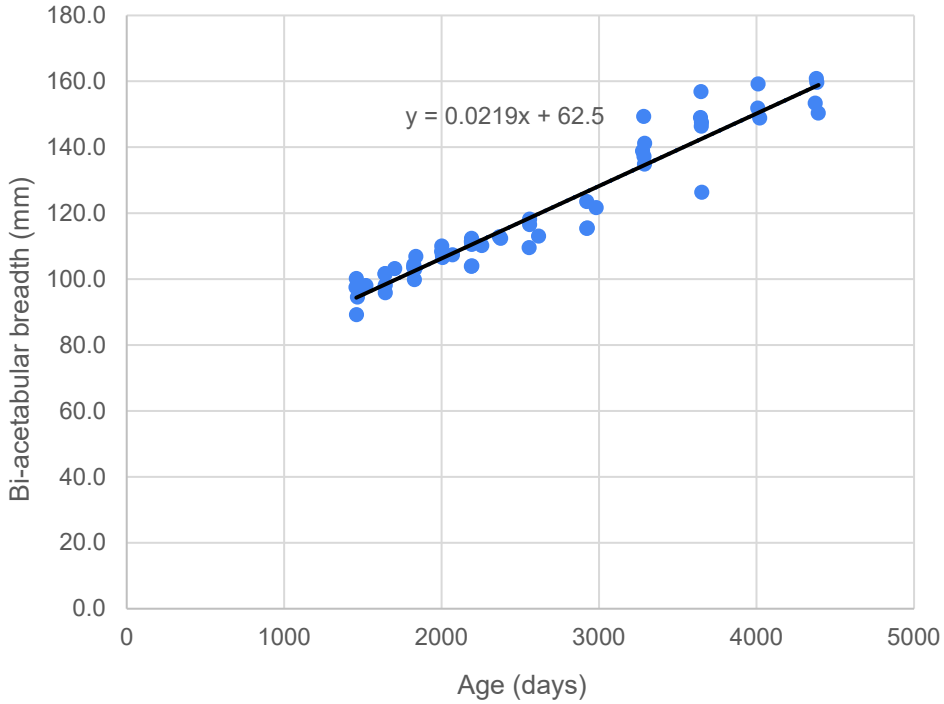

Fig. S1. Chimpanzee bi-acetabular breath growth curve. Data are derived from an x-ray dataset of nine, laboratory-reared chimpanzees in a historical radiological study (see Thompson et al., 2020 for more details). Raw data shown in Table S2. Due to unequal and small sample sizes, simple linear regression was used to calculate a single growth rate (0.0219 mm/day). This growth rate generally led to only small increases to measured bi-acetabular size (1.1–3.2%).

Supplementary Materials & Methods

Script 1. Linear mixed model code and results for differences in dimensionless stride length versus dimensionless speed between sexes within humans.

The following is the summary of a model (m103.2.2) which incorporates only the human data, with sex as fixed effect and subject as a random effect (light blue and purple curves of Figure 2a).

```
summary(m103.2.2)

## Linear mixed model fit by REML ['lmerMod']
## Formula: DimensionlessStrideLength ~ DimSpeed + I(DimSpeed^2) + Sex +
##     (DimSpeed | Subject)
##    Data: rotation_data[which(rotation_data$Species == "Human"), ]
## Control: lmerControl(optimizer = "bobyqa", optCtrl = list(maxfun = 1e+05))
##
## REML criterion at convergence: -2805.8
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -3.7322 -0.5911  0.0159  0.6299  3.6588
##
## Random effects:
##  Groups   Name        Variance Std.Dev. Corr
##  Subject  (Intercept) 0.011810 0.10867
##           DimSpeed    0.050467 0.22465  -0.88
##  Residual             0.002321 0.04817
## Number of obs: 900, groups:  Subject, 10
##
## Fixed effects:
##               Estimate Std. Error t value
## (Intercept)    0.76744    0.03907  19.645
## DimSpeed       1.80666    0.08974  20.133
## I(DimSpeed^2) -0.44727    0.07478  -5.981
## SexM           0.10458    0.03272   3.196
##
## Correlation of Fixed Effects:
##             (Intr) DimSpd I(DS^2
## DimSpeed    -0.744
## I(DimSpd^2)  0.198 -0.600
## SexM        -0.418 -0.004  0.008
```

This model (m103.2.2) was tested against a null model, which is identical to m103.2.2, except without the including sex as an effect (m103.2.2_n). This null model resulting in a slightly lower, but nearly equivalent, AIC score. However, an ANOVA between the models shows that the model including sex significantly outperforms the model which does not include sex ($p = 0.008543$).

```
AIC(m103.2.2, m103.2.2_n)

##            df       AIC
## m103.2.2    8 -2789.781
## m103.2.2_n  7 -2790.619

anova(m103.2.2, m103.2.2_n)
```

```
## refitting model(s) with ML (instead of REML)

## Data: rotation_data[which(rotation_data$Species == "Human"), ]
## Models:
## m103.2.2_n: DimensionlessStrideLength ~ DimSpeed + I(DimSpeed^2) + (DimSpeed |
## m103.2.2_n:     Subject)
## m103.2.2: DimensionlessStrideLength ~ DimSpeed + I(DimSpeed^2) + Sex +
## m103.2.2:     (DimSpeed | Subject)
##            npar     AIC     BIC logLik deviance Chisq Df Pr(>Chisq)
## m103.2.2_n    7 -2803.3 -2769.7 1408.7  -2817.3
## m103.2.2      8 -2808.2 -2769.8 1412.1  -2824.2 6.916  1   0.008543 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Script 2. Linear mixed model code and results for differences in dimensionless stride length versus dimensionless speed between chimpanzees and humans

The following is the summary of a model (m103.2.2_s) which incorporates both human and chimpanzee data with species and subject as a random effects (red and blue curves of Figure 2a).

```
summary(m103.2.2_s)

## Linear mixed model fit by REML ['lmerMod']
## Formula: DimensionlessStrideLength ~ DimSpeed + I(DimSpeed^2) + (DimSpeed |
##     Species) + (DimSpeed | Subject)
##    Data: chimp_human_data
## Control: lmerControl(optimizer = "bobyqa", optCtrl = list(maxfun = 1e+05))
##
## REML criterion at convergence: -2771.4
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -3.5491 -0.5790  0.0091  0.6226  6.7741
##
## Random effects:
##  Groups   Name        Variance Std.Dev. Corr
##  Subject  (Intercept) 0.009083 0.09530
##           DimSpeed    0.049044 0.22146  -0.73
##  Species  (Intercept) 0.023830 0.15437
##           DimSpeed    0.916419 0.95730  -1.00
##  Residual             0.002585 0.05085
## Number of obs: 923, groups:  Subject, 12; Species, 2
##
## Fixed effects:
##               Estimate Std. Error t value
## (Intercept)    0.71183    0.11457   6.213
## DimSpeed       2.47903    0.68669   3.610
## I(DimSpeed^2) -0.44616    0.07879  -5.663
##
## Correlation of Fixed Effects:
##             (Intr) DimSpd
## DimSpeed    -0.980
## I(DimSpd^2)  0.076 -0.084
## convergence code: 0
## boundary (singular) fit: see ?isSingular
```

This model (m103.2.2_s) was tested against a null model, which is identical to m103.2.2_s, except without including species as an effect (m103.2.2_s_n). The model including species resulted in a lower AIC score, and significantly outperformed the null model (p=0.002123).

```
AIC(m103.2.2_s,m103.2.2_s_n)

##              df       AIC
## m103.2.2_s   10 -2751.398
## m103.2.2_s_n  7 -2740.052

anova(m103.2.2_s,m103.2.2_s_n)

## refitting model(s) with ML (instead of REML)
```

```
## Data: chimp_human_data
## Models:
## m103.2.2_s_n: DimensionlessStrideLength ~ DimSpeed + I(DimSpeed^2) + (DimSpeed |
## m103.2.2_s_n:     Subject)
## m103.2.2_s: DimensionlessStrideLength ~ DimSpeed + I(DimSpeed^2) + (DimSpeed |
## m103.2.2_s:     Species) + (DimSpeed | Subject)
##              npar     AIC     BIC logLik deviance  Chisq Df Pr(>Chisq)
## m103.2.2_s_n    7 -2751.1 -2717.3 1382.5  -2765.1
## m103.2.2_s     10 -2759.7 -2711.4 1389.9  -2779.7 14.668  3   0.002123 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Script 3. Linear mixed model code and results for differences in pelvic rotation range of motion versus dimensionless speed between chimpanzees and humans

The following is the summary of a model (m102.2.2_s) which incorporates both human and chimpanzee data with species and subject as a random effects (red and blue curves of Figure 2b).

```
summary(m102.2.2_s)

## Linear mixed model fit by REML ['lmerMod']
## Formula: PelvicRotationROM ~ DimSpeed + I(DimSpeed^2) + (DimSpeed | Species) +
##     (DimSpeed | Subject)
##    Data: chimp_human_data
## Control: lmerControl(optimizer = "bobyqa", optCtrl = list(maxfun = 1e+06))
##
## REML criterion at convergence: 4324.2
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -4.1086 -0.6621 -0.0276  0.5836  3.7481
##
## Random effects:
##  Groups   Name        Variance Std.Dev. Corr
##  Subject  (Intercept)   36.650  6.054
##           DimSpeed     294.823 17.170   -0.79
##  Species  (Intercept)    0.000  0.000
##           DimSpeed    2166.785 46.549    NaN
##  Residual                5.693  2.386
## Number of obs: 923, groups:  Subject, 12; Species, 2
##
## Fixed effects:
##               Estimate Std. Error t value
## (Intercept)     16.129      1.917   8.414
## DimSpeed       -23.747     33.532  -0.708
## I(DimSpeed^2)   96.726      3.699  26.150
##
## Correlation of Fixed Effects:
##             (Intr) DimSpd
## DimSpeed    -0.137
## I(DimSpd^2)  0.215 -0.080
## convergence code: 0
## boundary (singular) fit: see ?isSingular
```

This model (m102.2.2_s) was tested against a null model, which is identical to m102.2.2_s, except without including species as an effect (m102.2.2_s_n). The model including species resulted in a lower AIC score, and significantly outperformed the null model (p=0.008494).

```
AIC(m102.2.2_s,m102.2.2_s_n)

##              df      AIC
## m102.2.2_s   10 4344.196
## m102.2.2_s_n  7 4352.280

anova(m102.2.2_s,m102.2.2_s_n)

## refitting model(s) with ML (instead of REML)
```

```
## Data: chimp_human_data
## Models:
## m102.2.2_s_n: PelvicRotationROM ~ DimSpeed + I(DimSpeed^2) + (DimSpeed | Subject)
## m102.2.2_s: PelvicRotationROM ~ DimSpeed + I(DimSpeed^2) + (DimSpeed | Species) +
## m102.2.2_s:     (DimSpeed | Subject)
##              npar    AIC    BIC  logLik deviance  Chisq Df Pr(>Chisq)
## m102.2.2_s_n    7 4365.8 4399.6 -2175.9   4351.8
## m102.2.2_s     10 4360.1 4408.4 -2170.1   4340.1 11.698  3   0.008494 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Script 4. Linear mixed model code and results for differences in pelvic step contribution versus dimensionless speed between chimpanzees and humans

The following is the summary of a model (m101.2.2_s) which incorporates both human and chimpanzee data with species and subject as a random effects (red and blue curves of Figure 2c).

```
summary(m101.2.2_s)

## Linear mixed model fit by REML ['lmerMod']
## Formula: PelvicRot_Percent ~ DimSpeed + I(DimSpeed^2) + (DimSpeed | Species) +
##     (DimSpeed | Subject)
##    Data: chimp_human_data
## Control: lmerControl(optimizer = "bobyqa", optCtrl = list(maxfun = 1e+05))
##
## REML criterion at convergence: 1809.4
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -5.1282 -0.5017 -0.0008  0.5364  3.3686
##
## Random effects:
##  Groups   Name        Variance Std.Dev. Corr
##  Subject  (Intercept)  1.2800  1.1314
##           DimSpeed    18.7460  4.3297   -0.92
##  Species  (Intercept)  0.9943  0.9971
##           DimSpeed    98.2706  9.9132   1.00
##  Residual              0.3757  0.6130
## Number of obs: 923, groups:  Subject, 12; Species, 2
##
## Fixed effects:
##               Estimate Std. Error t value
## (Intercept)    -0.6557     0.8059  -0.814
## DimSpeed       14.5722     7.1617   2.035
## I(DimSpeed^2)  -1.8063     0.9501  -1.901
##
## Correlation of Fixed Effects:
##             (Intr) DimSpd
## DimSpeed     0.781
## I(DimSpd^2)  0.132 -0.094
```

This model (m101.2.2_s) was tested against a null model, which is identical to m101.2.2_s, except without including species as an effect (m101.2.2_s_n). The model including species resulted in a lower AIC score, and significantly outperformed the null model (p=0.0002871).

```
AIC(m101.2.2_s,m101.2.2_s_n)

##              df      AIC
## m101.2.2_s   10 1829.398
## m101.2.2_s_n  7 1845.696

anova(m101.2.2_s,m101.2.2_s_n)

## refitting model(s) with ML (instead of REML)
```

```
## Data: chimp_human_data
## Models:
## m101.2.2_s_n: PelvicRot_Percent ~ DimSpeed + I(DimSpeed^2) + (DimSpeed | Subject)
## m101.2.2_s: PelvicRot_Percent ~ DimSpeed + I(DimSpeed^2) + (DimSpeed | Species) +
## m101.2.2_s:     (DimSpeed | Subject)
##              npar    AIC    BIC  logLik deviance  Chisq Df Pr(>Chisq)
## m101.2.2_s_n    7 1849.6 1883.4 -917.80   1835.6
## m101.2.2_s     10 1836.7 1885.0 -908.35   1816.7 18.898  3  0.0002871 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Table S1. Subject anthropometrics

	Subject	Sex	Height (mm)	Weight (kg)	Age (y)	Effective lower limb length (mm)	Bi-acetabular breadth (mm)
Humans	1	F	1575	59.7	26.6	860	143
	2	M	1710	72.1	23.7	909	164
	3	M	1780	74.1	24.6	916	146
	4	M	1820	83.0	24.2	970	167
	5	M	1800	74.4	24.8	990	153
	6	F	1462	42.6	24.3	800	146
	7	F	1600	50.5	23.8	835	115
	8	F	1640	66.0	25.5	910	179
	9	F	1652	52.6	25.9	903	172
	10	M	1915	96.2	24.7	1019	155
	male mean	-	1805	79.9	24.4	961	157
	male st. dev.	-	74	10.0	0.5	47	8
	female mean	-	1586	54.3	25.2	862	151
	female st. dev.	-	76	8.9	1.2	46	26
	total mean	-	1695	67.1	24.8	911	154
	total st. dev.	-	135	16.2	0.9	68	18
Chimpanzees[a]	1 mean	M	1032	35.7	7.0	441	129
	1 st. dev.	-	3	0.8	0.1	9	1
	2 mean	M	1016	33.9	7.1	418	127
	2 st. dev.	-	5	1.0	0.1	13	1
	total mean	-	1023	34.8	7.1	429	128
	total st. dev.	-	9	1.2	0.1	16	1

Abbreviations: st. dev., standard deviation. [a] Chimpanzee means and standard deviations are based on multiple experimental days.

Table S2. Growth curve data on chimpanzee bi-acetabular breadth

Subject	Sex	Morphosource subject ID	Subject ID	Image #	Age (days)	Bi-acetabular breadth (mm)
Ken	M	YLPB-55	55-19	549	2003	110.0
Ken	M	YLPB-55	55-24	784	3278	138.8
Ken	M	YLPB-55	55-25	145	3646	149.0
Ken	M	YLPB-55	55-26	429	4009	151.8
Ken	M	YLPB-55	55-27	690	4374	153.3
Art	M	YLPB-57	57-16	715	1521	98.0
Art	M	YLPB-57	57-17	52	1704	103.2
Art	M	YLPB-57	57-19	575	2071	107.3
Art	M	YLPB-57	57-21	66	2617	113.0
Art	M	YLPB-57	57-22	470	2983	121.7
Alf	M	YLPB-59	59-21	852	2192	112.3
Alf	M	YLPB-59	59-22	186	2560	118.2
Alf	M	YLPB-59	59-24	848	3291	141.2
Alf	M	YLPB-59	59-25	204	3651	146.3
Alf	M	YLPB-59	59-26	479	4022	148.8
Bard	M	YLPB-61	61-21	129	1460	100.2
Bard	M	YLPB-61	61-22	390	1642	101.5
Bard	M	YLPB-61	61-23	631	1825	104.3
Bard	M	YLPB-61	61-24	820	2007	107.2
Bard	M	YLPB-61	61-25	941	2194	111.5
Bard	M	YLPB-61	61-26	124	2376	112.3
Bard	M	YLPB-61	61-27	335	2560	116.5
Bard	M	YLPB-61	61-28	646	2923	123.5
Bard	M	YLPB-61	61-29	2	3287	137.2
Bard	M	YLPB-61	61-30	269	3652	147.5
Scarf	M	YLPB-65	65-30	871	1826	103.7
Scarf	M	YLPB-65	65-32	240	2193	110.5
Jed	M	YLPB-67	67-29	690 & 687	1461	89.2
Jed	M	YLPB-67	67-30	846 & 848	1644	95.8
Jed	M	YLPB-67	67-31	2	1829	99.8
Jed	M	YLPB-67	67-32	390	2191	103.8
Jed	M	YLPB-67	67-33	694	2557	109.5
Jed	M	YLPB-67	67-34	61 & 53	2927	115.5
Jed	M	YLPB-67	67-36	634	3654	126.3
Web	M	YLPB-79	79-23	464	1644	98.2
Web	M	YLPB-79	79-25	953 & 959	2194	104.0
Web	M	YLPB-79	79-26	239	2257	110.2
Web	M	YLPB-79	79-27	548	2923	115.3
Banka	F	YLPB-98	79-29	533	1467	94.5

Banka	F	YLPB-98	79-30	893	1831	103.0
Banka	F	YLPB-98	79-31	44 & 51	2008	106.5
Banka	F	YLPB-98	79-32	270	2196	111.2
Banka	F	YLPB-98	79-35	227	3290	134.8
Banka	F	YLPB-98	79-38	31	4394	150.3
Jenny	F	YLPB-90	90-22	141	1458	97.5
Jenny	F	YLPB-90	90-23	420	1643	101.7
Jenny	F	YLPB-90	90-24	636	1825	103.5
Jenny	F	YLPB-90	90-25	827	2001	108.3
Jenny	F	YLPB-90	90-26	949	2191	111.3
Jenny	F	YLPB-90	90-27	113	2368	112.8
Jenny	F	YLPB-90	90-30	13	3285	149.3
Jenny	F	YLPB-90	90-31	2868	3649	156.8
Jenny	F	YLPB-90	90-32	591	4011	159.2
Jenny	F	YLPB-90	90-33	843	4381	160.8
Jojo	F	YLPB-94	94-26	716	1838	106.8
Jojo	F	YLPB-94	94-27	7	2192	111.7
Jojo	F	YLPB-94	94-32	888	4384	159.7

Bi-acetabular breadth was measured in nine, laboratory-reared chimpanzees in a historical radiological study (see Thompson et al., 2020 for more details). Measurements were taken on all x-ray images where it was possible to visualize the center of the femoral head bilaterally. Subject ID's are as in Thompson et al. (2020). Bi-acetabular breadth is the average of three measurements.

Table S3. Application of growth curve data to measured chimpanzee bi-acetabular breadths

Chimpanzee	Image date	Experimental date	Days past imaging date	Expected additional growth (mm)	Original bi-acetabular measurement (mm)	Corrected bi-acetabular measurement (mm)	Increase (%)
Subject 1	6/11/2013	8/13/2013	63	1.38	125.2	126.6	1.1
Subject 1	6/11/2013	9/4/2013	85	1.86	125.2	127.1	1.5
Subject 1	6/11/2013	11/21/2013	163	3.57	125.2	128.8	2.9
Subject 1	6/11/2013	11/21/2013	163	3.57	125.2	128.8	2.9
Subject 1	6/11/2013	11/21/2013	163	3.57	125.2	128.8	2.9
Subject 1	6/11/2013	12/12/2013	184	4.03	125.2	129.2	3.2
Subject 1	6/11/2013	12/12/2013	184	4.03	125.2	129.2	3.2
Subject 1	6/11/2013	12/12/2013	184	4.03	125.2	129.2	3.2
Subject 1	6/11/2013	12/12/2013	184	4.03	125.2	129.2	3.2
Subject 1	6/11/2013	12/12/2013	184	4.03	125.2	129.2	3.2
Subject 1	6/11/2013	12/12/2013	184	4.03	125.2	129.2	3.2
Subject 2	6/6/2013	8/26/2013	81	1.77	124.8	126.6	1.4
Subject 2	6/6/2013	8/26/2013	81	1.77	124.8	126.6	1.4
Subject 2	6/6/2013	8/26/2013	81	1.77	124.8	126.6	1.4
Subject 2	6/6/2013	8/26/2013	81	1.77	124.8	126.6	1.4
Subject 2	6/6/2013	8/26/2013	81	1.77	124.8	126.6	1.4
Subject 2	6/6/2013	8/29/2013	84	1.84	124.8	126.6	1.4
Subject 2	6/6/2013	8/29/2013	84	1.84	124.8	126.6	1.4
Subject 2	6/6/2013	10/31/2013	148	3.24	124.8	126.6	1.5
Subject 2	6/6/2013	10/31/2013	148	3.24	124.8	126.6	1.5
Subject 2	6/6/2013	10/31/2013	148	3.24	124.8	128.0	2.6
Subject 2	6/6/2013	10/31/2013	148	3.24	124.8	128.0	2.6
Subject 2	6/6/2013	10/31/2013	148	3.24	124.8	128.0	2.6

The expected growth increases to bi-acetabular breadth are based on the growth rate (0.0219 mm/day, Fig. S1) measured herein and the number which passed between the previous measurement of the chimpanzees in this study.