role of the environment in the process of motor development. The aim of this study was to compare the motor performance of children enrolled in sports centers to that of children only attending physical education classes. Eighty-seven children aged 8 to 10 years enrolled in centers offering training in rhythmic gymnastics (n=20), handball (n=26) and indoor soccer (n=16) and children attending only physical education classes (n=25) participated in the study. Data were analyzed by inferential statistics using the Kruskal-Wallis test, Mann-Whitney U test and discriminant analysis, adopting a level of significance of α=0.05. The results showed differences between groups ($p<0.001$). Children attending only physical education classes showed lower performance, whereas children enrolled in sports centers performed better in the motor skills related to the requirements of each discipline. The statistical model also discriminated and classified correctly 79.3% of the children participating or not in some sports discipline. Finally, it is possible to conclude that the sport context influences the level of motor performance and motor skills according to the requirements of the sport practiced.

Key words: Child; Motor development; Motor skills

Resumo – *Nos últimos 30 anos, houve um aumento considerável de pesquisas na área do desenvolvimento motor. Embora as primeiras explicações estivessem fundamentadas em aspectos biológicos, atualmente, as discussões incluem o papel do ambiente neste processo de desenvolvimento motor. O objetivo desse estudo foi comparar o desempenho motor de crianças engajadas em escolinhas esportivas com crianças inseridas apenas nas aulas de educação física. Oitenta e sete crianças oriundas de escolinhas da Ginástica Rítmica (n=20), Handebol (n=26), Futsal (n=16) e crianças inseridas nas aulas de Educação Física (n=25), com idades entre 8 e 10 anos, fizeram parte do estudo. O teste TGMD-2 foi utilizado para verificar o desempenho motor das crianças. A estatística inferencial foi realizada por meio dos testes Kruskal-Wallis, U de Mann-Whitney e Análise Discriminante, com valor de significância α=0,05. Os resultados demonstraram diferenças entre os grupos ($p<0,001$), sendo que as crianças que participavam apenas das aulas de Educação Física apresentaram menores níveis de desempenho motor, e as crianças engajadas em escolinhas esportivas desempenharam melhor nas habilidades motoras relacionadas às demandas do contexto esportivo. Ainda, o modelo estatístico foi capaz de discriminar e classificar corretamente 79,3% das crianças engajadas ou não, em algum contexto esportivo. Por fim, é possível concluir que o contexto esportivo influencia o nível de desempenho motor e o desempenho das habilidades de acordo com as exigências*

Palavras-chave: *Criança; Desenvolvimento motor; Habilidades motoras*

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INTRODUCTION

Since the beginning of the last century, the search for a better understanding of the factors involved in the process of motor development has been contemplated in the literature. However, it can be seen that children show individual variations in the onset of new behaviors and levels of motor performance which cannot be explained only by genetic influences or maturation rate.

Over the last few years, several studies[1-5] have restructured the theoretical basis of motor behavior and motor development is now accepted as the product of a dynamic process. By interpreting this motor development from the viewpoint of the bioecological theory[6], it can be seen that personal characteristics, processes, contexts and time directly influence the process of human development. From this perspective, Newell[5] developed a theoretical restriction model that explains motor development and considers the restrictions of the person, the task and the environment. According to this model[5], the motor proficiency of children is influenced by restrictions related to the task, the individual and the context. On this basis, each sport context has particular demands and requires specific characteristics and skills, which delimit the motor behavior of a child. In addition, the demands of the environment (context) tend to delineate the motor repertoire and act on the level of performance of each motor skill (task). The characteristics of the child (individual) can be of a structural (e.g., weight and height) and functional (e.g., motivation and maturation of the nervous system) nature. The environment, in turn, is related to physical structures or sociocultural factors and the task may be linked to the objective (e.g., recreational or competitive)[5].

In agreement with these theoretical precepts, Krebs[7] stated that the multiple contexts in which a child is engaged may somehow interfere with the process of his motor development. Thus, it becomes essential to understand the intervening role of contexts in the process of child motor development. To this end, studies have been conducted in school[8,5] and sports[9,10] contexts in order to better understand the relation between motor development and context. However, there still is a gap of knowledge regarding the area of motor development concerning the role of the context in the motor proficiency of children.

Considering the relevance of the subject in question and the intention to discriminate the influence of the sport context in the process of child motor development, the objectives of the present study were: 1) to identify the level of motor performance of children enrolled in sports centers and of children only participating in physical education classes, 2) to determine in which motor skills the children show a better performance according to the sport context in which they participate, and 3) to identify and quantitate the contribution of each fundamental motor skill in each context. Two conceptual hypotheses were raised based on the bioecological theory[6] and Newell's constraints model[5]: 1) children

involved in a sport context may show better levels of motor development than children only attending physical education classes, and 2) the demands of the context may influence the motor profile and level of motor proficiency of children.

METHODOLOGICAL PROCEDURES

Participants

Eighty-seven children of both sexes aged 8 to 10 years (9.0±1.0) were selected intentionally at two schools in the city of Florianópolis, Santa Catarina. The children were supposed to be regularly enrolled and frequenting their classes. The sample consisted of children attending centers of rhythmic gymnastics (n=20), handball (n=26), and indoor soccer (n=16) twice a week for about 90 minutes and of children only attending regular physical education classes in school (n=25). All children participated in physical education classes in their respective schools twice a week for 50 minutes. The children involved in sports initiation were additionally enrolled in centers that provided training in their own schools and had been practising for at least 6 months. Children who participated in more than one program of sports initiation were excluded. All persons responsible for the children gave written informed consent for their participation in the study.

Instruments and Measures

Motor development was assessed using the TGMD-2 test battery o (Test of Gross Motor Development – Second Edition) proposed by Ulrich[11]. The TGMD-2 consists of 12 fundamental motor skills, six of them involving locomotion and six involving object control.

Study Procedures

The study was approved by the Research Ethics Committee of the State University of Santa Catarina (Protocol No. 0031/2011). A time table for data collection was scheduled with the schools and the parents or persons received the free informed consent for together with the authorization for filming. Each child was evaluated individually for a period of approximately 25 minutes according to the test protocol[12].

Statistical Analysis

Data were first analyzed descriptively as mean and standard deviation. Non-normal distribution of the data was confirmed by the Kolmogorov-Smirnov test. Thus, the Kruskal-Wallis test was used to compare motor performance among the four groups and the Mann-Whitney U test was used to determine differences among them. The level of significance was set at $\alpha = 0.008$ according to Bonferroni correction in order to control the rate of type I errors. Discriminant analysis was also performed in order to determine the relative contribution of each fundamental motor skill within each sport context. The Mahalanobis distance was used to

identify extreme multivariable cases, with exclusion of levels higher than the level of significance adopted, considering the degrees of freedom of the model (d.f. = 11). Finally, leave-one-out cross-validation was performed in order to determine the classifying capacity of the developed model in new cases, available in the statistical package. The SPSS 16.0 software was used for statistical analysis, with the level of significance set at $\alpha = 0.05$.

RESULTS

The values of the motor skills of each group (mean ± SD) are shown in Table 1. As can be seen, children involved in sport contexts showed better levels of motor performance than children only attending physical education classes.

Table 1. Age, motor performance according to motor skills and motor quotient of the children of each group (mean ± SD).

TGMD-2		Physical education (n=25)	Rhythmic gymnastics (n=20)	Handball (n=26)	Indoor soccer (n=16)
	Age	9.4 ± 0.1	8.94 ± 0.1	10.1 ± 0.7	8.4 ± 0.1
Locomotion	Run	5.7 ± 1.3	7.0 ± 1.2	7.5 ± 0.9	8.0 ± 0.0
	Gallop	4.3 ± 1.8	6.0 ± 0.0	6.4 ± 1.3	7.1 ± 1.5
	Hop	5.6 ± 1.8	8.2 ± 1.5	9.5 ± 0.7	7.5 ± 1.5
	Leap	2.5 ± 0.8	4.0 ± 0.6	4.8 ± 0.8	4.4 ± 0.6
	Horizontal jump	4.2 ± 1.5	5.3 ± 0.9	5.3 ± 1.5	5.8 ± 1.3
	Slide	5.8 ± 0.8	7.1 ± 1.0	6.1 ± 0.6	7.5 ± 1.0
Object control	Two-hand strike	4.0 ± 1.9	5.3 ± 1.5	8.0 ± 1.9	8.6 ± 1.1
	Stationary Bounce	7.1 ± 1.2	7.3 ± 1.1	6.8 ± 1.0	6.7 ± 1.4
	Catch	2.8 ± 0.8	4.0 ± 0.9	4.6 ± 1.3	5.4 ± 0.9
	Kick	4.8 ± 2.0	6.2 ± 1.0	7.2 ± 1.2	7.8 ± 0.4
	Overhand Throw	3.4 ± 1.5	3.5 ± 1.7	6.0 ± 1.7	6.0 ± 1.1
	Underhand roll	5.3 ± 1.0	5.6 ± 1.2	6.4 ± 1.1	7.0 ± 0.7
Motor quotient		62.8 ± 7.2	80.2 ± 6.9	89.0 ± 11.9	90.8 ± 6.7

The Kruskal-Wallis test revealed significant differences between groups regarding the motor quotient ($H(3) = 48.91$, $p<0.001$) and all 12 motor skills evaluated ($p<0.001$), except for bouncing ability ($p=0.336$). Thus, the Mann-Whitney U test was used to determine where the differences lay and Bonferroni correction was applied to minimize type I statistical errors, with the level of significance for these comparisons being set at $\alpha = 0.008$. The results of these group comparisons are shown in Table 2.

Regarding the differences between the handball and indoor soccer centers, the children enrolled in indoor soccer showed better lateral running skills ($p<0.00$). However, regarding the skipping on one foot skill, the children enrolled in the handball center showed significantly higher levels of performance ($p<0.00$) than children practicing indoor soccer.

Table 2. Level of significance of the comparisons between groups regarding fundamental motor skills and motor quotient.

TGMD-2		Physical education			Rhythmic gymnastics	
		Rhythmic gymnastics	Indoor soccer	Handball	Indoor soccer	Handball
Locomotor skills	Run	0.004*	0.000*	0.000*	0.002*	0.070
	Gallop	0.000*	0.000*	0.000*	0.000*	0.025
	Hop	0.000*	0.003*	0.000*	0.125	0.001*
	Leap	0.000*	0.000*	0.000*	0.017	0.001*
	Horizontal jump	0.019	0.001*	0.045	0.041	0.874
	Slide	0.001*	0.000*	0.192	0.204	0.001*
Object control skills	Two-hand strike	0.015	0.000*	0.000*	0.000*	0.000*
	Stationary Bounce	0.539	0.415	0.335	0.189	0.086
	Catch	0.000*	0.000*	0.000*	0.000*	0.119
	Kick	0.012	0.000*	0.000*	0.000*	0.002*
	Overhand throw	0.942	0.000*	0.000*	0.000*	0.000*
	Underhand roll	0.407	0.000*	0.001*	0.000*	0.021
	Motor quotient	0.000*	0.000*	0.000*	0.000*	0.007*

* Significant difference ($p<0.05$, Mann-Whitney U-test).

Discriminant statistical analysis was performed in order to identify and quantitate the contribution of each fundamental motor skill according to the context in which each child was enrolled. To this end, the assumption of equality of the dispersion matrices of the data was determined by the Box's M test, with the option of using the variance matrix of separate groups in order to increase the accuracy of the discriminant statistical model ($F \approx 0.880$, $p>0.05$). After this procedure, the model demonstrated three significant functions (Wilks' lambda <0.001), as shown in Table 3.

Based on Wilks' lambda values, the discriminant function (FD2) explains 77.5% of the variance, while the discriminant functions 2 (FD2) and 3 (FD3) explain 14.4% and 8.1% of the remaining variance among groups, respectively. Standardized coefficients identify and quantitate the potential of each variable for discriminating the children according to whether or not they are enrolled in a sports center. As demonstrated in Figure 1, the distance from group centroids, especially for FD1, represents the differences in motor performance between the children attending only physical education classes and the children enrolled in the sports centers. The skills with a greater impact on this difference were returning, receiving and forward pass.

FD2 represents the difference between children practicing handball and indoor soccer. The skills primarily accounting for this difference were lateral running and skipping on one foot. FD3 explains less properly the difference between practicing rhythmic gymnastics and those practicing indoor soccer and handball. The skills that discriminate this difference are: throwing over, running, rolling, forward pass, and returning. Table 4 shows

the capacity of the model to classify correctly the children in their respective sports centers or those who only attend physical education classes. After model validation, 79.3% of the children were classified correctly according to their performance in fundamental motor skills.

Table 3. Statistically significant functions and standardized and non-standardized coefficients for the three discriminant functions (FD1, FD2, FD3).

	Standardized coefficients			Non-standardized coefficients		
Variables	FD1	FD2	FD3	FD1[a]	FD2[b]	FD3[c]
Run	0.038	0.290	0.469	0.036	0.275	0.445
Gallop	0.287	0.350	0.026	0.207	0.252	0.019
Hop	0.330	-0.731	0.364	0.232	-0.513	0.255
Leap	0.429	-0.146	0.433	0.557	-0.190	0.562
Horizontal jump	-0.142	0.226	0.183	-0.103	0.164	0.133
Slide	0.005	0.783	0.214	0.005	0.880	0.241
Two-hand strike	0.523	-0.226	-0.412	0.303	-0.131	-0.239
Stationary Bounce	-0.334	-0.103	-0.002	-0.276	-0.085	-0.001
Catch	0.480	0.115	-0.168	0.439	0.105	-0.154
Kick	0.222	0.369	-0.052	0.165	0.273	-0.039
Overhand throw	0.092	-0.197	-0.617	0.058	-0.124	-0.387
Underhand roll	0.330	-0.104	-0.434	0.302	-0.095	-0.398
(Constant)				-10.109	-4.891	-3.021

[a] FD1: eigenvalue of the function ($V = 227,1$, d.f. = 36, $p<0.001$). [b] FD2: ($V_1 = 87,5$, d.f. = 22, $p<0.001$). [c] FD3: ($V_2 = 37,3$, d.f. = 10, $p<0.001$). All functions are significant since the eigenvalue of the function, the first residue (V_1) and the second residue (V_2) are all significant at $p<0.05$. d.f.: degrees of freedom, *V*: residue.

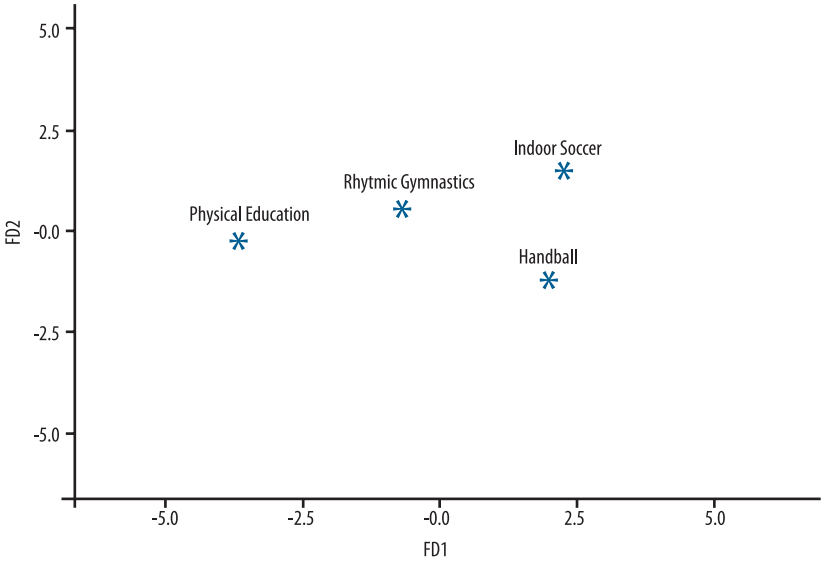

Figure 1. Territorial map obtained by discriminant analysis of the study groups. The asterisks indicate the group centroids. FD1: discriminant function 1; FD2: discriminant function 2.

Table 4. Classification of all significant discriminant functions after validation

			Group prediction, n (%)			
	Groups	n	1	2	3	4
Original model[1]	1. Physical education	25	20 (100)	0 (0.0)	0 (0.0)	0 (0.0)
	2. Rhythmic gymnastics	20	0 (0.0)	19 (95.0)	1 (5.0)	0 (0.0)
	3. Handball	26	0 (0.0)	1 (3.8)	24 (92.3)	1 (3.8)
	4. Indoor soccer	16	0 (0.0)	0 (0.0)	1 (6.3)	15 (93.8)
Cross-validation[2]	1. Physical education	25	18 (90.0)	2 (10.0)	0 (0.0)	0 (0.0)
	2. Rhythmic gymnastics	20	0 (0.0)	18 (90.0)	1 (5.0)	1 (5.0)
	3. Handball	26	1 (3.8)	4 (15.4)	17 (65.4)	4 (15.4)
	4. Indoor soccer	16	0 (0.0)	1 (6.3)	3 (18.8)	12 (75.0)

[1] Percentage of correctly classified cases in the original model: 95.1%. [2] 79.3% of the children were classified correctly after cross-validation.

DISCUSSION

By about 7 years of age, a child should be able to execute the fundamental motor skills in an adequate manner, before starting the process of movement specialization[13,14]. However, the motor performance of the children studied here who only attend physical education classes was classified as "very poor", below the level expected for age according to the criteria of the test[12] (Table 1). On the other hand, the children enrolled in the rhythmic gymnastics and handball centers were classified as "below average" and those enrolled in the indoor soccer center were classified as "average".

In a study[15] conducted in Porto Alegre, RS, on 1248 children aged 3 to 10 years, the authors observed that the scores were below the normative values of the test for age for 69% of the boys and 82% of the girls. Similarly, in a study[16] conducted in Florianópolis, SC, on children aged 5 to 10 years, 73% of the subjects were classified as "below average". From another perspective, a study[9] on children aged 4 to 6 years demonstrated superiority of those who practiced systematic physical activity compared to those who only attended physical education classes. In a study[10] conducted in the state of Paraná comparing the motor development of children with a mean age of 9 years who practiced mini-volleyball (n=50) and children only attending physical education classes (n=50), the children practicing mini-volleyball were classified as "average", while the others were classified as "below average". The results agree with the evidence obtained here, since the present children enrolled in systematic sports practice showed better levels of motor development than children only attending physical education classes. This finding also satisfies the first conceptual hypothesis of the present study.

In this respect, it is possible to observe variations in the levels of motor performance of children that cannot be explained only by genetic influences or by maturation rate. On this basis and according to ecological approaches[5,6,17], the hypothesis that the sport context plays an intervening role in the process of motor development was confirmed by the present results.

Regarding the motor skill showing the best performance in each context, the results also confirm the second conceptual hypothesis raised in

the present study. Children practicing indoor soccer showed a better performance in the motor skill "kicking", for example, compared to children practicing rhythmic gymnastics and handball. Again, children enrolled in indoor soccer showed better performance in the "lateral running" skill than children practicing handball. In turn, children practicing handball showed better performance in the "skipping on one foot" skill than all others and a better performance in the "throwing over" skill than children practicing rhythmic gymnastics. In addition to supporting the hypothesis of the present study, the sport context seems to direct the motor task according to the requirements of the modality, facilitating motor proficiency in specific skills of the sport.

The requirements and demands of the context (e.g., type of sport), the characteristics of the children (inborn and acquired) and time (e.g., amount of practice, experience) may also limit or facilitate motor development (process) in some skills at the expense of others, as suggested by Krebs[7] and by the bioecological theory[6]. This agrees with the theoretical models[5,13,17] related to motor development that were created based on an ecological approach, which emphasize the need to observe the phenomenon, motor development, based on the characteristics of the person, context, task, and time.

The statistical discriminant model created was able to classify correctly 79.3% of the cases after validation (Table 4). In other words, it is possible to classify each child according to his motor performance in each skill in the sports centers investigated. These results suggest that each sport context analyzed has its own characteristics regarding the motor profile required and mainly point out the difference in motor performance between children enrolled in sport contexts and children who only attend physical education classes. This evidence agrees with a study[18] of the environmental influences on the throwing over pattern of 20 children aged 10 to 12 years, in which the authors demonstrated that environmental changes provoke changes in this pattern even though they do not lead to reorganization of movement as a whole. Finally, these findings agree with the concepts of Newell[5] and of the bioecological theory[6], since the context of sports centers has an impact on the performance in fundamental motor skills required by each discipline.

Some limitations of the study should be pointed out: 1) the arrangement during data collection was not controlled, and 2) the motor activities practiced by the children on a daily basis were not investigated. The practical implications of the present study indicate the need to provide the children with structured and guided practice in order to promote the minimum conditions necessary for the children to achieve proficiency in their fundamental motor skills which are at the basis of movement specialization, and to engage in a competitive or even recreational sport context. Future studies should investigate characteristics of the contexts (e.g., interpersonal relations and contents administered) in which the children are enrolled and their preferred activities performed in their daily life.

CONCLUSION

The results obtained permit the conclusion that children enrolled in sports centers have better levels of motor performance than children who only attend physical education classes. The children also showed variations in the level of performance in fundamental motor skills according to the specific requirements of each context, in agreement with the theoretical basis for the study. Thus, we believe that enrollment in sports centers may positively or negatively influence the motor development of children. It was also possible to identify and quantitate the contribution of each fundamental motor skill in each context. Finally, it is inconsistent to attribute variations in the level of motor development only to genetic and maturation factors. On this basis, we conclude that the use of research models that take into consideration the characteristics of a person, the context and the time is more efficient for the study of motor development.

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