79 - BIOMECHANICAL ANALYSIS OF THE LONG JUMP OF CHILDREN IN DIFFERENT PHASES OF MOTOR DEVELOPMENT

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Introduction

During the child development regular increments happen in the size of the body and in the force, and for that, they are also expected consistent increments in the basic skills of running, jump and to throwing, once the childhood is considered the golden phase of the learning and of the motor development (Eckert, 1993). Gallahue and Ozmun (2003) affirm that the child's motor skills increase their complexity after the mielinization of the cerebellum and, because of that; the motor development can be noticed by the progressive improvement of the movement abilities. In agreement with Ferreira Neto (1995), the motor development follows a series of modifications in the movements, and that they differ from individual to individual with relationship to the period of the evolution, however not as the sequence which those modifications happen.

In that sense, Ferreira and Böhme (1998) consider the age group of 6 to approximately 12 years of age the period in that the child begins to use with great frequency fundamental patterns of acquired movements during the first childhood, perfecting them and applying them in the several athletic modalities.

The domain of the fundamental pattern skills - locomotors and manipulative movements - it is basic for the development of specialized movements. The locomotion constitutes a fundamental aspect in the learning of effective and efficient way of moving, and he/she learns how to walk, to run and to jump, among other movements. Those movements gradually improve, becoming sport skills, as the horizontal long jump, which is considered a complex motor pattern that requests the coordinated motor performance of all of the parts of the body (Gallahue & Ozmun, 2001).

The first of the authors above mentioned created a model of motor development that classifies the fundamental skills, according to a motor pattern, in three motor phases: initial, elementary and mature. Ferreira Neto (1995) still complements saying that a cognitive and physically normal child progresses from one phase to another, in a sequential way, influenced so much by maturation and experience. Also, environmental conditions including opportunities for practice, encouragement and instruction are crucial for the development of mature patterns of movements.

The model proposed by Gallahue allows Physical Education teachers and researchers to evaluate the phases of motor development that the child the child accomplishes day by day, in a qualitative way. However several researchers, including the author of this model, propose that these matrixes of child's development phases are good for qualitative analysis of the motor development, and that the process of evaluation is subjective.

Regarding these considerations the present study has as objective to do a biomechanical analysis of the children's long jump considering their phases of motor development according to the Gallahue's model.

Materials and Methods

This study is characterized as being both descriptive and exploratory, because it looks for the possibility of using biomechanics variables of the long jump. Participated in this research a group of 9 children, being 5 of the masculine gender, with ages between 5 and 12 years and, 8,5 ±1,7 year-old average. This age group was chosen for the study because it encompasses the late childhood, when occur an improvement and stabilization of physical capacities previously acquired (Gallahue & Ozmun, 2001).

The selection of the subjects was accomplished in random way from a group of children with age between 5 and 12 years and not possessing any type of apparent physical dysfunction. The sample was divided into three groups of three children in each, according to their classification of motor development. According to Gallahue and Ozmun (2001), the groups were labeled: initial phase (IP), elementary phase (EP) and mature phase (MP).

The place of the collection of data was the laboratory of Biomechanics of the University of the State of Santa Catarina - UDESC. A force platform was used (AMTI - OR6-5 Inc.) calibrated to a frequency of sampling of 900 Hz, a camera of the Peak Motus t System 60 Hz, and the matrix for qualitative analysis of the long jump proposed by Gallahue (Gallahue & Ozmun, 2001).

After the approval of the Committee of Ethics in Research of UDESC the study had the following procedures: 1) Permission of the schools principal; 2) agreement of the parents through the term of free and illustrious consent; 3) schedule of the collection of data; 4) collection of data; 5) classification of the children in the development phases; 6) data analysis in the Peak Motus System; 7) descriptive statistical analysis through Excel.

In the day of the data collection the children were led to the laboratory by the an assistant researcher. In the laboratory they went by a spontaneous practice of jumps to create a favorable atmosphere and adaptation with the instruments and with the researchers. After a demonstration of the task, they performed the movement of the long jump on the force platform. Soon after that, the relative points of the articulations were marked in the children's body, for acquisition of the relative angles and displacement of the limbs, as the illustration 1 sketches shows, and after that the children would accomplish 3 valid jumps.

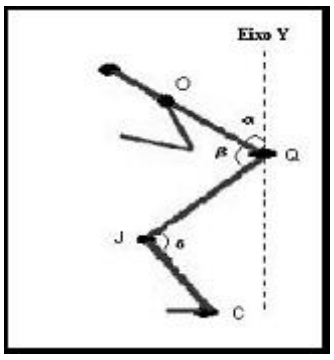


Illustration 1 - illustration of the space model used for the calculation of the angles.

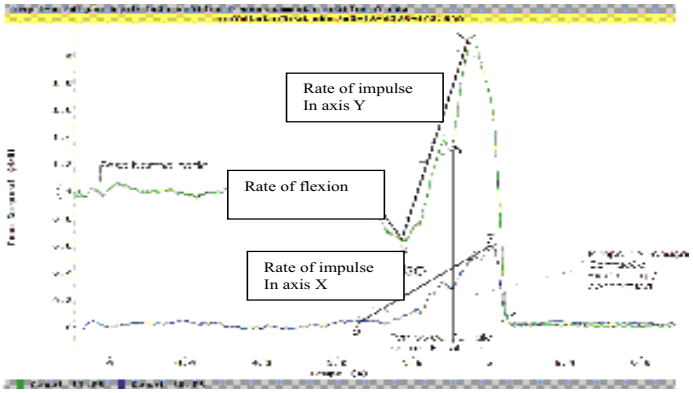


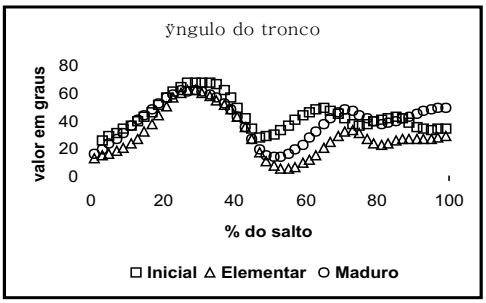
Illustration 2 - illustration of the curve of vertical force and reaction in the propulsion phase of the long jump.

The variables of the study can be divided in angular and kinetics. Angle of the log and of the knee during the execution of the jump (angular variables), Para the kinetic variables the vertical force was inferred as in the axis " Y " and subsequent long force as in the axis " X ", having the following kinetic variables being normalized by the children's corporal weight: peak of force in the axis " Y " (PIy), point 3 in the illustration above; peak of force in the axis " X " (PIx), point 7; It rates of the pulse in the axis " Y " (TxIy), of the point 2 to the 3; It rates of the pulse in the axis " X " (TxIx). Besides these the time of execution was varied and it was calculated (YOU) and the jumped distance (DS), being this normalized by the length of the inferior limb (mi).

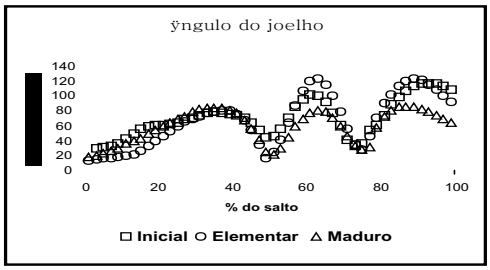
Results and Discussion

The results of this preliminary study with will be divided in two parts: angular variables and kinetics. In the angular variables, angles of the trunk and of the knee during the long jump will be presented. Two graphs that demonstrate the performance of the subject of the sample during the execution of the technique of the jump. The values of angles (in degrees) are referring to the beginning of the movement (leaving of the orthostatic position), until the beginning of the recovery of the balance in the landing.

The graph 1 presents the values of angle of the trunk, which were measured through the straight line that unites the articulation gleno-umeral to the lame-femoral, in relation to the vertical axis, in other words, the inclination angle of the trunk.



Graph 1 - curves of the angle of the trunk during the long jump.



Graph 2 - curves of the angle of the knee during the long jump.

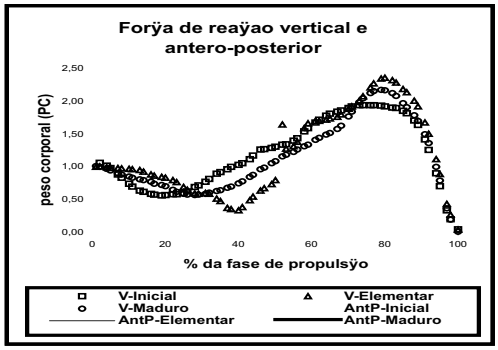
The behavior of the angle of the trunk can be characterized by a flexion wave (previous inclination) during the propulsion phase, finishing this phase with an extension wave. In the aerial phase a new flexion wave begins as preparation for the landing phase, being stabilized in the initial phase of the landing. It was not found similar studies in this situation of stationary long jump, for this reason the difficulty of comparison of this variable with other studies already published.

Making an analysis considering the child's development phase, in different moments of the jump, the angle of the trunk in the moment of the take-off had a smaller inclination in IP that for the others (27,36°), while EP 13,63 and the MPt was 16,63°. This difference can be associated to the children's instability in the IP group, knowing that they are not able to acquire a pattern of mature movement at that phase.

The curve of angle of the knee is characterized by three flexion waves, being the first one in the propulsion phase, the second one in the aerial phase and the third one in the landing phase. All the children of the three groups presented the same angular behavior, just differing in the values of time.

The curves of force of vertical and long reaction of the ground during the phase of propulsion of the long jump can be observed below in the graph. This graph contains the curves of forces normalized by each subject's corporal weight. Besides, for the best visualization of the curve of all the subjects in a same graph, it was interpolated all the curves for a sampling of 100 points.

For the visualization of the vertical and long reaction forces in the studied phases the graph 3 was structured. It presents values of force normalized by the corporal mass of the subjects of the study.



Graph 3: curves of the vertical and long reaction force of the ground during the phase of propulsion of the long jump.

In the kinetic variables it can be observed some specificities of each phase of motor development. The peak of vertical of reaction force of the ground in the propulsion phase measured for the largest value of force during this phase of the jump, was larger for the elementary phase group (2,36pc), decreasing for the mature phase group (2.18pc) and initial (1,95pc). According to values found in the literature, the results of the elementary phase group were similar with those reported by Ashby

and Heedaard (2002), with the value for this variable of 2,31pc, for adult men not skilled. The results of the mature phase group are similar with those of the study of Horita et al (1991) that found 2,16pc for beginning volleyball players. The low value of this variable found in that initial phase group can be explained by the fact that these children didn't have previous practice in executing this technique.

The peak of force of long reaction is characterized by the largest value in the curve of force of long reaction during the phase of propulsion of the jump. In this variable the results found had values below average when compared with the studies of the literature. The children in the mature phase group presented the largest value (0,76pc), decreasing for the elementary phase (0,69pc.) and initial phase (0,52pc). This may indicates that this variable can discriminates the level of maturation in the execution of the jump.

The variable impulse rate in the axis Y, that is calculated by the inclination of the curve (forces x time) during the flexion phase in the propulsion presented growing values for the three phases, being initial phase 3,98 N/s; elementary phase 5,09 N/s and mature phase of 9,81 N/s. In the variable impulse rate in the axis X, the values were 1,72 N/s for the initial phase, 2,30 N/s for the elementary phase and 3,72 N/s for the mature phase. Through these variables it can be inferred that by the time that the motor development is increasing, the values of pulse rate also increase, and these are directly related with the potency of the jump.

The time of execution of the jump decreased of the initial apprenticeship to the ripe, presenting the following values: 0,90 s for the initial phase, 0,72 s for the elementary phase and 0,63 s for the mature phase. With this result we can infer that the children of the mature group execute a jump with larger consistence and smaller preparation need.

Another important variable was the distance that the children jumped. According to the maturation process the child increase the distance of his/her jump, being of 2,12 times the size of the lower limb for the initial phase group, 2,45 times for the elementary phase group and of 2,51 times for the mature phase group. These results point out the difference among the patterns of motor development in each phase, since the mature phase group jumped a larger distance that the initial and elementary phase groups.

Final considerations

With these preliminary results we can conclude that the behavior of the angle of the trunk presents difference in some moments of the jump when we compare children of one phase with those of another one. These differences can be important for the identification of the level and the phase where a child stands regarding his/her motor development.

The angle of flexion of the knee showed different patterns for initial elementary and mature phase in the present study, during the aerial phase of the jump, however larger exploration of the propulsion phase is needed for this variable. More studies like this are needed for the understanding of the biomechanics characteristics of the long jump and their relations with motor development.

The variable peak of force in the axis Y in the propulsion phase demonstrated that the children at the initial phase reach maximum values of smaller force than the one of the children at the other phases. The peak of force in the axis X is of great importance for the characterization of the phases of motor development that the child meets.

The impulse rate in the axes X and Y are very important for the differentiation of the phases, or in other words, it could be assumed that as the larger this rate is, more developed is the child. These variables are related to the power, so they are of fundamental importance for the evaluation of the long long jump.

With this study it can be concluded that the analysis of biomechanics parameters can be used in the classification of the phases of children's motor development, and that quantitative values could help the qualitative analysis proposed by the model of Gallahue.

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BIOMECHANICAL ANALYSIS OF THE LONG JUMP OF CHILDREN IN DIFFERENT PHASES OF MOTOR DEVELOPMENT

Abstract: The children motor development is an area of study with few quantitative researches. More specifically, most of the studies in that area are of the descriptive type, with the objective of identifying patterns of motor skills executed by children. Considering that the jump is a complex task and present in the daily activities of the children, the objective of this study was to do a biomechanical analysis of the children's long jump considering their phases of motor development, according to the matrix proposed by Gallahue. For this exploratory descriptive study 9 children's long jump with age between 5 and 12 years of the municipal net of teaching of the city of Florianópolis SC were analyzed. After the approval of the Committee of Ethics in Research of UDESC the collections of data were accomplished at the Laboratory of Biomechanics of UDESC, being used a platform of force AMTI-OR6-5 to calibrated to a frequency of sampling of 900 Hz, a camera of the Peak Motus t System 60 Hz, and the matrix for qualitative analysis of the long jump proposed by Gallahue, that allows to classify the performer in three phases of motor development: initial, elementary and mature. It was analyzed the angular variables (angle of the log and knee), kinetic variables (peak of force, impulse rate), time of execution of the jump and reached distance. The results of the study demonstrate that some variables can be extremely important for the differentiation of the development phases. The angles of the trunk and knee can indicate differences among the development phases and could be used in a quantitative classification of these children. Among the kinetic variables the impulse rate can be mentioned in Y and X, that had larger values according to the evolution of the development phases. The distance reached in the mature phase was larger than those in the elementary and initial phases, could indicate relationship between the development phase and the performance of the jump. With this study it can be concluded that the analysis of biomechanics parameters can be used in the classification of the phases of children's motor development, and that quantitative values could help the qualitative analysis proposed by the model of Gallahue. **Keywords**: long jump, biomechanics, motor development, children.

ANALYSE BIOMÉCANIQUE DU SAUT HORIZONTAL D'ENFANTS DANS PHASES DIFFÉRENTES DE DÉVELOPPEMENT MOTEUR

Résumé: Le développement moteur des enfants est une champ d'étude avec peu de recherches quantitatives. Plus spécifiquement, la plupart des études dans cette champ est du type descriptif, avec l'objectif d'identifier des modèles de compétences moteur exécuté par les enfants. Vu que le saut est une tâche complexe et présente dans les activités journalières des enfants, l'objectif de cette étude était faire une analyse biomécanique du saut horizontal des enfants qui considère leurs phases de développement moteur, d'après la matrice proposée par Gallahue. Pour cette étude descriptive d'exploration le saut horizontal de 9 enfants avec âge entre 5 et 12 années du filet municipal d'apprendre de la ville de Florianópolis - SC a été analysé. Après l'approbation du Comité d'Éthique dans Recherche d'UDESC les collections de données ont été accomplies au Laboratoire de Biomécanique d'UDESC, être utilisé une plate-forme de force AMTI-OR6-5 à étalonné à une fréquence de goûter de 900 Hz, un appareil-photo du Motus t Système Maximum 60 Hz, et la matrice pour analyse qualitative du saut horizontal proposée par Gallahue qui autorise à classer l'enfant dans trois phases de développement moteur: paraphez, élémentaire et mûr. Les variables anguleuses ont été analysées à lui (angle de la grosse bûche et genou), variables cinétiques (sommet de force, taux de l'impulsion), temps d'exécution du saut et est arrivé à la distance. Les résultats de l'étude démontrent que quelques variables peuvent être extrêmement importantes pour la différenciation des phases du développement. Les angles du tronc et genou peuvent indiquer des différences parmi les phases du développement et pourraient être utilisés dans une classification quantitative de ces enfants. Parmi les variables cinétiques le taux de l'impulsion peut être mentionné dans Y et X qui avaient de plus grandes valeurs d'après l'évolution des phases du développement. La distance atteinte dans la phase mûre était plus grande que ce dans les phases élémentaires et initiales, pourrait indiquer le rapport entre la phase du développement et la performance du saut. Avec cette étude il peut être conclu que l'analyse de paramètres de la biomécanique peut être utilisée dans la classification des phases du développement moteur d'enfants, et ces valeurs quantitatives pourraient aider l'analyse qualitative proposée par le modèle de Gallahue.

Les mots-clé: saut horizontal, biomécnique, développement du moteur, enfants.

ANÁLISIS BIOMECÁNICA DEL SALTO HORIZONTAL DE NIÑOS EN LAS FASES DIFERENTES DE DESARROLLO DE MOTOR

Resumen: El desarrollo motor de niños es una área de estudio con pocas investigaciones cuantitativas. Más específicamente, la mayoría de los estudios en esa área es del tipo descriptivo, con el objetivo de identificar modelos de habilidades motoras ejecutadas por los niños. Considerando que el salto es una tarea compleja y presenta en las actividades diarias de los niños, el objetivo de este estudio era hacer un análisis biomecánica del salto horizontal de los niños que considera sus fases de desarrollo motor, según la matriz propuesta por Gallahue. Para este estudio descriptivo exploratorio el salto horizontal de 9 niños con la edad entre 5 y 12 años de la ciudad de Florianópolis - SC fue analizado. Después de la aprobación del Comité de Ética en la Investigación de UDESC las colecciones de datos estaban cumplidas en el Laboratorio de Biomecánica de UDESC, usándose una plataforma de fuerza AMTI-OR6-5 a calibrado a una frecuencia de probar de 900 Hz, una cámara del Motus t Sistema Máximo 60 Hz, y la matriz para el análisis cualitativo del salto horizontal propuesto por Gallahue que permite clasificar al actor en tres fases de desarrollo de motor: iniciales, elemental y maduro. Se analizó las variables angulares (el ángulo del leño y rodilla), las variables cinéticas (la cresta de fuerza, proporción de impulso), tiempo de ejecución del salto y alcanzó la distancia. Los resultados del estudio demuestran que algunas variables pueden ser sumamente importantes para la diferenciación de las fases de desarrollo. Los ángulos del tronco y rodilla pueden indicar las diferencias entre las fases de desarrollo y podrían usarse en una clasificación cuantitativa de estos niños. Entre las variables cinéticas la proporción de impulso puede mencionarse en Y y X que tenían los valores más grandes según la evolución de las fases de desarrollo. La distancia alcanzada en la fase madura era más grande que aquéllos en las fases elementales e iniciales, podría indicar la relación entre la fase de desarrollo y la actuación del salto. Con este estudio puede concluirse que el análisis de parámetros de la biomecánica puede usarse en la clasificación de las fases del desarrollo del motor de niños, y esos valores cuantitativos podrían ayudar el análisis cualitativo propuesto por el modelo de Gallahue.

Las palabras claves: salto horizontal, biomecánica, el desarrollo motor, niños.

ANÁLISE BIOMECÂNICA DO SALTO HORIZONTAL DE CRIANÇAS EM DIFERENTES ESTÁGIOS DE DESENVOLVIMENTO MOTOR

Resumo: O desenvolvimento motor infantil é uma área de estudo pouco explorada em pesquisas quantitativas. Mais especificamente, a maioria dos estudos nessa área é do tipo descritivo, com o objetivo de identificar padrões de habilidades motoras executadas por crianças. Pelo fato do salto ser uma tarefa motora complexa e presente no cotidiano das crianças, o objetivo deste estudo foi fazer uma análise biomecânica do salto horizontal de crianças considerando seu estágio de desenvolvimento motor, segundo a matriz proposta por Gallahue. Para este estudo descritivo exploratório foram analisados o salto horizontal de 9 crianças com idade entre 5 e 12 anos da rede municipal de ensino da cidade de Florianópolis SC. Após a aprovação do Comitê de Ética em Pesquisa da UDESC foram realizados as coletas de dados no Laboratório de Biomecânica da UDESC, utilizando-se uma plataforma de força extensométrica AMTI-OR6-5 nivelada ao solo à uma freqüência de amostragem de 900 Hz, uma câmera do Sistema Peak Motus a 60 Hz, e a matriz de análise qualitativa do salto horizontal de Gallahue, que permite classificar o executante em três estágios de desenvolvimento motor: inicial, elementar e maduro. Analisou-se as variáveis angulares (ângulo do tronco e joelho), variáveis cinéticas (pico de força, taxa de impulsão), tempo de execução do salto e distância alcançada. Os resultados do estudo demonstram que algumas variáveis podem ser extremamente importantes para a diferenciação dos estágios. Os ângulos do tronco e joelho podem indicar diferenças entre os estágios em alguns instantes, podendo auxiliar numa classificação quantitativa destas crianças. Entre as variáveis cinéticas pode ser citada a taxa de impulsão em Y e X, que tiveram valores maiores conforme a evolução dos estágios. A distância alcançada no estágio maduro foi maior que as no elementar e inicial, podendo assim indicar relação entre o estágio de desenvolvimento motor com o desempenho do salto. Com este estudo pode-se concluir que a análise de parâmetros biomecânicos pode ser utilizada na classificação do estágio de desenvolvimento motor de crianças, com valores quantitativos, podendo auxiliar a análise qualitativa proposta pelo modelo de Gallahue.