Like father like son. Long legs and wide hips also reduce the cost of locomotion in subadults

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Biped locomotion is essential to human physical activities, and specially in those required to obtain resources. Due to the importance of human locomotion, the existence of some behavioural and morphological features to save energy that could be invested in other necessities, as individual maintenance, development or reproduction, may be expected. So, it is suggested that selective pressures could affect human morphology to favour locomotion efficiency. Several studies propose that some anatomical features, as larger legs or wider hips, reduce energy expenditure during locomotion (EE), due to an increased stride length or because of the reduction in the number of steps. Humans reach gait maturation between 8 and 10 years of age. Because of the importance of locomotion activities for playing and learning, we would expect the adult morphological features that save energy to emerge during the immature stages. Besides, leg length growth starts prior the pubertal body spurt. It is known that leg length influences the cost of locomotion, thus, the early ontogenetic development of this character might be related to a reduction in the cost of locomotion in children. The main purpose of this study is to test whether the anatomical features that have been shown to reduce the energetic cost of walking in adults effect also and in a similar way in subadults.

An experimental study was developed with 25 males and 17 females between 8 and 14 years of age. Each volunteer carried out 5 minutes outdoor walking tasks over 290, 333 and 500 meters, attaining speeds (V) of 3.5, 4, and 6 km/h. Walking EE was monitored using the Oxycon Mobile JAEGER® device. Body Mass (BM), Bi-iliac breadth (BIL) and Femur Length (FL) were measured with a digital scale to the nearest 0.1 kg and an anthropometer nearest to 0.1 cm. Multiple stepwise linear regressions via forward were computed, including BM as a covariate, to explore the relationship between BIL and FL and the energetic cost of locomotion trials (selection criterion to enter $p<.05$). Besides, a speed factor (V) was included into the multiple regression since it is known to be a fundamental factor in the cost of locomotion.

Moreover, BM and V, BIL and FL display significant correlations with EE ($R^2=.71$, $p<.001$) as revealed in previous studies on adults [1,2,3]. The main factor that determines EE is V, followed by BM, while a wider bi-iliac width and a longer femur decrease the cost of locomotion (Partial correlation: .807, .488, -.390, -.236, respectively). These results are similar to those obtained by Vidal-Cordasco et al. [1] for the locomotion of adults. However, our results show a minor influence of FL and a higher effect of BIL on energy expenditure. These differences might be explained by the effect of speed, since Vidal-Cordasco et al. carried out their experiments at a constant velocity of 4 km/h. A wider BIL might provide more stability and lesser cadence at higher velocities. Besides, children show higher tibial growth relative to the rest of body proportions [4], therefore FL does not reveal the total influence of leg length in walking cost. However, increasing leg length relative to body size before the pubertal spurt would reduce the energetic cost of a wide variety of physical activities.

In summary, an improved and mature gait during subadult phases could have reduced the mortality caused by predators throughout the human evolutionary history. Therefore, the evolutionary pressures that affected human locomotion would have a higher influence during the subadult phases [5] than during adulthood. So, we propose that the same morphological characters that save energy in adults, act also in children, juveniles and early adolescents. The importance of maintaining high levels of physical activity to learn by doing and the development of body segments involved in gait maturation would save energy to be invested in other issues like somatic growth.

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