Electronic Supplementary Materials

Healthy cardiovascular biomarkers across the lifespan in wild-born chimpanzees

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Supplemental methods

Veterinary exams and blood collection in sanctuary chimpanzees

Blood collection at the sanctuaries occurred during routine health exams where chimpanzees were monitored by veterinarians and animal caregivers. Following standard safety protocols, chimpanzees fasted overnight and then were anesthetized (5 mg/kg ketamine and 0.05 mg/kg medetomidine administered intramuscularly at both sites). Chimpanzees were generally darted or hand-injected with anesthetic inside a familiar indoor dormitory and then moved to an on-site veterinary clinic or exam table. During the exam, sanctuary veterinarians collected blood samples via venipuncture from either the median cubital vein or femoral vein. One female at Ngamba was nursing an infant across both sampling timepoints; none were known to be pregnant at time of sampling, but another two females had given birth previously.

As mentioned in the main text, we conducted rapid on-site diagnostics of blood lipid levels using a portable Alere Cholestech LDX System. This machine can use a small sample (40 μL) of either whole blood or heparinized blood to measure biomarker concentration using enzymatic methodology; this method conforms to clinical reference standards [1] and provides comparable readings across species due to the conservative structure of the cholesterol molecule [2,3]. Due to differences in exam procedures at the two sites, we used whole blood at Ngamba and heparinized blood at Tchimpounga; both sample types are well-validated to produce comparable readings in this analyzer [4,5]. At both locations, assays were initiated rapidly after blood collection (within approximately 1-2 minutes). We used the Lipid Profile/GLU cassette to measure total cholesterol (TC), triglycerides (TRG), and high-density lipoprotein (HDL). Low-density lipoprotein (LDL) was automatically calculated using the Friedewald equation (LDL = TC-HDL-[TRG/5]). We followed recommended guidelines for storing reagent cassettes at cool temperatures and allowing them to reach room temperature prior to use. We also ran two external quality controls with each new lot of cassettes as well as daily optics checks before exams to ensure quality control on the machine's readings.

In some cases, the chimpanzees' readings fell outside the instrument's sensitivity. For example, total cholesterol under 100 mg/dL could not be detected. In these cases, we assumed the most conservative possible value: a measurement reported as <100 mg/dL was assigned a value of 99 mg/dL (N = 1 observation); triglycerides <45 mg/dL were assigned 44 mg/dL (N = 21 observations); and HDL >100 mg/dL was assigned 101 mg/dL (N = 2 observations). In this way we followed the same approach for field work with human populations [3].

Statistical analyses

As described in the main text, we analyzed data in R version 3.6.1 [6]. We implemented linear mixed models using the *lmer* function from the lme4 software package. Our general approach was to first construct a base model accounting for *subject identity* (as a random factor to control for unbalanced within-subjects repeated measurements) and *sex*, and then add the subject's

age (and age^2 if relevant), *facility* (laboratory or sanctuary), and the *age X facility* interaction to subsequent models to test the importance of these predictors.

We compared the fit of these different models using likelihood ratio tests [7], and post-hoc tests (both age-related trends and pairwise comparisons of different groups) were implemented using the *emtrends* and *emmeans* functions from the *emmeans* package with a Tukey correction [8]. Linear mixed models were automatically refit using maximum likelihood for these model comparisons. Graphs showing predicted effects, and 95% confidence intervals (CIs) from these models were calculated using the *effects* package in R [9].

In statistical models, we used age as a continuous predictor, but for ease of interpretation some figures depict age cohorts: we considered individuals under 15 years to be juveniles, 15-30 to be adults, and over 30 to be older adults. In general, we collapsed across the three laboratory sites and two sanctuary sites for analyses, comparing across laboratory versus sanctuary-living chimpanzees. In some follow-up analyses, we used information about diet and housing characteristics assigned by the laboratories to assess effects of more specific lifestyle context, therefore splitting the different laboratory or sanctuary sites.

Supplemental results

Body weight

As reported in the main text, our first set of analysis examined age-related change in body weights of sanctuary versus laboratory-living chimpanzees. In model comparisons, body weights (1) increased with *age* [χ^2=12294.00, df=2, p<0.0001]; (2) were lower in sanctuaries [χ^2=77.11, df=1, p<0.0001]; and (3) including the *age X facility* interaction improved model fit [χ^2=101.08, df=2, p<0.0001].

In addition, we ran the same analyses on the subset of adult individuals (ages 15 and up); this included 285 observations from 64 sanctuary chimpanzees and 4262 observations from 304 laboratory chimpanzees. The analysis approach was the same as the full sample except that we only included age as a linear term (as visual inspection indicated weight increased only linearly in adults). As in the main analysis, we found that adult weights (1) increased with *age* [χ^2 = 611.96, df = 1, p < 0.0001]; (2) were lower in sanctuary chimpanzees [χ^2 = 43.00, df = 1, p < 0.0001; *parameter estimate* = -11.05, SE = 1.22, t = -9.05, p < 0.0001]; and there was (3) an interaction between *age* and *facility* [χ^2 = 18.36, df = 1, p < 0.0001]; post-hoc comparison of age trends showed that slopes were more positive in the laboratory sample [p < 0.0001]. Table S1 reports the parameters from the full models for both the complete sample and the adult-only sample.

Skinfolds

As reported in the main text, our first set of analyses examined the relationship between total body weight and combined skinfold thickness (subscapular, inguinal, biceps, triceps) in the adult sanctuary chimpanzees. Individuals with heavier weights had greater total skinfold thickness [χ^2 = 21.55, df = 1, p < 0.0001]. We also looked at each component measurement (see Figure S1).

We analyzed each individual skinfold measurement using the same approach described for the combined score and found similar results. In particular, the inclusion of weight improved model fit for the subscapular measurement [χ^2 = 5.18, df = 1, p < 0.05, N = 61], the inguinal measurement [χ^2 = 15.78, df = 1, p < 0.0001, N = 63], the biceps measurement [χ^2 = 16.12, df = 1, p < 0.0001, N = 63], and the triceps measurement [χ^2 = 12.48, df = 1, p < 0.001, N = 63]. It was not possible to obtain subscapular measurements for 2 individuals due to the timing of the exam.

Table S2 reports parameters from full models, and Figure S1 depicts the relationship between weight and skinfold thickness for each individual measurement.

	Full Sample	**Adult Sample**
Sex *(reference = female)*	*Est*. = 4.61 *SE* = 0.81 *t* = 5.72 *p* < 0.0001	*Est*. = 6.33 *SE* = 1.25 *t* = 5.07 *p* < 0.0001
Age	*Est*. = 4.39 *SE* = 0.03 *t* = 136.34 *p* < 0.0001	*Est*. = 0.45 *SE* = 0.02 *t* = 25.95 *p* < 0.0001
Age^2*	*Est*. = -0.07 *SE* < 0.001 *t* = -91.68 *p* < 0.0001	*NA*
Facility *(reference = laboratory)*	*Est*. = 7.53 *SE* = 3.19 *t* = 2.36 *p* < 0.05	*Est*. = -0.23 *SE* = 3.03 *t* = -0.08 *p* = 0.94
Age X Facility	*Est*. = -1.14 *SE* = 0.33 *t* = -3.45 *p* < 0.001	*Est*. = -0.54 *SE* = 0.13 *t* = -4.29 *p* < 0.0001
Age^2* X Facility	*Est*. < 0.01 *SE* < 0.01 *t* = 0.38 *p* = 0.70	*NA*

Table S1: Predictors for body weight in chimpanzees. The full sample included juvenile chimpanzees; the adult sample limited the analysis to only individuals 15+ years. Parameters are from the full models; note that in some cases the full model was not the best fit model, and relevant estimates for significant predictors are sometimes reported in the text. *The adult sample only included *Age*, not the *Age*^{2} term, as adult weights did not show a non-linear trajectory.

	Combined	**Subscapular**	**Inguinal**	**Biceps**	**Triceps**
Sex *(reference = female)*	*Est*. = -7.26 *SE* = 1.08 *t* = -6.72 *p* < 0.0001	*Est*. = -3.00 *SE* = 0.54 *t* = -5.52 *p* < 0.0001	*Est*. = -2.22 *SE* = 0.46 *t* = -4.86 *p* < 0.0001	*Est*. = -0.50 *SE* = 0.24 *t* = -2.10 *p* < 0.05	*Est*. = -1.84 *SE* = 0.31 *t* = -5.87 *p* < 0.0001
Age	*Est*. = 0.11 *SE* = 0.10 *t* = 1.15 *p* = 0.26	*Est*. < -0.01 *SE* = 0.05 *t* = -0.07 *p* = 0.95	*Est*. = 0.10 *SE* = 0.04 *t* = 2.54 *p* < 0.05	*Est*. = 0.01 *SE* = 0.02 *t* = 0.27 *p* = 0.79	*Est*. = 0.03 *SE* = 0.03 *t* = 1.03 *p* = 0.31
Weight	*Est*. = 0.34 *SE* = 0.07 *t* = 4.81 *p* < 0.0001	*Est*. = 0.08 *SE* = 0.04 *t* = 2.36 *p* < 0.05	*Est*. = 0.12 *SE* = 0.03 *t* = 4.08 *p* < 0.001	*Est*. = 0.06 *SE* = 0.01 *t* = 4.12 *p* < 0.001	*Est*. = 0.07 *SE* = 0.02 *t* = 3.57 *p* < 0.001

Table S2: Predictors for skinfold thickness in sanctuary chimpanzees. These analyses included only adult chimpanzees aged 15 years and older from the sanctuary sites. Parameters are from the full models.

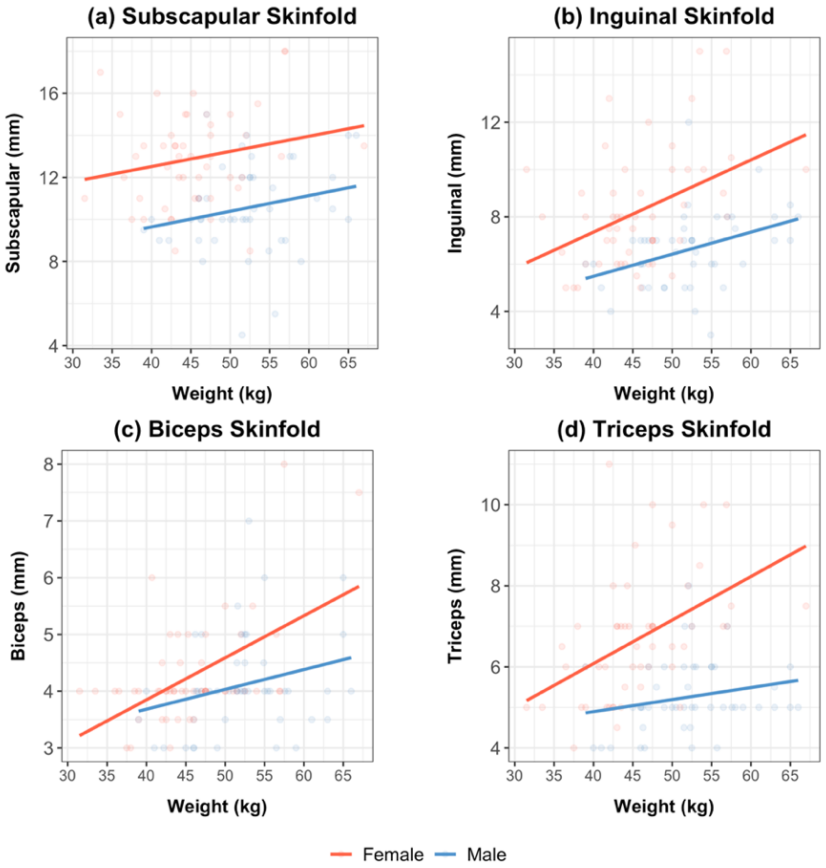

Figure S1: Skinfold measurements in adult sanctuary chimpanzees. Scatterplots of the relationship between body weight and skinfolds, split by sex for (a) subscapular skinfold; (b) inguinal skinfold; (c) biceps skinfold; and (d) triceps skinfold.

Total cholesterol

As reported in the main text, our first set of analysis for total cholesterol examined age-related change in sanctuary versus laboratory-living chimpanzees. Total cholesterol (1) decreased with *age* [$\chi^2 = 397.93$, df = 1, $p < 0.0001$]; (2) was lower overall in sanctuary chimpanzees [$\chi^2 = 52.81$, df = 1, $p < 0.0001$]; and (3) addition of the *age X facility* interaction improved fit [$\chi^2 = 7.43$, df = 1, $p < 0.01$]. In addition, we ran the same analyses on the subset of adult individuals (ages 15 and up) and for individuals where we had time-matched weight measurements. Table S3 reports the parameters from the full models for the complete sample, the adult-only sample, and the sample controlling for weights.

The adult analysis included 99 observations from 63 sanctuary chimpanzees and 2535 observations from 324 laboratory chimpanzees. As in the main analysis, we found that adult total cholesterol (1) declined with *age* [$\chi^2 = 22.93$, df = 1, $p < 0.0001$]; (2) was lower in sanctuary chimpanzees [$\chi^2 = 57.88$, df = 1, $p < 0.0001$]; and there was (3) a trend for an interaction between *age* and *facility* [$\chi^2 = 3.40$, df = 1, $p = 0.07$].

The analysis controlling for weight included 120 observations from 73 sanctuary chimpanzees and 2996 observations from 407 laboratory chimpanzees. As in the main analysis, we found that when controlling for weight, total cholesterol (1) declined with *age* [$\chi^2 = 14.12$, df

= 1, p < 0.001]; (2) was lower in sanctuary chimpanzees [χ^2 = 72.17, df = 1, p < 0.0001]; and there was (3) a trend for an interaction between *age* and *facility* [χ^2 = 2.74, df = 1, p = 0.10].

	Full Sample	**Adult Sample**	**Weight Sample**
Weight*	*NA*	*NA*	*Est*. = -0.67 *SE* = 0.05 *t* = -12.66 *p* < 0.0001
Sex *(reference = female)*	*Est*. = -17.13 *SE* = 3.41 *t* = -5.02 *p* < 0.0001	*Est*. = -15.29 *SE* = 3.96 *t* = -3.86 *p* < 0.001	*Est*. = -10.87 *SE* = 3.55 *t* = -3.06 *p* < 0.01
Age	*Est*. = -1.69 *SE* = 0.08 *t* = -20.56 *p* < 0.0001	*Est*. = -0.71 *SE* = 0.14 *t* = -5.13 *p* < 0.0001	*Est*. = -0.34 *SE* = 0.13 *t* = -2.74 *p* < 0.01
Facility *(reference = laboratory)*	*Est*. = -85.46 *SE* = 17.39 *t* = -4.91 *p* < 0.0001	*Est*. = -87.07 *SE* = 23.58 *t* = -3.69 *p* < 0.001	*Est*. = -71.87 *SE* = 16.50 *t* = -4.35 *p* < 0.0001
Age X Facility	*Est*. = 2.25 *SE* = 0.82 *t* = 2.72 *p* < 0.01	*Est*. = 1.94 *SE* = 1.05 *t* = 1.84 *p* = 0.07	*Est*. = 1.30 *SE* = 0.78 *t* = 1.66 *p* = 0.10

Table S3: Predictors for total cholesterol in chimpanzees. The full sample included all chimpanzees; the adult sample was limited to individuals 15+ years; the weight sample included measurements with associated weights. Parameters are from the full models; note that in some cases the full model was not the best fit model, and relevant estimates for significant predictors are sometimes reported in the text. *Weight was only controlled in the weight sample.

Triglycerides

As reported in the main text, our first set of analysis for triglycerides examined age-related change in sanctuary versus laboratory-living chimpanzees. Triglycerides (1) increased with *age* [χ^2 = 353.52, df = 1, p < 0.0001]; (2) were lower overall in sanctuary chimpanzees [χ^2 = 12.11, df = 1, p < 0.001; *parameter estimate* = -15.13, SE = 4.35, t = -3.48, p < 0.001]; and (3) including the *age X facility* interaction improved fit [χ^2 = 6.90, df = 1, p < 0.01]. In addition, we ran the same analyses on the subset of adult individuals (ages 15 and up) and for individuals where we had time-matched weight measurements. Table S4 reports the parameters from the full models for the complete sample, the adult-only sample, and the sample controlling for weights.

The adult analysis included 99 observations from 63 sanctuary chimpanzees and 2359 observations from 320 laboratory chimpanzees. As in the main analysis, adult triglycerides (1) increased with *age* [χ^2 = 58.33, df = 1, p < 0.0001]; (2) were lower in sanctuary chimpanzees [χ^2 = 7.43, df = 1, p < 0.01, *parameter estimate* = -15.36, SE = 5.64, t = -2.72, p < 0.01]; and there was (3) a trend for an interaction between *age* and *facility* [χ^2 = 3.47, df = 1, p = 0.06].

The analysis controlling for weight included 120 observations from 73 sanctuary chimpanzees and 2795 observations from 404 laboratory chimpanzees. As in the main analysis, we found that when controlling for weight, triglycerides (1) increased with *age* [χ^2 = 6.78, df = 1,

$p < 0.01$]; (2) trended to be lower in sanctuary chimpanzees [$\chi^2 = 3.16$, df = 1, p = 0.08; *parameter estimate* = -7.45, SE = 4.20, t = -1.77, p = 0.08]; and there was (3) a trend for improvement in model fit by including the interaction between *age* and *facility* [$\chi^2 = 5.07$, df = 2, p = 0.08].

	Full Sample	**Adult Sample**	**Weight Sample**
Weight*	*NA*	*NA*	*Est*. = 0.49 *SE* = 0.06 *t* = 8.62 *p* < 0.0001
Sex *(reference = female)*	*Est*. = -3.70 *SE* = 2.44 *t* = -1.52 *p* = 0.13	*Est*. = -10.48 *SE* = 3.65 *t* = -2.87 *p* < 0.01	*Est*. = -11.66 *SE* = 2.60 *t* = -4.49 *p* < 0.0001
Age	*Est*. = 1.58 *SE* = 0.08 *t* = 19.53 *p* < 0.0001	*Est*. = 1.26 *SE* = 0.16 *t* = 7.78 *p* < 0.0001	*Est*. = 0.37 *SE* = 0.12 *t* = 3.00 *p* < 0.01
Facility *(reference = laboratory)*	*Est*. = 19.32 *SE* = 13.82 *t* = 1.40 *p* = 0.16	*Est*. = 26.54 *SE* = 23.23 *t* = 1.14 *p* = 0.25	*Est*. = 9.71 *SE* = 13.14 *t* = 0.74 *p* = 0.46
Age X Facility	*Est*. = -1.72 *SE* = 0.65 *t* = -2.62 *p* < 0.01	*Est*. = -1.92 *SE* = 1.03 *t* = -1.86 *p* = 0.06	*Est*. = -0.86 *SE* = 0.62 *t* = -1.38 *p* = 0.17

Table S4: Predictors for triglycerides in chimpanzees. The full sample included juvenile chimpanzees; the adult sample limited the analysis to only individuals aged 15 years and older; the weight sample included only those individuals where there were associated weight measurements. Parameters are from the full models; note that in some cases the full model was not the best fit model, and relevant estimates for significant predictors are sometimes reported in the text. *Weight was controlled for only in the weight sample.

High-density lipoproteins

As reported in the main text, our first set of analysis for HDLs examined age-related change in sanctuary versus laboratory-living chimpanzees. We found that HDLs (1) decreased with *age* [$\chi^2 = 9.44$, df = 1, $p < 0.01$]; (2) sanctuaries trended to have lower levels overall than laboratories [$\chi^2 = 3.57$, df = 1, p = 0.06]; and (3) inclusion of the *age X facility* interaction improved fit [$\chi^2 = 7.10$, df = 2, $p < 0.05$]. In addition, we ran the same analyses on the subset of adult individuals (ages 15 and up) and for individuals where we had time-matched weight measurements. Table S5 reports the parameters from the full models for the complete sample, the adult-only sample, and the sample controlling for weights.

The adult analysis included 99 observations from 63 sanctuary chimpanzees and 100 observations from 38 laboratory chimpanzees. We found that adult HDLs (1) did not show significant age-related change [$\chi^2 = 0.44$, df = 1, p = 0.51]; (2) did not differ between sanctuary and laboratory facilities [$\chi^2 = 2.14$, df = 2, p = 0.34]; and there was (3) a trend for the interaction between *age* and *facility* to improve fit compared to the base model [$\chi^2 = 6.35$, df = 3, p = 0.10].

The analysis controlling for weight included 120 observations from 73 sanctuary chimpanzees and 206 observations from 84 laboratory chimpanzees. We found that when

controlling for weights, HDLs (1) did not show significant age-related change [$\chi^{2=}$ 0.33, df = 1, p = 0.57]; (2) but was lower in sanctuary chimpanzees [$\chi^{2=}$ 10.90, df = 1, p < 0.001; *parameter estimate* = -12.58; *SE* = 3.81; *t* = -3.31; *p* < 0.01]; and there was (3) no improvement in model fit by including the interaction between *age* and *facility* [$\chi^{2=}$ 0.19, df = 1, p = 0.67].

A final analysis examined the ratio of total cholesterol to HDLs [10] in the full sample. We found that TC/HDLs (1) did not show significant age-related change [χ^2 = 0.33, df = 1, p = 0.57]; (2) but was lower in sanctuary chimpanzees [χ^2 = 36.46, df = 2, p < 0.0001; *parameter estimate* = -1.10; SE = 0.18; t = -6.31; p<0.0001]; and there was (3) no improvement in model fit by including the interaction between *age* and *facility* [χ^2 = 1.81, df = 1, p = 0.18].

	Full Sample	**Adult Sample**	**Weight Sample**	**TC/HDLs ratio**
Weight*	*NA*	*NA*	*Est*. = -0.45 *SE* = 0.13 *t* = -3.47 *p* < 0.001	*NA*
Sex *(reference = female)*	*Est*. = -3.85 *SE* = 3.44 *t* = -1.12 *p* = 0.27	*Est*. = -3.99 *SE* = 4.62 *t* = -0.86 *p* = 0.39	*Est*. = -2.98 *SE* = 3.33 *t* = -0.90 *p* = 0.37	*Est*. = 0.10 *SE* = 0.16 *t* = 0.60 *p* = 0.55
Age	*Est*. = -0.65 *SE* = 0.23 *t* = -2.82 *p* < 0.01	*Est*. = -1.73 *SE* = 0.82 *t* = -2.11 *p* < 0.05	*Est*. = 0.25 *SE* = 0.35 *t* = 0.72 *p* = 0.47	*Est*. = 0.04 *SE* = 0.01 *t* = 3.29 *p* < 0.01
Facility *(reference = laboratory)*	*Est*. = -22.99 *SE* = 9.38 *t* = -2.45 *p* < 0.05	*Est*. = -52.37 *SE* = 23.36 *t* = -2.24 *p* < 0.05	*Est*. = -16.18 *SE* = 9.20 *t* = -1.76 *p* = 0.08	*Est*. = -0.56 *SE* = 0.45 *t* = -1.24 *p* = 0.22
Age X Facility	*Est*. = 0.86 *SE* = 0.46 *t* = 1.86 *p* = 0.06	*Est*. = 2.04 *SE* = 1.00 *t* = 2.03 *p* < 0.05	*Est*. = 0.21 *SE* = 0.48 *t* = 0.43 *p* = 0.67	*Est*. = -0.03 *SE* = 0.02 *t* = -1.33 *p* = 0.19

Table S5: Predictors for HDLs in chimpanzees. The full sample included juvenile chimpanzees (this was also the sample used in the analysis of TC/HDLs); the adult sample limited the analysis to only individuals aged 15 years and older; the weight sample included only individuals with associated weight measurements. Parameters are from the full models; note that in some cases the full model was not the best fit model, and relevant estimates for significant predictors are sometimes reported in the text. *Weight was controlled for only in the weight sample.

Low-density lipoproteins

As reported in the main text, our first set of analysis for LDL examined age-related change in sanctuary versus laboratory-living chimpanzees. LDLs (1) decreased with *age* [$\chi^{2=}$ 15.98, df = 1, p < 0.0001; *parameter estimate* = -1.51, SE = 0.37, t = -4.06, p < 0.0001]; (2) sanctuaries had lower levels than laboratories [χ^2 = 100.13, df = 1, p<0.0001]; but (3) there was no improvement by including *age X facility* [$\chi^{2=}$ 1.14, df = 1, p = 0.29]. In addition, we ran the same analyses on the subset of adult individuals (ages 15 and up) and for individuals where we had time-matched weight measurements. Table S6 reports the parameters from the full models for the complete sample, the adult-only sample, and the sample controlling for weights.

The adult analysis included 99 observations from 63 sanctuary chimpanzees and 93 observations from 38 laboratory chimpanzees. We found that adult LDLs (1) did not show significant age-related change [χ^2 = 1.83, df = 1, p = 0.18]; (2) but was lower in sanctuary chimpanzees [χ^2 = 76.21, df = 2, p < 0.0001]; and there was (3) a trend for improvement in model fit by including the interaction between *age* and *facility* [χ^2 = 3.83, df = 1, p = 0.05].

The analysis controlling for weight included 120 observations from 73 sanctuary chimpanzees and 196 observations from 84 laboratory chimpanzees. We found that when controlling for weights, LDLs (1) declined with *age* [χ^2 = 8.07, df = 1, p < 0.01]; (2) was lower in sanctuary chimpanzees [χ^2 = 114.73, df = 1, p < 0.0001]; and there was (3) no improvement in model fit by including the interaction between *age* and *facility*.

	Full Sample	**Adult Sample**	**Weight Sample**
Weight*	*NA*	*NA*	*Est*. = -0.72 *SE* = 0.19 *t* = -3.86 *p* < 0.001
Sex *(reference = female)*	*Est*. = -6.19 *SE* = 5.03 *t* = -1.23 *p* = 0.22	*Est*. = -2.93 *SE* = 6.23 *t* = -0.47 *p* = 0.64	*Est*. = -4.85 *SE* = 4.98 *t* = -0.97 *p* = 0.33
Age	*Est*. = -0.36 *SE* = 0.34 *t* = -1.04 *p* = 0.30	*Est*. = -1.57 *SE* = 1.11 *t* = -1.41 *p* = 0.16	*Est*. = 1.13 *SE* = 0.51 *t* = 2.20 *p* < 0.05
Facility *(reference = laboratory)*	*Est*. = -74.97 *SE* = 13.53 *t* = -5.54 *p* < 0.0001	*Est*. = -123.72 *SE* = 31.34 *t* = -3.95 *p* < 0.001	*Est*. = -63.33 *SE* = 13.63 *t* = -4.65 *p* < 0.0001
Age X Facility	*Est*. = 0.71 *SE* = 0.68 *t* = 1.05 *p* = 0.29	*Est*. = 2.59 *SE* = 1.35 *t* = 1.93 *p* = 0.06	*Est*. = -0.40 *SE* = 0.72 *t* = -0.55 *p* = 0.58

Table S6: Predictors for LDLs in chimpanzees. The full sample included juvenile chimpanzees; the adult sample limited the analysis to only individuals aged 15 years and older; the weight sample included individuals where there were associated weight measurements. Parameters are from the full models; note that in some cases the full model was not the best fit model, and relevant estimates for significant predictors are sometimes reported in the text. *Weight was controlled for only in the weight sample.

Lifestyle comparisons

As reported in the main text, we then used information of the different laboratory facilities' diet and housing space to examine how more specific lifestyle characteristics shaped weight, total cholesterol, and triglyceride profiles; HDL and LDL measurements were all from a single facility and thus could not be included here. For each biomarker, we conducted the same basic analyses as before but examined lifestyle category (free-ranging / plant diet; outdoors / mixed diet; some outdoors / chow diet; and indoors / chow diet) rather than facility (laboratory or sanctuary) as our predictor. In each case, we first added *age*, then *lifestyle* type, then the *age X lifestyle* interaction.

Figure S2 plots the effects and Table S7 reports the parameters from the full models for the each of these analyses. Parameters reported are from the full models.

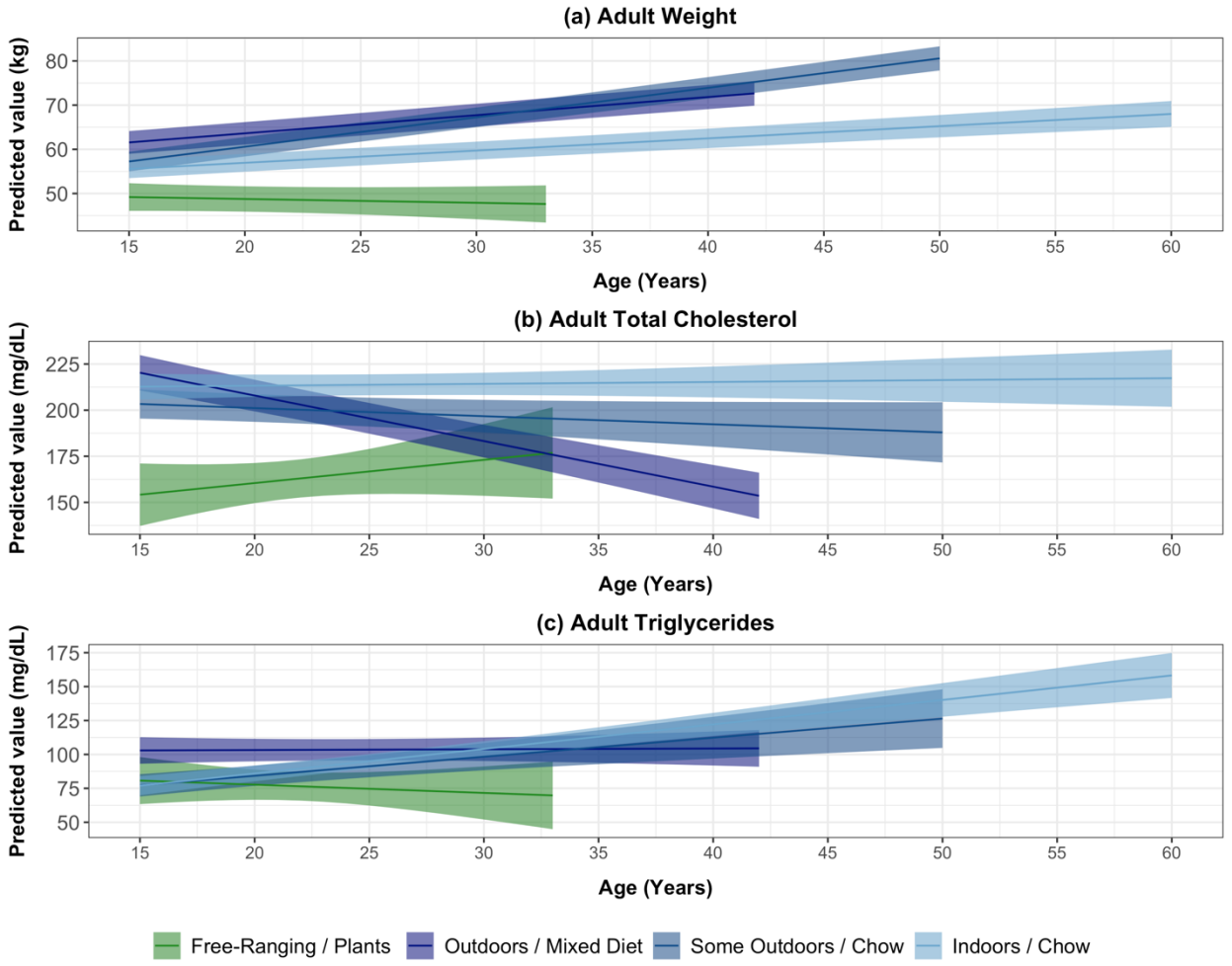

Figure S2: Age-related changes in adult chimpanzees' cardiac biomarkers by lifestyle. Estimates of age-related changes in adults' (a) weight; (b) total cholesterol, and (c) triglycerides. Ribbons indicate 95% confidence interval estimates from model accounting for individual identity, sex, age, and lifestyle. Here, sanctuary chimpanzees are denoted as 'Free-ranging / Plants' and laboratory populations are split based on diet and housing status.

For analyses of body weight, addition of *age* improved model fit [$\chi^{2} = 611.96$, df = 1, $p < 0.0001$; *parameter estimate* = 0.45, SE = 0.02, t = 25.83, $p < 0.0001$]. Inclusion of *lifestyle* type further improved model fit [$\chi^{2} = 64.96$, df = 3, $p < 0.0001$] with lower weights in the sanctuaries compared to all laboratories as well as specifically in the indoors / chow group compared to the other laboratories [$p < 0.01$ for all comparisons]. Addition of the *age X lifestyle* interaction further improved fit [$\chi^{2} = 101.72$, df = 3, $p < 0.0001$]; post-hoc comparisons of age trends revealed lower slopes in sanctuaries as well as in the indoors / chow group compared to the other laboratories [$p < 0.05$ for all comparisons]. As such, the laboratory group living inside had lower body weight as

well as less adult weight gain than the other laboratory groups, possibly due to reduced muscle mass stemming from differences in ranging and exercise access.

	Weight	**Total Cholesterol**	**Triglycerides**
Sex *(reference = female)*	*Est*. = 5.86 *SE* = 1.22 *t* = 4.82 *p* < 0.0001	*Est*. = -13.08 *SE* = 3.90 *t* = -3.35 *p* < 0.001	*Est*. = -8.22 *SE* = 3.78 *t* = -2.17 *p* < 0.05
Age	*Est*. = -0.09 *SE* = 0.12 *t* = -0.71 *p* = 0.48	*Est*. = 1.26 *SE* = 1.02 *t* = 1.24 *p* = 0.22	*Est*. = -0.61 *SE* = 1.03 *t* = -0.59 *p* = 0.56
Outdoors / mixed diet Lifestyle *(reference = free-ranging / plants)*	*Est*. = 4.88 *SE* = 3.22 *t* = 1.52 *p* = 0.13	*Est*. = 122.03 *SE* = 23.99 *t* = 5.09 *p* < 0.0001	*Est*. = 12.23 *SE* = 24.72 *t* = 0.50 *p* = 0.62
Some outdoors / chow Lifestyle *(reference = free-ranging / plants)*	*Est*. = -3.27 *SE* = 3.15 *t* = -1.04 *p* = 0.30	*Est*. = 74.64 *SE* = 23.55 *t* = 3.17 *p* < 0.01	*Est*. = -33.70 *SE* = 24.43 *t* = -1.38 *p* = 0.17
Indoors / chow Lifestyle *(reference = free-ranging / plants)*	*Est*. = 0.91 *SE* = 3.15 *t* = 0.29 *p* = 0.77	*Est*. = 75.88 *SE* = 23.45 *t* = 3.24 *p* < 0.01	*Est*. = -39.99 *SE* = 23.93 *t* = -1.67 *p* = 0.10
Age X Outdoors / mixed diet Lifestyle	*Est*. = 0.50 *SE* = 0.13 *t* = 3.96 *p* < 0.001	*Est*. = -3.73 *SE* = 1.05 *t* = -3.55 *p* < 0.001	*Est*. = 0.66 *SE* = 1.08 *t* = 0.62 *p* = 0.54
Age X Some outdoors / chow Lifestyle	*Est*. = 0.75 *SE* = 0.13 *t* = 5.97 *p* < 0.0001	*Est*. = -1.70 *SE* = 1.05 *t* = -1.62 *p* = 0.11	*Est*. = 2.01 *SE* = 1.09 *t* = 1.85 *p* = 0.06
Age X Indoors / chow Lifestyle	*Est*. = 0.36 *SE* = 0.13 *t* = 2.87 *p* < 0.01	*Est*. = -1.16 *SE* = 1.04 *t* = -1.11 *p* = 0.27	*Est*. = 2.41 *SE* = 1.05 *t* = 2.29 *p* < 0.05

Table S7: Lifestyle and chimpanzee cardiac biomarkers. All models examined adults only and parameters are from the full models. Note that in some cases the full model was not the best fit model, and relevant estimates for significant predictors are sometimes reported in the text.

For analyses of total cholesterol, addition of *age* improved model fit [$\chi^2 = 22.93$, df = 1, $p < 0.0001$, *parameter estimate* = -0.70, SE = 0.14, t = -5.00, $p<0.0001$]. Inclusion of *lifestyle* type further improved model fit [$\chi^2 = 73.46$, df = 3, $p < 0.0001$] with lower cholesterol in the sanctuaries compared to all laboratories as well as higher cholesterol in the indoor / chow group compared to the other laboratories [$p < 0.01$ for significant comparisons]. Addition of the *age X lifestyle* interaction further improved fit [$\chi^2 = 62.85$, df = 3, $p < 0.0001$]; post-hoc comparisons of age trends revealed lower slopes in the outdoors / mixed diet group compared to all others [$p < 0.01$ for significant comparisons]. As such, it seems like our overall finding of decreasing cholesterol with age is driven by this one laboratory population.

For analyses of triglycerides, addition of *age* improved model fit [$\chi^2 = 58.33$, df = 1, $p < 0.0001$, *parameter estimate* = 1.24, SE = 0.16, t = 7.73, $p < 0.0001$]. Inclusion of *lifestyle* type further improved model fit [$\chi^2 = 14.14$, df = 3, $p < 0.01$] with lower triglycerides in the sanctuaries compared to the outdoors / mixed diet group specifically [$p < 0.01$]. Addition of the *age X lifestyle* interaction further improved fit [$\chi^2 = 22.36$, df = 3, $p < 0.0001$]; post-hoc comparisons of age trends revealed lower slopes in the outdoors / mixed diet group compared to both of the other laboratories [$p < 0.05$ for significant comparisons].

Comparisons across all five sites

As reported in the main text, our final set of analyses compared weights, total cholesterol, and triglycerides across all five sites (i.e., similar to the prior set of analyses but here splitting the two sanctuaries). For each biomarker, we conducted a modified version of those analyses: a base model included *sex* and *age* as predictors, and the full model included *site* to test its importance. We did not examine the *age X site* interaction here, as one of the sanctuaries included a fairly restricted age range (and further, splitting the sanctuaries reduced their sample size). Table S8 reports the parameters from the full models for the each of these analyses. Parameters reported are from the full models.

	Weight	**Total Cholesterol**	**Triglycerides**
Sex *(reference = female)*	*Est*. = 6.23 *SE* = 1.22 *t* = 5.09 *p* < 0.0001	*Est*. = -14.25 *SE* = 3.92 *t* = -3.63 *p* < 0.001	*Est*. = -9.19 *SE* = 3.68 *t* = -2.50 *p* < 0.05
Age	*Est*. = 0.44 *SE* = 0.02 *t* = 25.63 *p* < 0.0001	*Est*. = -0.73 *SE* = 0.14 *t* = -5.25 *p* < 0.0001	*Est*. = 1.18 *SE* = 0.16 *t* = 7.28 *p* < 0.0001
Some outdoors / chow lifestyle *(reference = indoors / chow)*	*Est*. = 4.94 *SE* = 1.52 *t* = 3.25 *p* < 0.01	*Est*. = -16.06 *SE* = 4.87 *t* = -3.29 *p* < 0.01	*Est*. = -4.78 *SE* = 4.62 *t* = -1.04 *p* = 0.30
Outdoors / mixed diet lifestyle *(reference = indoors / chow)*	*Est*. = 7.41 *SE* = 1.66 *t* = 4.48 *p* < 0.0001	*Est*. = -16.71 *SE* = 5.18 *t* = -3.22 *p* < 0.01	*Est*. = 8.98 *SE* = 4.72 *t* = 1.90 *p* = 0.06
Ngamba *(reference = indoors / chow)*	*Est*. = -8.65 *SE* = 2.07 *t* = -4.18 *p* < 0.0001	*Est*. = -44.55 *SE* = 7.11 *t* = -6.27 *p* < 0.0001	*Est*. = -15.88 *SE* = 6.86 *t* = -2.32 *p* < 0.05
Tchimpounga *(reference = indoors / chow)*	*Est*. = -5.36 *SE* = 2.73 *t* = -1.96 *p* = 0.05	*Est*. = -71.81 *SE* = 9.78 *t* = -7.35 *p* < 0.0001	*Est*. = -11.88 *SE* = 10.02 *t* = -1.18 *p* = 0.24

Table S8: Specific site and chimpanzee cardiac biomarkers. All models examined adults only and parameters are from the full models. Note that in some cases the full model was not the best fit model, and relevant estimates for significant predictors are sometimes reported in the text.

For analyses of body weight, inclusion of *site* improved model fit [$\chi^{2} = 66.10$, df = 4, $p < 0.0001$] with lower weights in the sanctuaries compared to all laboratories as well as specifically in the indoors / chow group compared to the other laboratories [$p < 0.01$ for all comparisons]. For analyses of total cholesterol, inclusion of *site* again improved model fit [$\chi^{2} = 79.29$, df = 4, $p < 0.0001$] with lower cholesterol in the sanctuaries compared to all laboratories as well as higher cholesterol in the indoor / chow group compared to the other laboratories [$p < 0.01$ for significant comparisons]. For analyses of triglycerides, again inclusion of *site* improved model fit [$\chi^{2} = 14.26$, df = 4, $p < 0.01$] with lower triglycerides in one sanctuary compared to one of the labs, specifically the outdoors / mixed diet group [$p < 0.01$].

This confirmed that both sanctuaries had lower weight and total cholesterol in comparison to all three laboratory populations and did not differ from each other. Triglycerides were more similar across all five sites in this analysis, but note that sample size was here more limited, and we could not account for different age effects across populations in this analysis due to differences in site-specific age ranges.

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