34th Annual International Conference of the IEEE EMBS
San Diego, California USA, 28 August - 1 September, 2012

Evaluation of Pelvis Slope and Flattening on Children Gymnasts by Biophotogrammetry Technique

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Abstract - **This work proposes to detect possible affections or abnormalities in pelvic belt region in a group of rhythmic gymnastics due to the need for studies in the field of biomechanics and structural evaluation of human being. The methodology for this study used a tool called Biophotogrammetry. This technique has analyzed, through scanned images, the structural pelvic girdle bone profile of 64 practitioners of rhythmic gymnastics. The results of this study have presented weighted averages of 45.07±9.78° between the right pelvic slope (RPS) and left pelvic slope (LPS) and 91.74±2.50° for flattening of the pelvis (FP). Therefore, it is concluded that the Biophotogrammetry technique provides data related to the gold standard radiography test, used as reference for the pelvic girdle measurements.**

Keywords— **photogrammetry, posture, children, pelvis slope, flattening**

I. Introduction

The inclusion of new preventative methods for healthcare can represent a decrease in curative expenses of various avoidable diseases in clinical environment. To this end, innovative methods presenting low cost and easy applicability for the detection of these affections are being recently tested [1]. In the case of this study, specifically, a new technological resource is developed. It is able to ascertain, without incidence of radiation or any other harmful application, possible problems in spine and pelvic girdle. Analyzing the structure and proper body functioning, in order to promote and maintain a posture adjusted to the individual, thus, generating quality execution of movements [2] [3] [4].

Several movements of the spine and pelvic girdle are required in the practice of rhythmic gymnastics (RG). It can represent risks for bone-myo-articular system of these structures. Therefore, many analytical techniques of prevention and correction are necessary in training activities [4].

The use of radiography for evaluation of pelvic rotation is the most common method. It is also classified as gold standard. However, this technique requires several different protocols to separately analyze each region of the hip. The relationship between the horizontal distance from the pubic symphysis and sacrococcygeal, and both the diameters of the obturator foramen, located at the head of the femur are taken [5] for the measurement of hip rotation.

These tests reveal various abnormalities which, if discovered in time, can be corrected or softened. A very common type of occurrence among athletes is anterior pelvic tilt and extensibility of the hamstring muscle group [6].

The Biophotogrammetry, as a process of image analysis, innovates by making image processing simple. This process is currently done by robust integrated computer systems. In these systems, the collection is carried out in laboratories. Their infrastructure and operational costs make it inaccessible to most of health professionals and patients. Thus, the Biophotogrammetry, increases the quality of quantitative information to the context of the clinical monitoring. It can be used for motor syndromes or even functional monitoring of children's postural development.

Besides, unlike other closed kinematics systems, dedicated to specific analysis of a movement (joint angles, posture, march) Biophotogrammetry allows free measurements on any image. In other words, since valid images are acquired, any kind of movement can be measured by this process. It is also different from most commonly used systems in motion kinematics analysis for three main reasons: (1) the simplification of procedures for data collection, which have been adapted for use of equipment and process elements (markers), easy to handle for health professionals; (2) the transportability of infrastructure elements – such as camera, tripod, markers, computer – allowing the image acquisition outside of laboratories, in schools, private homes and clinics; (3) the reduction of the final cost due to all equipment and elements used in the method are commercially available and easily accessed.

The application of Biophotogrammetry technique seeks to develop new tools for detection and prevention of occurrences in skeletal structures of practitioners and professionals in rhythmic gymnastics. The methodology used in this technique involves recording digital images with anatomical landmarks previously marked then the images are inserted into a specific interface to be analyzed [7].

The main goal of this study was to develop (through a cross-sectional descriptive analysis) the determination of reference points of an evaluation routine of posture through Biophotogrammetry and observe the prevalence of affections in the pelvic girdle, without using harmful methods as radiography.

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II. METHODOLOGY

This work used the descriptive observational method with 64 practitioners of RG between 5 and 11 years old, in a sports initiation centre in the city of Curitiba, Brazil. The criteria used for inclusion of practitioners were: to be enrolled in the RG program; attending assiduously training; to be between 5 and 11 years old and present Free Consent Term (FCT).

Marking anatomical points with stickers of 13 *mm* in diameter was needed for execution of postural evaluation technique. These points were photographed by a Sony Cyber-Shot, 5.1 Mega Pixels digital camera, supported to a Silstar DF-30 tripod. The distance of positioning was standardized for all photos, the measurement of the distance between the machine and subject was measured by an 8 *m* precision metallic measuring tape with stand lock. Finally, the obtained photos were stored on a desktop computer and a backup disk.

The biophotogrammetric evaluation data were treated in CorelDraw ® software version 12, using the sizing tools for obtaining absolute angles called as: Left Pelvic Slope (LPS), Right Pelvic Slope (RPS) and Flattening of the Pelvis (FP). Anatomical predetermined points for use as biomechanical references in angular analysis were: the greater Trochanter of femur and the anterior superior iliac spine, as shown on the figures 1 and 2.

In the Biophotogrammetry process, calibration is a procedure carried out in two ways: (1) in angular measurements, the image calibration is done through alignment of the image coordinate system (defined by the orientation of the camera's CCD at the time of Image Acquisition) with the graphical interface coordinate system where images are processed; (2) linear calibration includes the measurement of an element of known dimensions in the image as referrer in estimative of other ones.

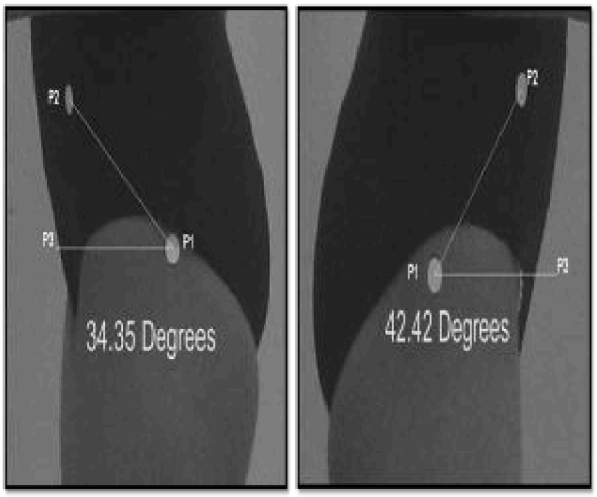

Fig 1. Anatomical points RPS and LPS example.

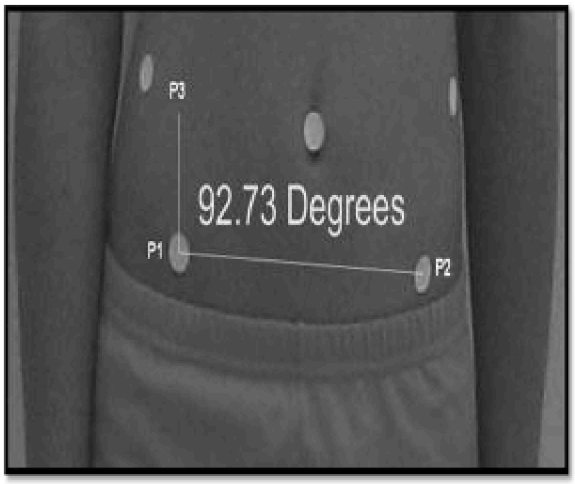

Fig 2. Anatomical points FP example.

Checking the distribution pattern of the data obtained in the evaluations was generated from the Kolmogorov–Smirnov method. The results showed a normal distribution allowing a parametric inferential statistical approach for the comparative analysis of two probabilistic distributions. This test is more susceptible when approached to median values and it has not presented modifications in the parameter estimation [13].

Software Statistical Package for the Social Sciences (SPSS) was used for the statistical processing of data obtained in the biophotogrammetric measurement considering the significance level $p < 0.05$. The data processing through average, weighted average, standard deviation and percentiles have been suggested in this program.

III. RESULTS

The average age of 64 participants evaluated was 7.66 ± 1.58 *years*. Average values obtained on body weight and stature of the gymnasts was 28.47 ± 7.85 *kg* and 128 ± 0.11 *cm*, respectively. The value of 45.07° ± 9.78 has been obtained through weighted average for the comparison of the value for the RPS and LPS. Through the acquisition of these data, it has been possible to establish the higher and lower average values within the sample that were 36.56° and 34.01° (M-DP) in right view and 56.33° and 53.41° (M+DP) in left view. Regarding to percentiles, it has been found that the female gymnasts who had angulations of 39.28° in right side view e 37.96° in left side view have been placed in percentile 25. However, female gymnasts that presented the angle in this point close to 46.88° and 44.72° have been placed in percentile 50. Finally, in percentile 75 have been placed those who presented values between 53.33° and 50.25° consecutively in right and left views as shown in tables 1 and 2.

TABLE I
DESCRIPTIVE STATISTICS OF THE RIGHT SLOPE ANGLE OF PELVIS [DEGREES].

N	Average	Standard deviation	M – DP	M + DP	Percentiles		
					25	50	75
64	46.44	9.88	36.56	56.33	39.28	46.88	53.33

TABLE II
DESCRIPTIVE STATISTICS OF THE LEFT SLOPE ANGLE OF PELVIS [DEGREES].

N	Average	Standard deviation	M - DP	M + DP	Percentiles		
					25	50	75
64	43.71	9.69	34.01	53.41	37.96	44.72	50.25

Regarding average values obtained for flattening angle of pelvis (FP), an average angulation of 91.74° ± 2.50 was observed. Compared to the reference value, the acquired data in this research surpass it in less than one degree the proposed right angle. Regarding to percentiles, only those female gymnasts placed on percentile 75 presented greater discrepancies in reference values, and these were above 93.64° as shown in table 3.

TABLE III
DESCRIPTIVE STATISTICS OF THE FLATTENING ANGLE OF PELVIS [DEGREES].

N	Average	Standard deviation	M – DP	M + DP	Percentiles		
					25	50	75
64	91.74	2.50	89.24	94.24	89.85	91.62	93.64

IV. DISCUSSION

The current literature points two determining factors for pelvic girdle misalignment. The first is related to pelvic rotation and the second refers to the pelvic misalignment, both affections are related to muscle weakness [5]. The anterior rotation is characterized by the decrease of its angle in relation to the thigh, creating lumbar lordosis posture. In this position, according to the authors, the contraction of hip flexors muscles and the weakness of abdominal muscles are observed [5]. Regarding posterior pelvic slope, the hip joints extend themselves and the lumbar region is flat, one of the determining factors for this to happen is the weakening of the flexor muscles [8]. In the case of this study, previous pelvic girdle presented higher prevalence, with the average value of 45.07° ± 9.78, according to the reference values obtained with x-ray (gold-standard). In studies of Gonzalez *et al.* [9], standard values for this type of posture vary in a range of up to 30° for women and 25° for men. Concurring with this information, Muyor, Alacid and López-Miñarro [6] demonstrated in their experiments that the evaluated cyclists presented angulations of 71.85 ± 5.89° anterior pelvic girdle to the group classified as athletes. It demonstrates that the high loads in training (associated with postures adopted in the execution of the movements) lead to the increase of the imbalance of bone in the pelvic region.

In their research with gymnasts, Silva *et al.* [8] revealed that the anteversion of pelvis occurred in 84.2% of the athletes. The authors also showed that the most relevant factor was an increase in tension of hip flexors and weakness of abdominal muscles and gluteus. In the same study, muscle length tests proposed by Kendall *et al.* [3] were executed and demonstrated shortening in all related muscles.

In the case of pelvic unbalance, it was observed in several studies that, besides bone affections, this angle can identify some kind of shortening of lower limbs or antalgic postures originated from imbalances in the region of the hip, knees or feet [10].

This study showed the average 91.74 ± 2.50° in FP angle, agreeing with the results presented in the study of Ricieri, Costa and Rosário Filho [7]. In that research, it was detected the influence of asthma in body posture of children from 8 to 14 years. It was obtained the value of 91.38 ± 3.04° for the FP angle, confirming the heterogeneity of application of Biophotogrammetry. In addition to this study, an analysis of flexibility of Tibial Ischia was proposed by Perin *et al.* [11], the study demonstrated the technical validation through standard sit and reach test (SRT).

Concurring with these results, Simas and Melo [12] observed the incidence of abnormalities in FP angle in their work with practitioners of classical ballet, according to them, as a result of the training routine imposed to the dancers. The abduction movements and external rotations are very present in this practice; however, the persistent use of dominant segment can generate permanent unevenness in evaluated subjects. Therefore, the viability of analysis through Biophotogrammetry it is observed because their results are similar to the values obtained with the gold standard technique. In addition, the ease of application of this method in any environment is pointed out and its low cost is highlighted.

V. CONCLUSION

The data obtained in this research showed that the angles used to detect the presence of hip rotation and misalignment provided higher mean values than observed in other studies. This demonstrates how RG practitioners must be specifically monitored because during this research it was noticed the need for monitoring and supervising the evolution of practitioners through more accurate techniques.

Through the results obtained in this study, it is noted that the accuracy of the data are real tools for the detection of deviations or possible structural problems present in the individual. It does not present risks of radiation and demonstrate viability in its application.

Despite the Biophotogrammetry technique is new in the context of postural evaluation, researches related to the technical improvement and validation of homogeneous and heterogeneous groups are suggested.

The research has presented some restrictions, because it hasn´t been simultaneously compared to application of standards tests as radiography. Therefore, it should be noted the need of application of Biophotogrammetry test along with gold-standard test.

ACKNOWLEDGEMENTS

Authors thank to Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES), National Counsel of Technological and Scientific Development (CNPq), Fundação Araucária (FA) and Federal University of Technology – Paraná (UTFPR) for financial support.

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