70 - EVALUATION OF STRUCTURAL CHANGES IN BALLERINA'S FEET FROM MANAUS

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INTRODUCTION

Dance is a physical activity that seeks several goals, such as: the playfulness, expression, rhythm, performance, and also the physical and psychological well-being of its practitioners. In the search for scientific explanations and understanding of the physical factors involved in dance practice, little has been discussed, or even experienced and diagnosed. It is known that the excessive practice of ballet, for example, when beginning in childhood, more specifically from 3 to 5 years old, usually generate several kinds of musculoskeletal changes. Typical injuries resulting from training "ballet" using pointe shoes are already documented in the medical literature: feet, ankles, knees and spine are constant targets of chronic and acute injuries (Caillet, 1989; Tuckman, Werner & Bayley, 1991).

The foot is a complex member of the locomotor system, and its main function is the ability to withstand, absorb and distribute the individual weight force, in many situations where it is functionally required (KNACKFUSS et al, 1993).

The foot must perform two essential functions: to give stability to the body while standing, and ensure its locomotion (MANFIO,1995).

Classical ballet has been demanding throughout its existence, performances requiring increasingly techniques of musculoskeletal structures from the ballerinas, these movements, which must be performed with the use of ballet shoes, which according to Sammarco and Miller (1982), are considered rigid and made with materials that don't bring stability nor protect the feet against the many external forces that they are exposed to.

The amount and intensity of these forces, explained by Wolf's Law, allow bone changes in the ballerina's body segment. According to this Law, densities, shapes and sizes of the bones of a certain human being are constituted according to the magnitude and direction of mechanical stresses acting on the bones, where the compression loads above a threshold of modeling, occurs the process of modeling the bone, with an increase in mass and bone density. (HALL, 2005).

Attributes such as cushioning, stability and direction have not been taken into consideration in the construction of pointe shoes, and this gap in the study of dance shoes enhances the possibility of changes or injuries stemming from the classical technique during the evolution of the ballerina, especially when this one is still in its infancy. The biomechanical measurement methods may yield a better understanding on the use of the locomotor system and overloads involved in the movements of classical dance and training in pointe shoes.

Evaluating the complexity of anatomical-functional structures that compose the foot, and its importance for carrying out activities related not only to dance but also the functional activities, it was formulated the goal of this research to analyze the anthropometric characteristics and longitudinal arch of ballerina's foot from the city of Manaus, realizing the structures of the most affected body part and most recurrent changes in the study sample.

MATERIALS AND METHODS

This research is characterized by being descriptive, according to Gay (1987), as it seeks to describe characteristics of ballerinas' foot, and even exploratory because it is a study looking for information not dealt by current literature, since we couldn't find studies related to deformities and changes that the practice of ballet for a long time can generate in the human foot.

The study population are ballerinas who practice ballet since childhood. The sample consisted of 10 dancers aged between 18 and 25 years old. We used as an inclusion criteria: being female, over 18 years old, with at least 5 years of experience in classical ballet and who used the pointe shoes for at least 4 years.

For measurement of anthropometric characteristics of the feet, we used the method of direct measurement, which consisted in the foot measurement using two calipers (one of 300 mm and another of 150 mm).

We also used the method of indirect measurement by analyzing images acquired through the footprint of a pedigraph. The prints were designed for the classification of plantar longitudinal arch (MLA) of each subject's foot. This rating was determined based on angle studies of Printing Plant and Staheli Index (FORRIOL & PASCUAL, 1990).

The feet were classified according to the types studied by Amadio and Viladot apud Duarte (1996), divided into three kinds: Egyptian, Greek and square. And some of them were characterized according to the most frequent pathologies.

The feet's anthropometric variables studied were: Foot Length (FL): distance between the most prominent point in the calcaneal tuberosity region, to the more prominent point in the anterior tuberosity of distal phalanx of the great toe, following the guidance of the foot's axis (heel - toe II). Heel - Finger Length I (HFI): distance between the most prominent point in the calcaneal tuberosity region to the more prominent point in the anterior tuberosity of distal phalanx of the finger I. Heel - Toe Length II (HTII): distance between the most prominent point in the calcaneal tuberosity region to the more prominent point in the anterior tuberosity of distal phalanx of the finger II. Heel - Toe Length V (HTV): distance between the most prominent point in the calcaneal tuberosity region to the more prominent point in the anterior tuberosity of distal phalanx of finger V. Foot width or Metatarsal Head width (FW): distance measured from the more prominent point in the medial tuberosity of metatarsal head [I], to the most prominent point of the metatarsal head lateral tuberosity [V]. Heel width (HW): measured distance between the most salient points of the lateral and medial heel.

We conducted a previous contact with the dance groups to perform the sample selection, where they were exposed to general information, the study objective and their contribution to the study population. After this phase, there were scheduled times for the collection, which was performed at UEA's Laboratory of Physical Fitness and dance schools.

The dance students were advised to use proper clothing (barefoot) and was given and explained the Term of Free Consent to each selected subject, which included all the procedures to be performed in the experiment, so that the person could know all the relevant information. Each anthropometric variable was tabulated using the Excel, calculating the values of mean, standard deviation, coefficient of variation, minimum and maximum.

RESULTS AND DISCUSSION

The results are expressed in tables containing descriptive statistics, and a table with general information about the subjects and the other containing the values of the dominant and nondominant members separately for analysis.

Table I: Anthropometric characteristics and plantar longitudinal arch from ballerina's feet.

Var.	$\bar{x}$	S	CV%	max.	min.
FL	24,13	0,91	3,76	25,60	22,90
HFI	24,12	0,95	3,93	25,60	22,90
HTII	23,54	0,97	4,14	25,30	22,10
HTV	20,16	0,76	3,77	21,40	18,50
FW	9,61	0,33	3,47	10,10	9,10
HW	5,76	0,35	6,03	6,30	5,20
CFP	49,68	3,20	6,44	54,00	42,00
SI	0,36	0,11	31,14	0,52	0,20

Legend: Foot length (FL), heel-toe length I (HTI), heel-toe length II (HTII), heel - finger length V (HFV), foot width or the metatarsal heads (FW), heel width (HW), angle-Clarke footprint (CFP), Staheli Index (SI).

After analysis and comparison of results, it was realized that the variables foot length, heel-toe length I and metatarsal heads width of the subjects of this study compared to the Manfio study (2001), with the Brazilian population showed the female similar average.

When comparing the measurements of the foot width and the metatarsal heads with the heel width, it was possible to observe that it is a general characteristic of the studied sample to show the anterior foot higher than the rear, even with the corroborating Manfio study (2001), where it was proved that the Brazilian population has a previous conformation foot higher when compared to Americans and Europeans. This could explain the incidence of hallux valgus between the subjects studied, since the pointe shoes are not manufactured with anthropometric profiles suitable for the Brazilian feet. According to Sammarco and Miller (1982), it can exert greater loads and external forces in the forefoot region, and force the fingers, especially the hallux metatarsophalangeal joint in a lateral deviation, to be with a large percentage of body weight on it.

Other changes occur in the bellerina's forefoot due to the footwear and external forces exerted on the foot. In his anthropometric study on the ballerina's feet practicing ballet in pointe shoes, Picon (2007) showed the presence of calluses (keratinization of epidermal tissue) in 60% of the sample, especially in the forefoot region (especially the 1st and 5th metatarsal) and fingers, which is believed to be in demand of the tips.

Pointe shoes are uncomfortable to the fingers that must fit in the vamp, the same occurs with the forefoot region, which suffers a high compression to achieve full flexion, as shown by the Tuckman, Werner and Bayley apud Picon study (2007).

The plantar longitudinal arch of the subjects were above the normal range when compared to literature Forriol and Pascual (1990), characterizing the ballerina's feet from the research having a high plantar arch, showing that changes can occur in the plantar arch, since this is total dependent on the stimuli to which the feet are subjected (VOLPON apud RODRIGUES et al, 2001).

The dancers of this study began practicing ballet in childhood, which is an important fact for understanding the change of the longitudinal arch, such amendment could not be found if they initiate their practices already in adolescence, which corroborates with the studies of Morioka et al (2005), stating that the MLA would already be formed from 6 to 9 years old. And even resemble the one found by Donatelli and Wolf (1990) who claim that the MLA is forming between 6 and 8 years old.

The increase of this longitudinal arch may lead to some implications on foot function. To Guedes et al (2005) this change can often be brought about by a muscle spasm, which would have direct correlation with the amplitude of foot motion, bringing to this segment the loss of functions.

When observing the averages, separating them according to the dominant member of the research subjects (Table II), new information emerged.

Table II: Anthropometric characteristics and plantar longitudinal arch of the dominant and nondominant ballerina's feet.

Var.	membro	$\bar{x}$	S	CV%	max.	min.
FL	dom	24,18	0,93	3,85	25,60	23,00
	Ndom	24,08	0,92	3,82	25,50	22,90
HTI	dom	24,18	0,93	3,85	25,60	23,00
	Ndom	24,06	1,00	4,16	25,50	22,90
HTII	dom	23,55	0,89	3,78	25,10	22,20
	Ndom	23,52	1,09	4,63	25,30	22,10
HFV	dom	20,32	0,64	3,15	21,20	19,20
	Ndom	19,99	0,86	4,30	21,40	18,50
FW	dom	9,56	0,38	3,97	10,10	9,10
	Ndom	9,66	0,27	2,80	10,10	9,30
HW	dom	5,77	0,36	6,24	6,30	5,20
	Ndom	5,74	0,35	6,10	6,20	5,30
CFP	dom	32,30	3,06	9,47	54,00	44,00
	Ndom	49,60	3,37	6,79	54,00	42,00
SI	dom	0,35	0,11	31,34	0,52	0,20
	Ndom	0,37	0,11	30,05	0,52	0,20

Legend: dom (dominant member) Ndom (nondominant member). Foot length (FL), heel-toe length I (HTI), heel-toe length II (HTII), heel - finger length V (HFV), foot width or the metatarsal heads (FW), heel width (HW) angle-Clarke footprint (CFP), Staheli Index (SI).

Comparing the anthropometric characteristics and longitudinal arch between the dominant and non-dominant research subjects, we observed that the average anthropometric characteristics except FW, showed superior results on the

dominant side, but such differences do not become relevant enough to conclude that changes occur in greater proportion in dominant members .

Measurements of the longitudinal arch, both CFP as SI, were obtained from higher average on the non-dominant hand, this difference can be explained by the fact that during the movement the dominant side is chosen to perform the movement, while the non-dominant side is used as a base for the movements they need to stand in one foot, so the ballerina's foot base and support (non-dominant) is responsible for withstanding and balancing the weight of her body in full plantar flexion according to Picon (2007) .

The variable SI, by having a high coefficient of variation above 10%, eventually becomes a method of classification of the longitudinal arch unspecific low reliability in this study for this variable.

Regarding the classification of the forefoot was observed that the study sample had the kind of Egyptian forefoot, corroborating with Manfio dissertation (1995), where there was a high incidence of Egyptian foot for both genders.

CONCLUSION

Through this research, we observed that the prolonged practice of classical dance, can cause changes in foot anthropometry of its practitioners on the external forces that such a body segment is exposed in this technique. In addition to the own national characteristics of the foot are factors that influence the increase of such modifications.

It's important to point out that these changes become more present and it's more frequently when the classical dance is performed since childhood, a phase in which the structures are still musculoskeletal modeling and fitness activities and both internal and external forces they are exerted on .

The study also shows the importance of enabling the encouragement of new research in order to understand the causes of changes and possible solutions for reducing these.

REFERENCES

AMADIO, A.C.; DUARTE, M. (Eds), **Fundamentos biomecânicos para a análise do movimento**. São Paulo, EEFEUSP, 1996.

CAILLET, R. **Pé e tornozelo: síndromes dolorosos.** São Paulo: Manole, 1989.

FORRIOL, F. & PASCUAL, J.: **Footprint analysis between three and seven- teen years of age.** Foot Ankle Int 11: 101-104, 1990.

GAY, L.R. **Education Research: competencies for and aplication**. 3ª ed London: Merril Publishing Company, p.101 - 119, 1987.

GUEDES, Fernanda Zago; RITTER, Alexandre Luis; SOUZA, Jorge Luiz. **Correlação entre a altura do arco plantar e a amplitude de movimento do pé: inversão e eversão.** Escola de Educação Física – UFRGS – Porto Alegre – RS; 2 UNILASALLE – Canoas – RS, 2005.

HALL, Susan J. **Biomecânica Básica**. 4.ed. Rio de Janeiro: Guanabara Koogan S.A, 2005.

KNACKFUSS, I. G.; ROSENBAUM, S. e GOMES, E. S. **Análise Biomecânica do pé: comportamento das pressões na região plantar.** V Congresso Brasileiro de Biomecânica - ANAIS. Imprensa Universitária: Santa Maria, 1993.

MANFIO, E. F. **Estudo de parâmetros antropométricos do pé**.Tese de Doutorado: Santa Maria, 2001.

MANFIO, E. F. **Estudo de parâmetros antropométricos e biomecânicos do pé humano para a fabricação de calçados segundo critérios de conforto, saúde e segurança.** Dissertação de Mestrado: Santa Maria, 1995.

MORIOKA, Eliana Harumi; ONODERA, Andrea Naomi; SACCO, Isabel de Camargo Neves; SÁ, Márcia Regina de; AMADIO, Alberto Carlos. **Avaliação do arco longitudinal medial através da impressão plantar em crianças de 3 a 10 anos.** Laboratório de Biomecânica do Movimento e Postura -Depto. Fisioterapia, Fonoaudiologia e Terapia Ocupacional FM USP, São Paulo – SP.

MOTA, C. B. **Concepção e implementação de um sistema de medição do pé humano baseado no processamento digital de imagens.** Tese de Doutorado. Santa Maria, RS, 1999.

PICON, Andreja Paley; FRANCHI, Silmara Spinardi . **Análise antropométrica dos pés de praticantes de ballet clássico que utilizam sapatilhas de ponta.** Revista Uniara,São Paulo, n.20, 2007.

RODRIGUEZ, M.D; SACCO, I.C.N; SÁ, M.R; SERRÃO, J.C; AMADIO, A.C. **Característica antropométrica e somato-sensoriais do pé humano: Um estudo com carteiros paulistas.** In: SIMPÓSIO BRASILEIRO DE BIOMECÂNICA DO CALÇADO, 1, 2001. Anais., Gramado, 2001, p.59-64.

SAMMARCO, G.J.; MILLER, E.H. **Forefoot conditions in dancers: part I. Foot and Ankle, Baltimore,** v.3, p.85-92, 1982.

TUCKMAN, A.S.; WERNER, F.W.; BAYLEY, J.C. **Analysis of forefoot on pointe in ballet dancers.** Footand Ankle, Baltimore, v.12, n.3, p.144-8, 1991.

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EVALUATION OF STRUCTURAL CHANGES IN BALLERINA'S FEET FROM MANAUS

ABSTRACT

The objective of this research was to examine the anthropometric characteristics and the longitudinal arch on the feet of ballerinas in the city of Manaus, realizing the most affected and most recurrent changes on the structures of this body part. The research sample consisted of 10 female ballerinas aged between 18 and 25 years old. To collect the data we used calipers and pedigraph. It was possible to see that the variables length of the foot, heel-toe length I and width of the metatarsal heads of the subjects of this study population, when compared to Brazilian women showed mean similar changes of the plantar arch, and presence of pathologies such as hallux valgus were also observed. Through this research, it was observed that the prolonged practice of classical dance, can cause changes in foot anthropometry of its practitioners due to external forces such as body segment is exposed in this technique. These changes become more present and more frequently when the classical dance is performed since childhood, a phase in which the musculoskeletal structures are still modeling and fitness activities and forces both internal and external are exercised over them.

KEY-WORDS: biomechanics, anthropometry, dancers.

CARACTERISTIQUES DES PIEDS DES DANSEURS DANS LA VILLE DE MANAUS

RÉSUMÉ

L'objectif de cette recherche était d'examiner les caractéristiques anthropométriques et la voûte plantaire longitudinale des pieds des danseurs dans la ville de Manaus, la réalisation des structures de la partie du corps les plus touchées et les changements les plus récurrents. L'échantillon était composé de 10 danseuses âgées entre 18 et 25. Pour recueillir les données, nous avons utilisé les étrier et les pedigraph. Il était possible de voir que la longueur variables du pied, longueur talon-pointe I et la largeur des têtes métatarsiennes des sujets de cette étude de population par rapport aux femmes brésiliennes ont montré implique des transformations similaires de la voûte plantaire, et la présence de pathologies telles que l'hallux valgus ont également été observées. Grâce à la présente étude, nous avons observé que la pratique prolongée de la danse classique, peut causer des changements dans l'anthropométrie pied de ses praticiens sur les forces externes qui un tel segment du corps est exposé dans cette technique. Ces modifications sont plus présents et plus fréquemment lorsque la danse classique est réalisée depuis l'enfance, une phase dans laquelle les structures sont encore la modélisation musculo-squelettiques et les activités de conditionnement physique et les forces internes et externes exercées sur eux.

MOTS-CLÉS: biomécanique, anthropométrie, danseurs.

EVALUACIÓN DE LOS CAMBIOS ESTRUCTURALES EN LOS PIES DE LAS BAILARINES DE LA CIUDAD DEL MANAUS

RESUMEN

El objetivo de esta investigación era examinar las características antropométricas y el arco longitudinal de los pies de los bailarines en la ciudad de Manaos, la realización de las estructuras de la parte del cuerpo más afectadas y los cambios más recurrentes. La muestra estuvo constituida por 10 bailarinas con edades comprendidas entre 18 y 25. Para recoger los datos que utiliza pinzas y pedigraph. Fue posible ver que la longitud variables de los pies, la longitud del talón-dedo del pie I y ancho de la cabeza de los metatarsos de los sujetos de esta población de estudio en comparación con las mujeres brasileñas mostraron cambios medios similares del arco plantar, y la presencia de patologías tales como hallux valgus también fueron observadas. A través del presente estudio, se observó que la práctica prolongada de la danza clásica, puede causar cambios en la antropometría del pie de sus practicantes en las fuerzas externas que ese segmento del cuerpo se expone en esta técnica. Estos cambios se hacen más presentes y con más frecuencia cuando la danza clásica se realiza desde la infancia, una etapa en la que las estructuras siguen siendo modelos musculoesqueléticos y actividades de fitness y de las fuerzas internas y externas ejercidas sobre ellos.

PALABRAS CLAVE: biomecánica, antropometría, bailarines, los pies.

AVALIAÇÃO DE ALTERAÇÕES NAS ESTRUTURAS DOS PÉS DE BAILARINAS DA CIDADE DE MANAUS

RESUMO

O objetivo desta pesquisa foi analisar as características antropométricas e o arco longitudinal dos pés de bailarinas da cidade de Manaus, percebendo as estruturas mais afetadas deste segmento corporal e alterações mais recorrentes. A amostra foi composta por 10 bailarinas do gênero feminino com idade entre 18 e 25 anos. Para a coleta dos dados utilizou-se paquímetro e pedígrafo. Foi possível perceber que as variáveis comprimento do pé, comprimento calcanhar-dedo I e largura da cabeça dos metatarsos dos sujeitos do presente estudo quando comparados com a população brasileira feminina apresentaram as médias semelhantes, alterações do arco plantar, e presença de patologias como hálux valgo também foram observadas. Mediante a apresente pesquisa, observou-se que a prática prolongada da dança clássica, pode acarretar alterações das características antropométricas dos pés de seus praticantes diante das forças externas a que tal segmento corporal está exposto nesta técnica. Estas alterações tornam-se mais presentes e com maior frequência quando a dança clássica é realizada desde a infância, fase em que as estruturas osteomioarticulares ainda encontram-se em modelagem e adequação às atividades e forças tanto internas quanto externas sobre elas exercidas.

PALAVRAS-CHAVE: biomecânica, antropometria, bailarinas.