

# The Symmetry of Children's Knees is Linked to Their Adult Sprinting Speed and their Willingness to Sprint in a Long-term Jamaican Study

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**Abstract:** Jamaican athletes are prominent in sprint running but the reasons for their success are not clear. Here we consider the possibility that symmetry, particularly symmetry of the legs, is high in Jamaican children and that this is linked to high sprinting speed in adults. Our study population was a cohort of 285 rural children (156 boys), mean age 8.18(1.72) years. Symmetry was measured in 1996 and 2006 from the fluctuating asymmetry (FA) of nine traits (six upper- and three lower-body traits) and we constructed an upper and a lower body composite FA trait [Comp ub-FA and Comp lb-FA respectively]. We found Comp lb-FA < Comp ub-FA, and both were lower than in comparable Caucasian norms. In 2010 we measured sprinting speed ([mean time for](#) 90m and 180m races) in

participants recruited from our original cohort. There were 160 untrained adults in our sample, we found: (i) high Comp lb and knee symmetry in 1996 and 2006 were linked to fast sprinting times in our 2010 runners and (ii) our sample of sprinters appears to have self-selected for greater symmetry. We conclude that Jamaican children have high symmetry in the legs, and that high knee symmetry is linked to an ability to sprint fast in adult Jamaicans as well as a readiness to sprint.

Caribbean sprinters, particularly Jamaican sprinters, have long been prominent in elite sprint running. However, the reasons for their disproportionate success in relation to the population size from which they are drawn are unclear. For example, ethnic comparisons of ACTN3 and ACE genotypes (1), mitochondrial haplotypes (2) and vertical jump and stride number/height ratio (3) have been made with mixed success.

Here we take a different approach and focus on long-term symmetry, and in particular symmetry of the legs, and its relationship to adult sprinting speed in rural Jamaicans. Our measure of symmetry is fluctuating asymmetry or FA. FA consists of small departures from perfect bilateral symmetry in such paired traits as finger length, knee circumference and foot length (4). FA has been shown to be a negative correlate of running speed in horses (5) and humans (6). With regard to FA in Jamaicans, the Jamaican Symmetry Project (JSP) has focussed on long-term correlates of FA in a rural cohort of 288 Afro-Caribbean children (7). The children were first measured in 1996 (when their mean age was 8.18 (1.72) years) and again in 2006. In 1996 nine paired traits were found to show FA (six upper body traits; ear height, finger length [3<sup>rd</sup>, 4<sup>th</sup> & 5<sup>th</sup> fingers], wrist and elbow width: three lower body traits; knee and ankle circumference,

foot length). A tenth trait, hand width, showed significant directional asymmetry and was discarded. It was found that composite FA of the lower body (Comp lb-FA) was much lower (~35%) than a composite measure of upper body FA (Comp ub-FA), and a comparison of FA in this sample with a large Caucasian sample of UK children showed lower FA in the former compared to the latter (7-9).

Here we tested whether symmetry in children (particularly symmetry of the legs) is related to their running speed when they are young adults. In order to consider this, we recruited adult participants in 2010 from our original 1996 cohort. The original cohort was asked to volunteer for further tests and informed that they would have to complete two sprints. Using the FA's measured in 1996 and 2006, we then examined the relationships between trait FA's and sprinting speed recorded in 2010 and also compared the Comp ub-FA and Comp lb-FA of the participants that did not volunteer to run with those that did. Our prediction was two-fold, i.e. (i) that FA measured in 1996 (and 2006) would be positively correlated with sprinting speed recorded in 2010 and (ii) that those that chose to run in 2010 would have been more symmetrical (particularly in the legs) in 1996 than those that chose not to run.

## **Methods**

The cohort was contacted by letter (reinforced by word-of-mouth) and informed of the aims of the study. The work was approved by the Human Subjects Committee of Rutgers University. In this rural area there was not a conventional running track available.

Therefore, we constructed one which was 90metres long. Our two races were 90m and 180m long (back and forth on the 90m track). The second race (180m) was run about a ½ hour after the first race. Subjects were run in pairs (same-sex whenever possible), in

order to increase competition during the run. When we had no one with whom to pair with a subject, he or she ran against a dummy runner of the same sex. [Mean sprinting time of 90m + 180m was calculated and used as our measure of performance.](#)

## Results

### *Descriptive statistics*

From the original cohort of 285 children (156 boys) we recruited 160 untrained adults (97 men) in our sample. Means (SD) were as follows: age 23.56 (SD 1.81) years, sprinting time [23.60 \(5.09\)](#) sec.. Males tended to run faster than females (males [20.60 \[2.97\]](#) sec., females [\[28.21\]\[4.12\]](#) sec.,  $t = 13.66, p < 0.0001$ ).

### *Relative FA*

The repeatability of signed absolute FA was significant for all traits (7). With regard to measurements of the original cohort, relative FA ( $(|L-R|)/(L+R*0.5)$ ) was calculated for each of the traits. Principal Components Analysis revealed five factors that accounted for 66% of the variance in FA's. An orthogonal transformation showed factor 1 (17% variance) was related to lower body traits (knee  $r = 0.66$ , ankle  $r = 0.68$ , foot  $r = 0.64$ ). The remaining factors were associated with one trait each (e.g. factor 2 13% variance, 4D  $r = 0.86$ ; factor 3 13% variance 3D  $r = 0.87$ ; factor 4 12% 3D  $r = 0.80$ ; factor 5 11%  $r = 0.93$ ). Two composite FA traits were constructed, Comp ub<sub>-</sub>FA and Comp lb<sub>-</sub>FA by calculating the mean of all upper body FA's for the former and all lower body FA's for the latter. Comp ub<sub>-</sub>FA (0.022 [0.007]) was significantly greater than Comp lb<sub>-</sub>FA with very large effect size (0.008[0.006]), paired  $t$  test  $x-y = 0.014, t = 23.36, p = 0.0001$ , Cohen's  $d = 2.15$ ). There was a significant sex difference in Comp ub<sub>-</sub>FA such that males (0.021[0.007],  $n = 152$ ) were more symmetric than females (0.023[0.008],  $n = 126, t =$

3.10,  $p = 0.002$ ,  $d = 0.46$ ), but Comp lb-FA showed no significant sexual dimorphism (males  $n = 144$ ,  $0.007[0.006]$ , females  $n = 126$ ,  $0.008[0.006]$ ,  $t = 0.27$ ,  $p = 0.79$ ,  $d = 0.17$ ).

#### *1996 and 2006 Lower Body FA and 2010 running speed*

We removed the influence of BMI from lower body FA by regressing FA (Comp lb-FA, knee FA, ankle FA & foot FA) from 1996 and 2006 on their current BMI and then considered the relationships between residuals (*Res* FA) and sprinting speed (Table 1). We found that *Res* Comp lb-FA was positively related to sprinting speed in 1996 ( $p = 0.04$ ) and 2006 ( $p = 0.04$ ). Furthermore, a multiple regression analysis with independent variables *Res* knee FA, *Res* ankle FA and *Res* foot FA, showed *Res* knee FA was positively related to sprinting speed in 1996 ( $p = 0.02$ ) and 2006 ( $p = 0.04$ ). We then calculated mean FA from 1996 and 2006 and regressed this on mean BMI from 1996 and 2006. The residuals from this regression showed significant positive relationships to 2010 sprinting times (*Res* Comp lb-FA ( $p = 0.04$ ) and *Res* knee FA ( $p = 0.01$ )).

#### *Relative FA in runners and those that did not run*

Our participants in the 2010 sprints numbered 157 individuals from our original cohort of 270 children. We considered whether these volunteers showed evidence of self-selection for high lower body symmetry by comparing 1996 Comp lb-FA of runners and non-runners in 2010. We found that runners had lower Comp lb-FA (mean = 0.0052) than non-runners (mean = 0.00073,  $t = 2.87$ ,  $p = 0.005$ ; Table 2). This finding suggested that children with symmetrical lower bodies were more likely to engage in sprinting when adults than children with more asymmetrical lower bodies.

[In addition to](#) the initial recruitment of our cohort in 1996 and the 2010 sprinting recruitment, there have been five other recruitments (1998, 2002, 2004, 2005, and 2006) which have focussed on a variety of target variables. There was no evidence for significant self-selection on the basis of lower body FA for the years of 1998, 2002, 2005 and 2006. The one exception to this finding was the 2004 recruitment. In common with 2010, the 2004 volunteers showed lower Comp lb-FA ([mean = 0.00070](#)) in comparison to non-volunteers ([mean = 0.0088](#),  $t = 2.14$ ,  $p = 0.03$ ). In this instance the target trait in 2004 was dancing ability (Table 2).

## **Conclusions**

We have the following findings:

Our original cohort of rural Jamaican children, measured in 1996, had high levels of symmetry (i.e. low FA) in comparison to Caucasian children of similar ages (7-9). In particular, lower body traits (knee, ankle & foot FA) showed high symmetry. These findings were at a mean age of 8.18 (1.72) years.

Some 14 years later, we attempted to recruit the entire cohort in order to measure sprinting speed. We found our new sub-set of participants showed evidence of self-selection. [Symmetry of the legs was greater in our 2010 sample of volunteers](#) in comparison to the [non-volunteers of that year](#). This effect suggests that Jamaican [children](#) with high symmetry in the legs, will readily take part in sprints when they are young men. We think the importance of this finding relates to the enjoyment of sprinting. In addition, although our sample was untrained this evidence of self-selection may map-on to a readiness to train for sprinting events. [A similar effect was found in 2004 when participants were asked to volunteer for dancing. We suggest that the traits necessary for](#)

successful sprinting may in part map on to traits that are important in dancing. More sedentary target traits were tested in 1998, 2002, 2005, and 2006. In these years volunteers and non-volunteers did not show significant differences in Comp lb-FA.

We found that lower body FA measured in 1996 and 2006 were positively related to sprinting performance in 2010. This was found for Comp lb-FA and the effect was driven by the association between knee FA and sprinting times. That is, children with symmetric knees in 1996 and 2006 ran faster than children with asymmetric knees when tested for sprinting speed in 2010. This effect was independent of other asymmetries in the legs.

There are clear links here between childhood symmetry of the lower body and both motivation to sprint and ability to sprint well among rural Jamaicans. The effect is all the more remarkable for the intervening period of 14 years between the first measurements of leg symmetry and self-selection and performance effects related to sprinting. We suggest that high symmetry in the legs—especially knees—may underlie at least some of the advantage that Jamaican sprinters enjoy over their Caucasian competitors.

## References

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Table 1

Relationships ([standardised regression coefficients, \*b\*](#)) between relative FA's independent of BMI (Res Comp lb-FA; Res FA knee; Res FA ankle; Res FA foot) and sprinting speed in 2010. Significant positive associations with sprinting speed were found for FA's measured in 1996 and 2006 and for mean FA's of 1996 + 2006.

<u>Year</u>	<u>n</u>	<u>b</u>	<u>p</u>
<b><u>1996</u></b>			
<u>Res Comp lb-FA</u>	<u>147</u>	<u>0.17</u>	<u>0.04*</u>
<u>Res FA knee</u>	<u>147</u>	<u>0.20</u>	<u>0.02*</u>
<u>Res FA ankle</u>	<u>147</u>	<u>-0.03</u>	<u>0.72</u>
<u>Res FA foot</u>	<u>147</u>	<u>0.10</u>	<u>0.21</u>
<b><u>2006</u></b>			
<u>Res Comp lb-FA</u>	<u>135</u>	<u>0.18</u>	<u>0.04*</u>
<u>Res FA knee</u>	<u>135</u>	<u>0.18</u>	<u>0.04*</u>
<u>Res FA ankle</u>	<u>135</u>	<u>0.06</u>	<u>0.52</u>
<u>Res FA foot</u>	<u>135</u>	<u>0.09</u>	<u>0.32</u>
<b><u>1996 + 2006</u></b>			
<u>Res Comp lb-FA</u>	<u>124</u>	<u>0.21</u>	<u>0.02*</u>
<u>Res FA knee</u>	<u>124</u>	<u>0.23</u>	<u>0.01*</u>
<u>Res FA ankle</u>	<u>124</u>	<u>0.02</u>	<u>0.81</u>
<u>Res FA foot</u>	<u>124</u>	<u>0.12</u>	<u>0.19</u>

Table 2

Mean Comp lb-FA for 1996 and for volunteers (**in bold**) and non-volunteers for recruitments in years 1998, 2002, 2004, 2005, 2006 and 2010. There was evidence for unequal variances between the samples for volunteers and non-volunteers in 2004 and 2010. Therefore, we used the unequal variance t-test (10). Volunteers had significantly lower Comp lb-FA than non-volunteers in year 2004 when recruitment was for dancing, and 2010 when recruitment was for sprinting.

<u>Year</u>	<u>Mean LBFA</u>	<u>N</u>	<u>SD</u>	<u>SE</u>	<u>t</u>	<u>~df</u>	<u>p</u>
<b>1996</b>	<b>0.0076</b> N/A	270	0.0062	0.0004			
<b>1998</b>	<b>0.0073</b> 0.0078	139 131	0.0060 0.0065	0.0005 0.0006	0.61	263	0.54
<b>2002</b>	<b>0.0072</b> 0.0082	173 97	0.0062 0.0063	0.0005 0.0006	1.26	197	0.21
<b>2004</b>	<b>0.0070</b> 0.0088	187 83	0.0059 0.0068	0.0004 0.0007	2.14	138	0.034*
<b>2005</b>	<b>0.0070</b> 0.0083	151 119	0.0063 0.0061	0.0005 0.0006	1.69	257	0.092
<b>2006</b>	<b>0.0072</b> 0.0082	168 102	0.0060 0.0066	0.0005 0.0007	1.33	197	0.19
<b>2010</b>	<b>0.0066</b> 0.0089	157 113	0.0052 0.0073	0.0004 0.0007	2.87	190	0.005*