"BIRTH IS LIKE A MARATHON" REVISITING CHILDBIRTH BY USING SPORT BIOMECHANICS APPROACHES

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Childbirth is a sport according to women who have experienced it. The physiological demand of this specific sport activity is indeed close to what is measured in many other sport activities. From a biomechanical point of view, it also seems possible to consider childbirth as a sport activity that can be optimized. After explaining how childbirth is similar to a sport activity, we will present the methodology and preliminary results of an innovative approach in delivery biomechanics. A biomechanical analysis of childbirth as performed in many sport activities seems to be appropriate in order to optimize some parameters of this sport activity so special in a lifetime.

KEY WORDS: childbirth, delivery, biomechanics, optimization.

INTRODUCTION: The expression "Giving birth is like running a marathon" is regularly used by women who have just given birth and midwifes or physicians when they try to explain to a future parturient, what giving birth looks like. It is indeed appropriate in terms of physiological and muscular demands to compare childbirth with a sporting event like marathon.
If we take into consideration the physiological demand, childbirth is quite as demanding as many sport activities. Regarding cardiac output, it increases by nearly 45% during pregnancy (Hunter & Robson, 1992) and can still increase by 50% during labour (Ouzounian & Elkayam, 2012). These findings are comparable to what can be observed during a marathon with an increase of nearly 68% during 210 minutes on average (Billat et al., 2012).
From the energy cost point of view, there are no precise data on the amount of energy expended during the expulsion. Regarding the oxygen consumption, it's of 4.28 ml/kg/min during labour (Eliasson, Phillips, Stajduhar, Carome, & Cowsar, 1992) which is closed to maximal consumption found for instance during a soccer game (Krustrup, Mohr, Ellingsgaard, & Bangsbo, 2005).
Childbirth solicits many muscle groups, even more during the second stage of labour which ends by birth. The smooth uterus muscle contraction that joins the efforts made during the expulsion phase may be akin to a repetition of Valsalva manoeuvres. These efforts also solicit striated muscles such as the diaphragm and rectus abdominal. These muscle contractions may be responsible for a force of at least 120 Newton according to some estimates (Ashton-Miller & DeLancey,2009).
If we continue the parallel between delivery and sport, it has been shown that to train had a positive effect on the performance and help to prevent pathologies. Authors have thus shown that physical activity during pregnancy and therefore a workouts increases the efficiency of delivery and was even associated with a decreased risk of caesarean section (Domenjoz, Kayser, & Boulvain, 2014). Moreover, one can even consider a training effect since a woman who has given birth will statistically give birth better in a future pregnancy (Fussing-Clausen et al., 2014).
From a physiological point of view, to give birth is then comparable to a sport activity. Now, what about the technical analysis of the gesture? How can we improve the performance of the "athletes" during this sport activity? What are the key parameters of performance? And what biomechanics and movement analysis can bring to this special sport activity?
For this specific sport activity, the game is over when the mother succeeds in bringing out an object (the foetus) from a cage (the uterus) by bypassing several obstacles (the cervix, the pelvic floor, the pelvis) and by using to push the object the uterine contractions associated to pushing efforts just before birth.
In its last stage, this sport activity is mainly isometric. Therefore, here, it seems that the posture of the mother rather than a movement is to be analysed and optimized.

Although delivery is performed since time immemorial, many questions remain about the mechanisms involved during delivery especially when birth position is considered. During delivery, continuous mechanical and biological interactions occur between the different players aforementioned and culminate at birth.
Among the questions that remain to be treated, figure the optimal position to give birth. Currently, only the rough position of the trunk is considered when mentioning delivery positions even though the posture taken by the pelvic and the vertebra column relatively to the foetus have been shown to be important to optimize delivery. Thus, in 1952, Rosa (Hainaut & Rosa, 1952) described the possible optimization of the woman's position to ease the course of labour based on Gold's work (Gold, 1950), who described "the Pelvic drive" that is "the best route to follow for deliver".
The present project named OPTIMAC (OPTImisation des Mécanismes de L'Accouchement namely, in English, Optimization of Delivery Mechanisms) proposed to follow this idea by better characterizing and investigating the "optimal" posture to give birth. From a biomechanical point of view, the "optimal posture" should reduce barriers to the advance of the foetus and especially favours the matching between the axis of progression of the foetus with the pelvic curve. Moreover, to optimize the path that the foetus has to take, the thoracolumbar junction has to be flattened and the axis of progression of the foetus has to be aligned with the engagement axis of the foetus in the pelvis.
The current means available for obstetricians do not allow them exploring these mechanisms without using ionizing radiation, or invasive procedures which are not justifiable in this context of pregnancy. The means commonly used for sport movement analysis could provide access to new approaches in the exploration, understanding and optimization of the childbirth. In this first part of this OPTIMAC project we proposed to assess the influence of childbirth positions on the posture of the female body (including legs, trunk and pelvis).

METHODS: For this first set of experiments, 15 pregnant women at 1st semester took part in this study. They were measured in static position with different hip flexion (0/30/60/90/110/maximal hip flexion) and abduction (30/60/maximal hip abduction).

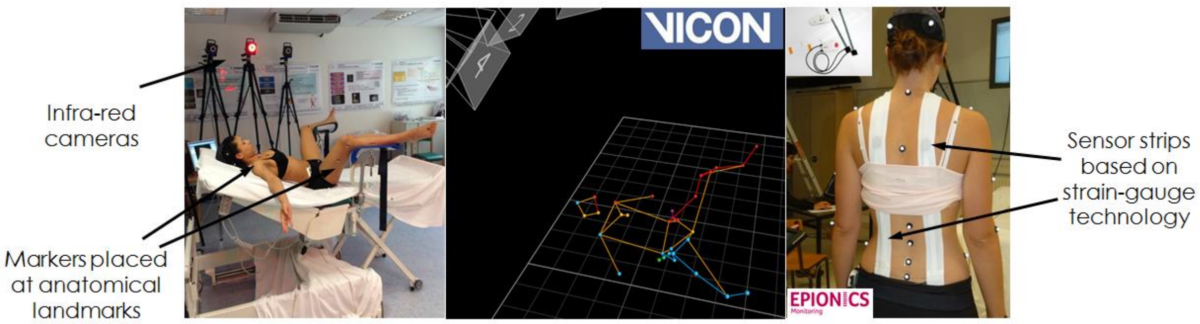

Figure 1: optoelectronical system and lumbar curve measure system used during the experiment.

A traditional 3D motion analysis was performed to analyse the positions (Figure 1). It was based on a optoelectronical motion capture system made up 12 infrared cameras cadenced at 100Hz. 33 reflective markers were placed on anatomical landmarks according to a adapted version of the Plug in gait model (Kadaba, Ramakrishnan, & Wootten, 1990). Additionally, in order to investigate the lumbar curve, the Epionics lumbar curve measure system was used (Consmüller et al., 2012). The Epionics system consists of two strips including strain-gauge sensors. These sensors measure the relative segment angles at a frequency of 50 Hz. The device is positioned in a standardized manner by fixing the caudal sensor segment to the spina iliaca posterior superior. A three-dimensional accelerometer is also located at the lower end of each sensor strip in order to detect the sensor's orientation in

relation to the earth's gravitational field. The sensors are connected by cables to a storage unit, which is able to either transmit the data in real-time via Bluetooth to a local PC.
The positions of the reflective markers on the subjects were then used to define the hip joint flexion/extension, abduction/adduction; the anteversion/retroversion of the pelvis. The lumbar curve was assessed by measuring the lordosis according to Consmüller et al. (2012). A lordosis of 0° corresponds according to this measure to a back perfectly flattened.

RESULTS: Pelvic and lumbar curve responses to hip flexion are not linear as illustrated for one subject by Figure 2. Moreover, inter-individual differences are found regarding the relationship between hip flexion and pelvic anteversion and between hip flexion and lumbar curve.
The abduction hasn't an important effect on the pelvic anteversion and lumbar curve flattening.
For the subject of Figure 2, one could suggest that a hip flexion of 90° was sufficient to induce a neutral position of the pelvis. However, the back was perfectly flattened (lordosis of 0°) only when the hip were in maximal flexion.

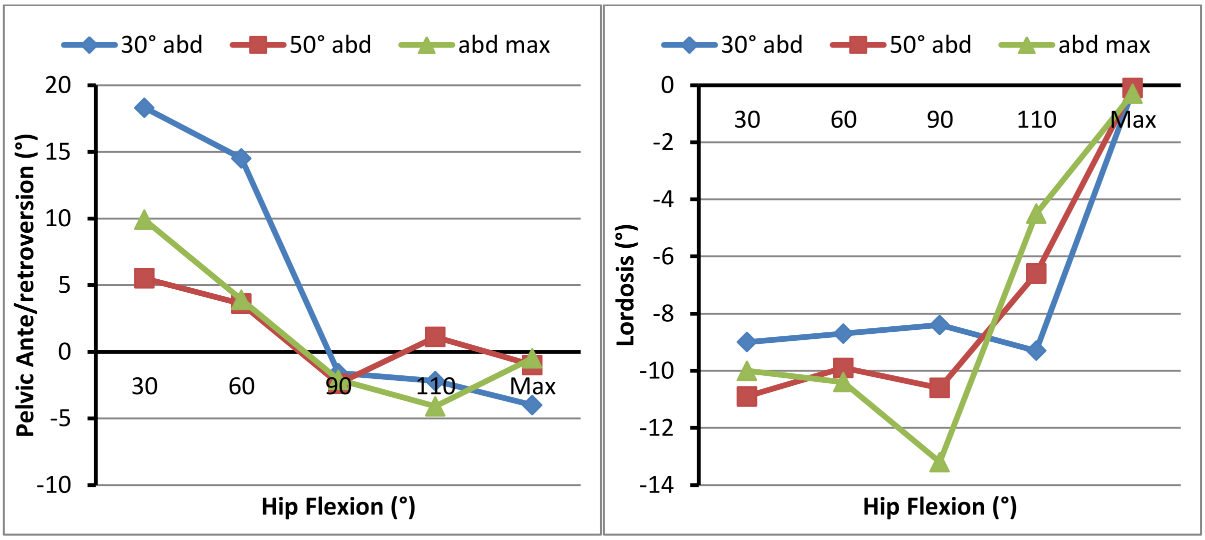

Figure 2: On the left: pelvis ante/retroversion according to hip angles for one subject; On the right: lumbar lordosis according to hip angles for one subject.

DISCUSSION/CONCLUSION: This first study has shown that it was possible with a biomechanical approach to better characterize the influence of delivery position on the pelvic and lumbar curve, whose positions are fundamental in order to optimize delivery.
The results tend also to suggest that, as for many sport activities, individual characteristics have to be taken into account to explain performance. Here, joint laxity is to be investigated to better understand the inter-individual differences in terms of pelvic and lumbar curve responses to hip flexion.
This first step in the OPTIMAC project has also demonstrated that a biomechanical analysis as performed in many sport activities could be beneficial by helping to understand and characterize the underlying mechanisms involved during this sport activity so special in a lifetime.

REFERENCES:

Ashton-Miller, J. A., & DeLancey, J. O. L. (2009). On the Biomechanics of Vaginal Birth and Common Sequelae. *Annual review of biomedical engineering*, *11*, 163-176.

Billat, V. L., Petot, H., Landrain, M., Meilland, R., Koralsztein, J. P., & Mille-Hamard, L. (2012). Cardiac output and performance during a marathon race in middle-aged recreational runners. *The Scientific World Journal*, *2012*, 810859.

Consmüller, T., Rohlmann, A., Weinland, D., Druschel, C., Duda, G. N., & Taylor, W. R. (2012). Comparative evaluation of a novel measurement tool to assess lumbar spine posture and range of motion. *European Spine Journal: Official Publication of the European Spine Society, the European Spinal Deformity Society, and the European Section of the Cervical Spine Research Society*, *21*(11), 2170‑2180.

Domenjoz, I., Kayser, B., & Boulvain, M. (2014). Effect of physical activity during pregnancy on mode of delivery. *American Journal of Obstetrics and Gynecology*, *211*(4), 401.e1‑11.

Eliasson, A. H., Phillips, Y. Y., Stajduhar, K. C., Carome, M. A., & Cowsar, J. D. (1992). Oxygen consumption and ventilation during normal labor. *Chest*, *102*(2), 467‑471.

Fussing-Clausen, C., Geirsson, R. T., Hansen, T., Rasmussen, S., Lidegaard, Ø., & Hedegaard, M. (2014). Mode of delivery and subsequent reproductive patterns. A national follow-up study. *Acta Obstetricia Et Gynecologica Scandinavica*, *93*(10), 1034‑1041.

Gold, E. M. (1950). PELVIC DRIVE IN OBSTETRICS-AN X-RAY STUDY OF 100 CASES. *American Journal of Obstetrics and Gynecology*, *59*(4), 890–896.

Hainaut, J., & Rosa, P. (1952). [Example of rational mechanics applied to obstetrics]. *Bulletin De La Fédération Des Sociétés De Gynécologie Et D'obstétrique De Langue Française*, *4*(4), 659‑663.

Hunter, S., & Robson, S. C. (1992). Adaptation of the maternal heart in pregnancy. *British Heart Journal*, *68*(6), 540‑543.

Kadaba, M. P., Ramakrishnan, H. K., & Wootten, M. E. (1990). Measurement of lower extremity kinematics during level walking. *Journal of Orthopaedic Research*, *8*(3), 383–392.

Krustrup, P., Mohr, M., Ellingsgaard, H., & Bangsbo, J. (2005). Physical demands during an elite female soccer game: importance of training status. *Medicine and Science in Sports and Exercise*, *37*(7), 1242‑1248.

Ouzounian, J. G., & Elkayam, U. (2012). Physiologic changes during normal pregnancy and delivery. *Cardiology Clinics*, *30*(3), 317‑329.