



Fatherhood, egalitarianism, and child health in two small-scale societies in the Republic of the Congo

Adam H. Boyette¹  | Sheina Lew-Levy² | Mallika S. Sarma³ |
Miegakanda Valchy⁴ | Lee T. Gettler⁵ 

¹Department of Human Behavior, Evolution, and Culture, Max Planck Institute for Evolutionary Anthropology, Leipzig, Germany

²Department of Psychology, Simon Fraser University, Burnaby, British Columbia, Canada

³Department of Anthropology, University of Notre Dame, Notre Dame, Indiana, USA

⁴Laboratoire de Santé Publique, Brazzaville, Republic of the Congo

⁵Department of Anthropology, Eck Institute for Global Health, William J. Shaw Center for Children and Families, University of Notre Dame, Notre Dame, Indiana

Correspondence

Adam H. Boyette, Department of Human Behavior, Evolution, and Culture, Max Planck Institute for Evolutionary Anthropology, Deutscher Platz 6, 04103 Leipzig, Germany.
Email: ahboyette@gmail.com

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Abstract

Objectives: The study goals were to (a) characterize the cultural model of fatherhood among the BaYaka, a community of egalitarian foragers in the Republic of the Congo; (b) test if BaYaka fathers' quality in relation to the cultural model predicts their children's energetic status; and (c) compare the variance in BaYaka children's energetic status to that of children of neighboring Bondongo fisher-farmers, among whom there is less cooperative caregiving, less resource sharing, and greater social inequality.

Methods: We used informal interviews to establish the cultural model of fatherhood, which we used to build a peer ranking task to quantify father quality. Children's energetic status was assessed by measuring height, weight, and triceps skinfold thickness. We then tested for associations between father quality scores derived from the ranking task and children's energetic status using ordinary least squares regression. Equality of variance tests were used to compare BaYaka and Bondongo children's energetic statuses.

Results: The BaYaka described fathers as responsible for acquiring resources and maintaining marital harmony, welcoming others to the community and sharing well with them, and teaching their children about the forest. Agreement on men's quality in these domains was high, but father quality did not significantly predict children's energetic status. BaYaka children had lower variance in energetic status overall compared to Bondongo children.

Conclusions: We suggest that the core BaYaka values and practices that maintain egalitarian social relations and distribution of resources help buffer children's health and well-being from variation in their fathers' qualities in culturally valued domains.

1 | INTRODUCTION

As a species, humans have a “slow” life history strategy, but it is coupled to the production of costly offspring with

overlapping periods of dependency. Mothers' cooperation with a diverse array of caregiving partners was crucial to the evolutionary emergence and success of this strategy (Hawkes & Coxworth, 2013; Hill & Hurtado, 2009;

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Kaplan, Hill, Lancaster, & Hurtado, 2000; Kramer, 2010; Rosenbaum & Gettler, 2018). Drawing on these perspectives, a growing body of evolutionary-oriented research has helped shed light on allomaternal caregivers' contributions to family resources and function, and to children's survival, health, and development in various socioecological contexts (Hawkes, O'Connell, Blurton Jones, & Charnov, 1998; Hrdy, 2009; Meehan, Helfrecht, & Quinlan, 2014; Sear, Mace, & McGregor, 2000; Shenk, Starkweather, Kress, & Alam, 2013). For example, research in Jamaica has found that both familial and institutional (nonkin) alloparental care, respectively, can promote healthy trajectories for children's growth (Nelson, 2016). Within the family, research incorporating framing from the Grandmother Hypothesis has demonstrated that grandmothers have a greater overall effect on child survival and health than do fathers in multiple small-scale societies (Sear & Mace, 2008). However, fathers do often allocate resources to indirect and direct care of their offspring, and studies in multiple settings have shown that fathers often commit more time and capital to their biological- vs step-children, aligning with evolutionary predictions (Anderson, Kaplan, Lam, & Lancaster, 1999; Anderson, Kaplan, & Lancaster, 1999; Marlowe, 2003). Moreover, evolutionary-framed research on fathering in small-scale societies has helped expand our understanding of the pathways through which fathers can influence child outcomes, including via direct care (Boyette, Lew-Levy, & Gettler, 2018), cultivation of social capital (Scelza, 2010), and acquisition of status (C. von Rueden, Gurven, & Kaplan, 2008).

Meanwhile, the variation in these patterns within- and across-cultures speaks to the utility of integrative, biocultural approaches that seek to understand how humans' evolved biological systems are expressed in and shaped by cultural value systems and institutions, yielding bio-behavioral profiles and health outcomes that vary by context (Dressler & Bindon, 2000; Fox, Thayer, & Wadhwa, 2017; Gettler, 2014; Hoke & McDade, 2014; Worthman, 2010). Indeed, from a number of theoretical perspectives, such as the embodied capital model (Kaplan, 1996; Kaplan et al., 2000) as well as the family systems/family ecology perspective (Bronfenbrenner, 1996; Cox & Paley, 1997), parents are an important conduit between the social and ecological context and their children's growth and development. As one component of human family systems, fathers contribute in diverse ways to their children's growth, development, and social and emotional well-being across societies. Evolutionary research suggests that men have evolved a "biology of fatherhood" that has facilitated paternal care throughout our evolutionary history (Gettler, McDade, Agustin, & Kuzawa, 2011; Gettler, McDade, Feranil, & Kuzawa, 2011; Gray & Crittenden, 2014; Gray, McHale, & Carré, 2017). However, the ways in which men care for their children vary across

societies depending on the ecology and culture in which men are raised and become fathers (Gettler, 2016; Gray & Anderson, 2010; Harkness & Super, 1992; Shwalb, Shwalb, & Lamb, 2013). Additionally, while societies may have a set of culturally-derived expectations around what men's responsibilities are as fathers, men are also likely to vary in their ability to meet those expectations, and this variation can affect children's health (Boyette et al., 2018).

Most research on fathers' contributions to child outcomes has been conducted in the U.S. and Europe or similar settings and these studies often focus on how the quality of father's caregiving affects children's socioemotional or cognitive development (Lamb, 2010). However, in small-scale, subsistence societies, variation in care can have greater consequences for physical aspects of development (ie, energetic status) (Winking & Koster, 2015). For example, in our prior work, we showed that among the Bondongo, a small community of subsistence fishers and farmers in the Republic of the Congo (ROC), fathers who provided greater direct care (eg, in this case, guiding socialization and caring for children who were ill) had children who were in better energetic status than their peers who received less care (Boyette et al., 2018). Bondongo fathers who were seen as better providers for their families through fishing, hunting, and commercial activities away from the home also had children in better energetic condition, and these indirect care behaviors were more culturally valued than fathers' direct care. Although these findings for fathers' provisioning were no longer significant after controlling for relevant family demographic covariates, these results are consistent with the idea that between-father variation in parenting has implications for children's health in this socially stratified, hierarchical society in which families are largely independent economic units who are responsible for their own production/consumption and community sharing and egalitarianism are not core cultural values (Boyette et al., 2018).

Across societies, fathers' roles are also embedded in larger systems of childcare and community cooperation that differ in the degree of formal and informal support available for families. These systems can potentially buffer children from variation in the quality or quantity of father care. For example, in northern ROC, Bondongo families share their ecology with neighboring BaYaka foragers, whose social values and institutions are largely oriented around sharing (eg, resources, space, time) and egalitarian social relationships within the community (Lewis, 2016). These contrast starkly with the more hierarchical and exchange-based values and institutions of the Bondongo fisher-farmers (Boyette & Lew-Levy, In Press; Hewlett, Lamb, Leyendecker, & Schölmerich, 2000; Hewlett, Lamb, Shannon, Leyendecker, & Schölmerich, 1998). In the present analyses, reflecting the greater influence of egalitarian values and institutions over BaYaka

childrearing, we hypothesized that we would observe relatively attenuated associations between BaYaka fathering quality and children's health and reduced overall variation in children's energetic measures in comparison to patterns among the Bondongo. Specifically, the unique combination of norms of unconditional sharing, respect for children's autonomy, and an intimate but fluid residential context that characterize the rearing environment for BaYaka children means that any one specific caretaker is less critical for meeting their basic needs (Boyette, 2019; Boyette & Lew-Levy, In Press; Hewlett, Hudson, Boyette, & Fouts, In Press). Past research from BaYaka (or Aka) in nearby Central African Republic generally supports this notion, as children in larger camps were in better energetic condition, likely due to the greater number of adults to support dependents, suggesting that cooperative caregiving networks could buffer children against the loss of critical allomaternal care (Meehan et al., 2014). Yet, while BaYaka children receive care and resources from a number of individuals across the day and over the course of childhood, some are more influential than others (Hewlett et al., 2000; Meehan et al., 2014), and who provides more care (at least to infants) depends on the relationship between parents and other potential caretakers (Hewlett, 1988; Meehan, 2005). In particular, among the BaYaka in Meehan and colleagues' study, fathers appear to be less critical to child nutritional well-being than grandmothers (Meehan et al., 2014), mirroring patterns from some other small-scale societies (Sear & Mace, 2008). There is also allomaternal care among the Bondongo, but the social and geographic boundaries of care are more rigid. In other words, while empirical research is needed to confirm it, our ethnographic impression is that care is received only from members of a child's extended family if not from the nuclear family household. Relationships between families are organized by norms of economic exchange (eg, reciprocity) and political status—especially men's status. Thus, in these contexts, we expect the quality of Bondongo fathers as important providers of care and resources, to have a relatively greater effect on their children's well-being.

Our approach to the study of paternal care and child well-being draws from research that has demonstrated that individuals' congruity, or “consonance” to a cultural model (eg, of social status) impacts their health (Dressler & Bindon, 2000; McDade, 2002; Sweet, 2010). In our case, our study design was partially geared toward testing whether men's congruity with locally-valued concepts of fathering correlated with their children's health, which could include pathways that go beyond traditionally measured forms of paternal care such as food/economic provisioning. Our interests in this area are motivated by the fact that definitions of a “good” father vary (Shwalb et al., 2013) and meeting the expectations

of the role of father can influence a range of factors with downstream effects for child health and well-being. For example, while we did not expect Bondongo men's quality as contributors of culturally valued but relatively rare forms of direct care (eg, socialization, caring for sick children) to influence their children's current energetic status, this form of care was a more robust predictor than was quality as a resource provider (ie, contributor of indirect care) (Boyette et al., 2018). However, in the current study, we used qualitative comparison of our prior work among the Bondongo with the current analysis of BaYaka fatherhood to test the idea that cultural differences in values around social inequality and egalitarianism would predict the magnitude to which fathers' “fit” to their culture's model of fatherhood associates with their children's health outcomes. Specifically, while we did not anticipate that BaYaka men would necessarily be more similar in their quality as fathers than the Bondongo, we did predict that the impact of variation in fathering quality on their children's health would be buffered by BaYaka values and institutions.

Additionally, we conducted a direct statistical comparison of the ranges of variation in BaYaka and Bondongo children's energetic statuses, hypothesizing that there would be less variance in BaYaka children's health based on the emphasis on equality of resource access and social status that organizes BaYaka family and community life (eg, Sherry & Marlowe, 2007).

2 | METHODS

2.1 | Study populations

Data for this study were collected in June and July of 2016 (for Bondongo) and 2017 (for BaYaka) in a village along the Motaba river in the Likouala Province of the ROC. Initial permission to conduct research in the village was given by the village council during a community meeting with AHB in 2015. Subsequently, permission was granted each year after a community meeting during which that's year's work was explained. Individual verbal consent was received from all participants upon recruitment for the study subsequent to the village-wide meeting. All fathers and their wives, if married, were eligible to participate if they had children younger than 18 years old. Permission to conduct research in ROC was granted by the Centre de Recherche et D'Études en Sciences Sociales et Humaines, and the research was approved of by the institutional review board of Duke University and the University of Notre Dame.



The study village is home to roughly 400 people, around half BaYaka and half Bondongo, who live in ethnically segregated neighborhoods. The Bondongo part of the village is roughly spatially organized by patrilineal clan, and individual households have their own defined compounds, typically with at least one dwelling house and one kitchen, each made of mud-brick with a thatch roof. The BaYaka neighborhood consists of roughly five “hamlets” of families related loosely by kinship, whose membership is highly fluid. Individual BaYaka residing in the village leave for the forest on a daily basis to collect resources, and typically live in forest camps for up to 2 months at a time at least twice a year. While in the village, BaYaka men and women are routinely employed by the Bondongo to perform a range of domestic and subsistence tasks, and may sometimes reside with a Bondongo family for a time (eg, to pay off a debt through work). One participating BaYaka family was housed with a Bondongo family during the study period. As forest specialists, BaYaka are also hired to collect forest products (eg, housing materials, foods such as caterpillars or *Gnetum* leaves) for Bondongo home consumption or commercial sale.

As noted, BaYaka culture is characterized by a strong value for egalitarianism that demands all people be treated with equal respect, as well as strict social norms regarding resource sharing. Respect for individual autonomy is also a core value that means no person can be coerced by another (Boyette & Lew-Levy, In Press; Hewlett, Fouts, Boyette, & Hewlett, 2011). There is a “chief” of the BaYaka village community, but he is afforded no special privileges, though he is well-respected and his views are taken seriously on that basis. These values and norms contrast with those of the Bondongo whose society is organized by a strict status hierarchy based on gender, age, and ascribed or achieved social position. There is an elected “chief”, and a number of other positions in the village council, all held by men. There is a women’s council as well, which does have power over some village affairs. However, their power tends to be collective, coming from the council as a whole, rather than from the prestige of specific individuals, as is the case for the men.

It is important to note that while we refer to the BaYaka as “foragers” and the Bondongo as “fisher-farmers” following prior comparative research in the Congo Basin (Bahuchet & Guillaume, 1982; Boyette & Hewlett, 2017; Fouts, Hewlett, & Lamb, 2005; Grinker, 1994; Hewlett et al., 1998; Meehan & Roulette, 2013), we acknowledge that these terms gloss over complex histories and identities (Köhler & Lewis, 2001; Rupp, 2011). What is important to the biocultural foundations of this research is that these groups share highly contrasting

views of their relationship to the environment and to each other, and these are associated with alternative strategies of living within their ecological context. Both groups do perform swidden agriculture, hook-and-line fishing, bail fishing, and barricade fishing. However, BaYaka gardens are tended less frequently and harvested opportunistically. Moreover, they view themselves as forest experts, as do the Bondongo, and they obtain a major part of their daily subsistence from wild foods in the forest. Additionally, they, like many contemporary foragers, maintain a set of values for egalitarianism, sharing, and individual autonomy that is an essential part of an adaptive complex that sustains a livelihood derived from flexible, opportunistic resource extraction—from the forest, from neighboring farming villages, from researchers, from logging companies, and so forth (Coddling & Kramer, 2016; Kelly, 1995; Lewis, 2005). Thus, we argue that this research adds to the literature on forager child development (eg, Hewlett & Lamb, 2005) but our claims are about egalitarian societies, not foragers per se.

2.2 | Cultural models of fatherhood

The data examined here come from a larger comparative, mixed-method project on culture, parenting, and family ecology in the Congo Basin (Boyette et al., 2018; Boyette, Lew-Levy, Sarma, & Gettler, 2019). A foundational goal of the project is to understand the local cultural models of parenting and child development held by the two groups living in the village where we work, beginning with a focus on fatherhood. These cultural models are important to a biocultural approach because they determine the meanings of parents’ and children’s social interactions, the care practices used by parents, and the expectations of care children come to hold; they at least partially define the local standards of care and development within which relative differences can be compared (Chapin, 2018; Super & Harkness, 2002).

Accordingly, we began our investigation of BaYaka fatherhood and child development by conducting informal interviews with men and women ($N = 9$). Responses to our questions were highly consistent and we extracted four domains of “good” fatherhood from the interviews that we then used as questions for a peer-ranking task to obtain a measure of father quality as the fit to a cultural ideal. We also included a question about child health in the peer-ranking task as a subjective measure of men’s children’s health. The specific questions used in the ranking task are presented in Table 1 along with results from tests of agreement from the peer ranking-task, as explained below. Our informants reported that a healthy child ate well, grew bigger, and played and socialized

with others (Health domain in Table 1). They also reported that good fathers hunted and gathered honey and other resources from the forest (Provide); that they did not fight with their wives (Marital Discord); that they welcomed others to the community and shared well with them (Share); and that they taught their children to forage (Teach).

For the ranking task, we recruited an opportunistic subsample of BaYaka fathers from the larger study ($N = 20$) to rank the other participating fathers on the cultural domains we extracted from the interviews. Participants varied in their skill and patience with this task. While we are confident everyone understood the task, participants took from 45 minutes to over 2 hours to complete the task. Thus, for some participants multiple sessions were needed for them to finish their rankings for all five questions. During the session, we showed each participant a set of photographs of their peers (their own photo was removed) and then asked them to place these in order from “first” to “last” in terms of each question. Participants were urged to uniquely rank each father, but ties were allowed. Thus, rankings could range from 30 piles (one for each father) to as few as one, lumping everyone as the same in their quality in that domain. The last position was recorded as 1 and the highest as the total number of piles made. For each of the 31 fathers, we then calculated a fathering quality “score” as their average rank in that domain across each of the 20 rankings. This represents a measure of the men’s fit to the cultural model as perceived by their peers. The “agreement” across the rankers can be measured using Cronbach’s α values (Weller, 2007). For all scores except for Health (see below), the participants’ rankings were in strong agreement (Cronbach’s $\alpha > .7$; Table 1), indicating a shared familiarity with each other’s quality in terms of the positively valued domains investigated.

TABLE 1 Questions derived from interviews with BaYaka informants regarding fatherhood

Question	Cronbach’s α
Whose children are in the best health? [Health]	NA ^a
Who disputes with their wife the most? [Marital discord]	.76
Who is the most welcoming to others, shares the most with others? [Share]	.85
Who works the hardest? [Provider]	.79
Who teaches children the most? [Teach]	.86

Note: Cronbach’s α values are based on 20 informant’s rankings of 30 other fathers.

^aCould not be calculated because 16/20 (80%) of informants said every fathers’ children were in equally good health.

The descriptive statistics of each of the scores are presented in Table 2. Note that the range of scores for the Health domain is quite small. In fact, as can be seen in Table 1, we could not calculate a reliability score using Cronbach’s α for this score because most participants (16 out of the 20 who performed the ranking task) ranked everyone’s children as in equally good health. Additionally, the pair-wise correlation matrix of these scores (Table 3) suggested to us that, while qualitatively distinct and of interest, the Provide, Share, and Teach domains were all components of a single domain of fatherhood quality from our informants’ view, rather than separate domains. Results of a factor analysis of Provide, Share, Teach, and Marital Discord scores was consistent with this prediction, as these three loaded highly together on the first factor, with a small fraction of the variance in the data explained by Marital Discord as a second factor. Following a similar line of reasoning for direct caregiving aspects of Bondongo fathering (Boyette et al., 2018), we computed the average of Provide, Share, and Teach scores for each father to use as a single independent variable, Father Quality, for all statistical analyses.

2.3 | Anthropometrics

Height, weight, and triceps skinfold thickness (SFT) measurements for both BaYaka and Bondongo children were collected according to standard procedures (Lohman, Roche, & Martorell, 1988). Height was measured using a Seca stadiometer; weight was measured with a digital bathroom scale; and triceps skinfolds were measured using Lange calipers. Weight and height measurements were then used to compute weight-for-height (WFH). Triceps SFT was measured three times per participant and the average value used in all analyses. Data for some measures is missing for some children of participating fathers because they were unavailable or unwilling to participate in some measurement tasks. Bondongo parents knew their own and their children’s ages. The BaYaka do not keep track of their ages, so a relative birth order for all members of the community was established

TABLE 2 Descriptive statistics for BaYaka average peer-ranking scores

	N	Mean	SD	Min	Max
Health	31	2.59	.54	1.67	3.75
Marital discord	31	3.20	.98	1.35	4.65
Share	31	5.68	2.16	2.21	10.89
Provider	31	6.92	1.84	3.80	10.68
Teach	31	4.85	1.74	2.30	8.75

through extensive interviews. This rank order of ages was then used as the basis for estimation of ages in years using the procedure developed by Diekmann et al. (2017).

2.4 | Statistical analysis

2.4.1 | Fathering quality and BaYaka children's health

All statistical analyses were done in Stata/SE 15.1. First, associations between BaYaka fathers' peer-ranking scores and their children's anthropometrics were evaluated using ordinary least squares (OLS) regression. In the models, we used robust standard errors clustered by father to account for the nonindependence of cohabiting children. In separate models, the dependent variables were children's height, weight, WFH, and SFT, each standardized for age and sex. The measures were standardized by regressing the anthropometric measures on age and sex, saving the residuals, and adding them to the mean of each measure. This procedure maximizes the relatively sparse sampling within age groups, and is also justified by recent findings suggesting procedures drawing on standards from other populations, such as the WHO standards, can lead to misleading or irrelevant findings

when compared to measures based on population-specific reference measures (Martin, Blackwell, Kaplan, & Gurven, 2019).

In each regression, the independent variables included the Father Quality, Marital Discord, and Health scores. Additionally, father's age was included as a covariate to account for the possibility that men's fathering ability changes with their familiarity with the cultural model and their experience as a father. Lastly, the number of children in the household (including those of the father and any other cohabiting children) was included as a covariate to control for the possibility that larger households might generate greater resource competition or, in the case of multifamily households, more resource pooling, that would have effects on children's energetics above and beyond paternal contributions. Descriptive statistics for these covariates are presented in Table 4.

2.4.2 | Comparison of BaYaka and Bondongo children's health

To evaluate the effect of ethnicity alone (as a proxy for both cultural context and genetic variation) on children's energetics, we used OLS regression to model the associations between ethnicity, sex, and age on children's

	Marital discord	Share	Provider	Teach
Marital discord	1.00			
Share	-0.21	1.00		
Provider	-0.01	0.81***	1.00	
Teach	-0.09	0.89***	0.78***	1.00

Note: *** $P \leq .001$.

TABLE 3 Intercorrelation matrix of average peer-ranking scores (Pearson's r values)

	n	Mean	SD	Min	Max
Age (years)	70	7.65	4.81	0.02	17.69
Sex	70	0.63	0.49	0	1
Father quality score	70	6.00	1.64	3.77	9.83
Father marital discord score	70	3.50	0.82	1.35	4.65
Father's children's health score	70	2.65	0.45	1.67	3.60
Father's age (years)	70	36.76	9.12	22	63
Total children in father's household	70	4.23	1.93	1	8
Height (cm)	58	113.47	19.39	77.5	160.3
Weight (kg)	70	18.98	9.21	5.4	52.2
Weight for height (cm/kg)	58	0.18	0.04	0.12	0.33
Triceps skinfold thickness (mm)	58	7.14	2.26	3.5	15.67

TABLE 4 Descriptive statistics for BaYaka children

unadjusted anthropometrics (height, weight, WFH, and SFT). Because age is highly correlated with each anthropometric measure (except triceps SFT) and because males and females have different growth trajectories (Bogin, 1999), we also evaluated the interaction between age and sex, and age and ethnicity. Additionally, to reduce collinearity and variance inflation, age was centered before inclusion in these models (Robinson & Schumacker, 2009). The models used robust standard errors clustered by household to control for nonindependence of men's children. The notion of "household" is defined somewhat differently between the BaYaka and the Bondongo in that BaYaka children do not always sleep in the same abode as their biological fathers but may still regularly come to his house for meals and other care. For the Bondongo, it is more typical that children within the same house receive the majority of their care from within that household. Thus, this clustering variable represents a culturally distinct but comparable notion of "household." Table 5 shows the descriptive statistics for this comparative sample.

In addition, to test the hypothesis that there would be greater variance in energetic status among the Bondongo than among the BaYaka, we evaluated the equality of variances between the groups for each of the four anthropometric measures (Power, 1983). First, because we were interested specifically in the variance in energetics not accounted for by age or sex, we regressed each of the anthropometric variables on age and sex, saved the residuals of this regression, and then added the residuals to the mean for each measure. Then, because each of these standardized measures was positively skewed and had high kurtosis, we used Stata's *robvar* command to run robust tests for equality of variances and reported the results of the Levene's test. (Brown & Forsythe, 1974; Levene, 1960; Markowski & Markowski, 1990). Stata's *robvar* command also yields two additional test statistics recommended by Brown and Forsythe (1974), and the results of those were qualitatively equivalent to those for the Levene's test.

TABLE 5 Descriptive statistics for combined Bondongo/BaYaka sample

	n	Mean	SD	Min	Max
Ethnicity ^a	150	0.53	0.50	0	1
Sex ^b	150	0.55	0.50	0	1
Age (years)	150	7.43	4.70	0.01	17.69
Height (cm)	132	115.28	21.71	68.6	169.6
Weight (kg)	150	20.50	10.49	4	58.5
Weight for height (cm/kg)	132	0.19	0.05	0.09	0.36
Triceps skinfold Thickness (mm)	124	8.27	2.90	3.5	19

^aBaYaka = 0; Bondongo = 1.

^bFemale = 0; male = 1.

3 | RESULTS

BaYaka fathers' quality scores were not significantly associated with their children's energetic measures. Children's fathers' scores for marital discord were significantly and negatively associated with children's height. Additionally, contrary to what we would have predicted, children were shorter when their fathers were rated as having healthier offspring, and this was independent of father's age or the number of children in the household. Results of the regression models for all measures of BaYaka children's anthropometrics are presented in Table 6. In Figure 1, we also present the relationships between SFT and Children's Health, Marital Discord, and Father Quality score below comparable results from our prior analysis of Bondongo data. As can be seen, among the Bondongo, fathers' quality as providers and as direct caretakers are each positively associated with children's age- and sex-standardized anthropometric values, in contrast to the results presented here for the BaYaka. Meanwhile, both Bondongo and BaYaka men's perceptions of each other's children's health were consistent with their children's current energetic status (as measured by SFT): our Bondongo informants accurately predicted variation in their peers' children's health, whereas the BaYaka perceived little variation in children's health, and relatively little was apparent (compare Figure 1A and E).

Table 7 reports the results of our analysis of ethnicity, sex, age, and the interactions between ethnicity and age, and sex and age. Bondongo children are taller and heavier and have greater WFH and SFT. The relationships between height and weight—and thereby WFH—are also augmented with age, as indicated by the significant interaction term for ethnicity * age. The results of the interaction indicate that Bondongo children gain weight and height at a faster pace than do BaYaka as they get older. The significant ethnicity * age interaction term for children's SFT yields a different, cross-over moderation effect. With increasing age, Bondongo children have greater SFT values (ie, a positive slope), whereas with

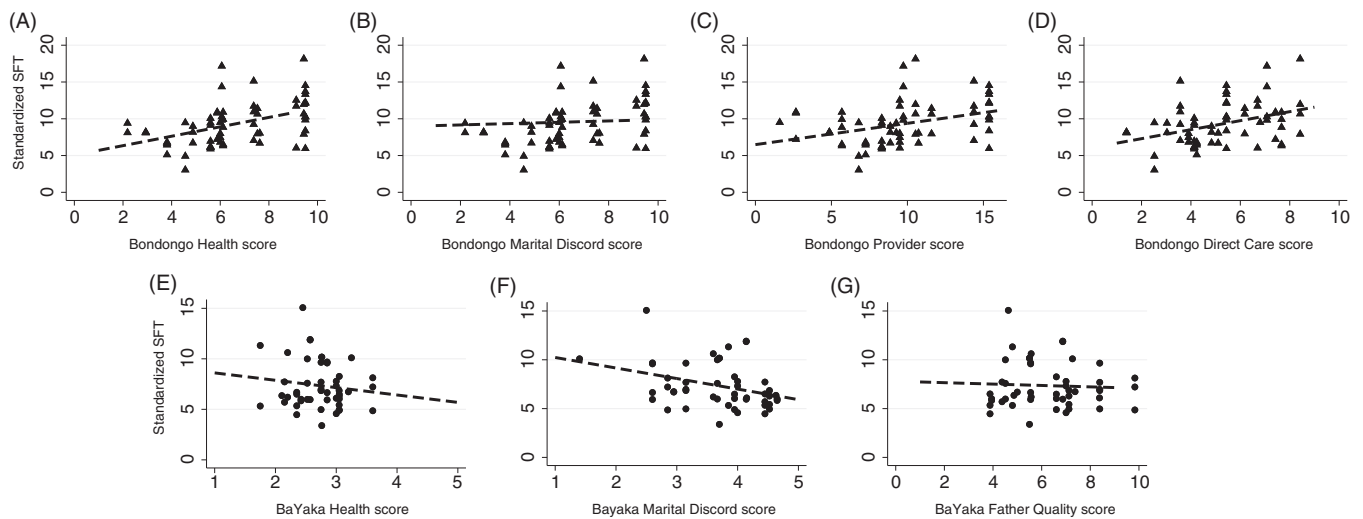
TABLE 6 Results of OLS regression models children's standardized energetics measures on father's average peer-ranking scores and covariates

	Height ^a	Weight ^a	WFH ^a	SFT ^a
Father quality	0.19 (0.57)	-0.13 (0.21)	0.0003 (0.002)	0.02 (0.21)
Marital discord	-1.91 (0.88)*	-1.12 (0.88)	-0.005 (0.006)	-0.47 (0.36)
Health	-6.57 (2.05)**	-2.95 (1.65) [^]	-0.02 (0.01)	-0.48 (1.74)
Father's age	0.38 (0.08)***	0.18 (0.11)	-0.001 (0.001)	-0.04 (0.06)
Total children in the household	0.87 (0.33)*	0.55 (0.32) [^]	0.003 (0.003)	-0.33 (0.28)

^aAll anthropometric variables standardized by age and sex. Values shown are regression coefficients (robust SE).

Abbreviations: OLS, ordinary least squares; SFT, skinfold thickness; WFH, weight-for-height.

Note: $P \leq .1$; * $P \leq .05$; ** $P \leq .01$; *** $P \leq .001$.

**FIGURE 1** OLS regression linear fit plots of children's triceps skinfold thickness (SFT; y-axis) on their father's average peer-ranking scores on the relevant cultural model domains (x-axis). These domains include, for the Bondongo: (A) provider, (B) direct care, and (C) children's health (see Boyette et al., 2018 for more details); and for the BaYaka: (D) father quality (average of provider, teach, and share—see text), (E) marital discord, and (F) children's health. OLS, ordinary least squares**TABLE 7** Regression coefficients (robust SE) for OLS regression of ethnicity, sex, and age on unadjusted anthropometric measures

	Height (N = 132)	Weight (N = 150)	WFH (N = 132)	SFT (N = 124)
Ethnicity	8.36 (1.24)***	3.66 (0.72)***	0.02 (0.004)***	1.56 (0.61)*
Sex	-1.86 (0.97) [^]	-0.68 (0.60)	0.0001 (0.003)	-0.95 (0.45)*
Age (centered)	4.73 (0.15)***	1.90 (0.16)***	0.009 (0.001)***	-0.07 (0.10)
Ethnicity * age	0.51 (0.26)*	0.52 (0.18)**	0.002 (0.001) [^]	0.27 (0.12)*
Sex * age	-0.33 (0.22)	-0.16 (0.16)	-0.001 (0.001)	-0.18 (0.14)
Constant	107.78 (0.78)***	19.12 (0.62)***	0.17 (0.003)***	8.06 (0.41)***

Note: Robust standard errors are reported, clustered by father to account for shared variation among siblings.

Abbreviations: OLS, ordinary least squares; SFT, skinfold thickness; WFH, weight-for-height.

$P \leq .1$; * $P \leq .05$; ** $P \leq .01$; *** $P \leq .001$.

increasing age BaYaka children's SFT values are lower (ie, a negative slope).

Finally, in support of our hypothesis, the Levene's robust test statistic for equality of variances for these measures, standardized across age and sex, indicated

significantly greater variances among the Bondongo for height ($W = 10.00$, $P \leq .01$), WFH ($W = 5.17$, $P \leq .05$), and SFT ($W = 6.79$, $P \leq .01$). These results are presented visually in Figure 2, which displays overlaid kernel density plots for each of the age- and sex-standardized height,

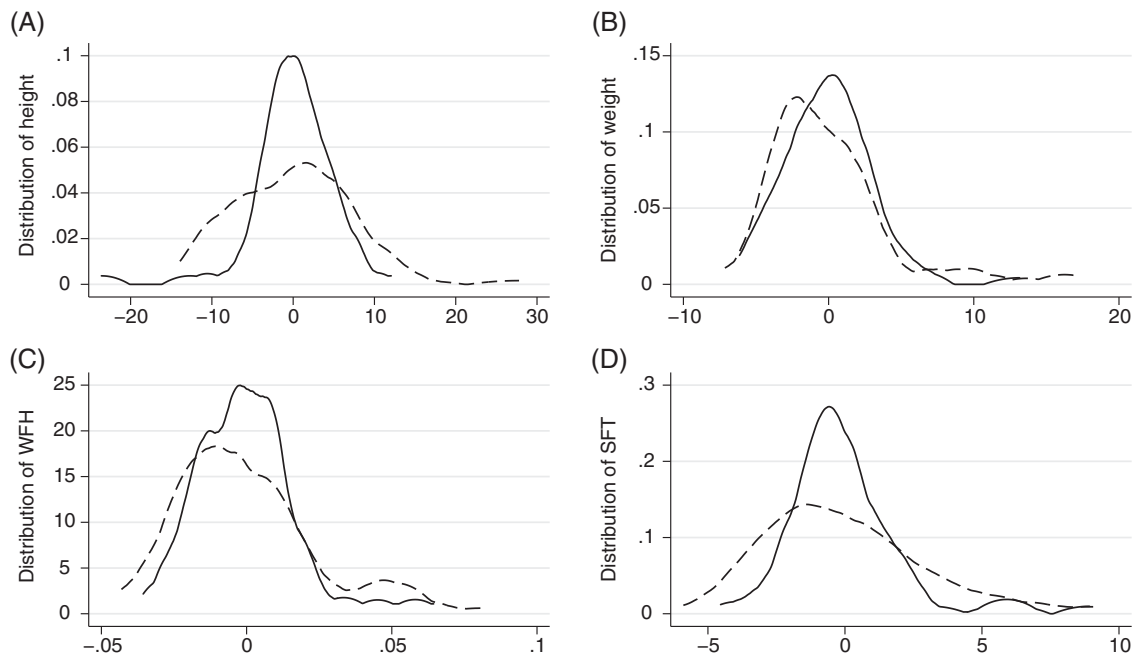


FIGURE 2 Kernel density plots showing the distributions of age- and sex-standardized values for children's (A) height, (B) weight, (C) weight-for-height (WFH), and (D) triceps skinfold thickness (SFT). Each variable was centered at the mean for each group. Solid lines are BaYaka and dotted lines are Bondongo values

weight, WFH, and SFT values for each ethnicity, centered at their mean. As can be seen, there is a wider distribution of values for Bondongo children for most of the indicators of growth and energetic status examined here, compared to the range of variation among the BaYaka. As we used age- and sex-standardized measures, these differences in variance in distribution cannot be attributed to children's age or sex and thus are most likely related to some aspect of being either Bondongo or BaYaka. We now turn to a discussion of what we believe it is about being BaYaka that leads to less variance in children's health.

4 | DISCUSSION

As we note in the introduction, evolutionary research on human fathering has demonstrated that men across human societies contribute to the development and well-being of their offspring in a variety of ways (Anderson, Kaplan, & Lancaster, 1999; Boyette et al., 2018; Gray & Crittenden, 2014; Shenk & Scelza, 2012). In all contexts, fathers face time and/or energy trade-offs in their decisions regarding parental care (eg, invest in current vs future offspring). Yet, it is local cultural meanings and practices that determine the roles fathers play and the specific pathways through which fathers may and are expected to provide care (Harkness & Super, 1992). One of the key features of a biocultural approach is an interest in embedding social phenomena and their meanings

within specific cultural frameworks of the individuals who share that culture (Dressler, 2005). This perspective acknowledges that individuals vary in the degree that they fit and adhere to cultural ideals, and opens up inquiries into the importance of intracultural variation for health- and biology-related dimensions of social behavior (Dressler, 2005). Specifically, we were interested in the outcomes for children of variation in men's fathering as defined in relation to the cultural models we observed. As we will discuss in detail below, our findings are consistent with the interpretation that BaYaka and Bondongo fathers have varied effects on their children's health, and we suggest that the egalitarian cultural context of the BaYaka provides a potential explanatory framework for interpreting these patterns.

Our qualitative inquiry into the role of the father in BaYaka society revealed insights into their perspectives on fathers that overlap somewhat with their Bondongo neighbors but also differentiate them in ways consistent with BaYaka views on society in general. First of all, our BaYaka informants' discussions of fatherhood paralleled those of the Bondongo in that they emphasized that fathers should provide key resources and maintain marital harmony. However, the BaYaka also described the importance of fathers taking children into the forest for the opportunity to learn. This is consistent with a general emphasis on the forest in BaYaka identity as well as their ecological adaptation as forest specialists (Lewis, 2005). In contrast, our Bondongo informants also described



fathers as having a role in socialization of the children, but emphasized responsibility to their own family and proper behavior in relation to other families in their views of fathers' role. This aligns with the wider Bantu concern over status and family reputation. The BaYaka also emphasized that good fathers welcome others to their community and “share well”, statements that implicate fathers' roles in key institutions and practices. Specifically, “sharing” has been described as a foundational cultural schema for the BaYaka (Boyette, 2019; Hewlett et al., 2011; Lew-Levy, Lavi, Reckin, Cristóbal-Azkarate, & Ellis-Davies, 2018) because it refers to more than the economic dimension of an equal distribution of food and material goods. “Sharing” also permeates multiple domains of daily life, including concepts of sharing space (Hewlett et al., In Press) and sharing ecstatic experiences that BaYaka say only come from large social gatherings, where alcohol and other substances are shared and knowledge of *ekondi* spirit dances and other news is distributed (Lewis, 2016). In this respect, BaYaka fathers are seen to play a key role in maintaining the knowledge and institutions that sustain an egalitarian society.

To review, resource acquisition, marital harmony, teaching, and sharing were reliably seen as defining the father's role among the BaYaka. At the same time, the results of the ranking task revealed that our informants were in strong consensus that men in the community were not equal in their abilities to fulfill these cultural ideals (Table 1). Statistical evidence for this comes from the relatively high Cronbach's α values (Table 2). It is worth noting that the ranges in fatherhood quality scores for each domain were smaller among the BaYaka than among the Bondongo, but still showed meaningful variation and similarly high reliability (compare Table 2 to Table S1). Thus, there is intercultural diversity in what defines fatherhood, and fathers in both groups demonstrate (intracultural) variation in quality in their society's respective domains. This in and of itself is not surprising as we did not predict that all fathers would be perceived to play equivalent roles within their families, nor be of equal quality in their fulfillment of these roles. Rather, we predicted that BaYaka fathers' rankings on these parenting dimensions would have minimal or modest associations with their children's health, which would qualitatively distinguish those findings from the patterns we observed among the Bondongo that we discuss below. Moreover, we hypothesized that we would see less variance in energetic status among the BaYaka children (compared to the Bondongo). Evidence from our statistical analysis was largely consistent with these predictions. As shown in Figure 1, the associations between BaYaka fathers' rankings and children's triceps SFT—a measure of current energetic status—were small, not statistically

significant, and the slopes thereof were relatively flat. Surprisingly, we did find a significant negative association between marital discord and children's height. That result is consistent with the possibility that fathers who had more conflicts with their wives may have impacted their children's growth over the longer term. However, as visually illustrated in Figure 2, BaYaka children had significantly narrower distributions for height, WFH, and triceps SFT compared to the ranges of variation observed among the Bondongo. Thus, even the possible effects of marital conflicts on growth among the BaYaka appear less impactful on individual variation than what is observed among the Bondongo. These results are relatively consistent with prior complementary work among the BaYaka (Aka) in the Central African Republic, a different community within the broader region of the same cultural group. They showed that fathers' presence was not significantly linked to children's growth and energetic condition (Meehan et al., 2014). Rather, Central African BaYaka grandmothers appeared to play critical roles in benefitting their grandchildren's health. Nonetheless, Meehan et al. (2014) found that community support networks could buffer children from poorer outcomes even in the face of the loss of a grandmother, and that children in larger camps were in better energetic condition. Thus, those patterns generally align with our suggestion that the egalitarian, socially supportive cultural values of the BaYaka are a potential explanation for the largely null associations between fathering and child energetic condition and the relatively reduced range of variation in children's anthropometric measures compared to their Bondongo neighbors.

Despite those findings, we think it is likely that BaYaka fathers contribute to their children's health and well-being in other domains. Indeed, Hewlett (1991) has demonstrated that among the Aka, fathers are important attachment figures to their children, and will readily take on the role of infant caregiver. However, we suspect that our informants did not mention the importance of infant care in our interviews about fatherhood because this is not a role specific to fathers and perhaps more of a secondary parental responsibility for them. Rather, Hewlett (1992) emphasized that, while mothers do the majority of direct care overall, husbands and wives have complementary and flexible roles, including cooperation in holding, carrying and soothing infants. Thus, it is likely that fathers play positive roles in children's social and emotional development (Lamb, 2010) as well as in their acquisition of skills that are relevant to BaYaka life in this ecology, consistent with our informants' emphasis on the domain of “Teach”. Notably, our results do suggest that the quality of fathers' relationships with their wives may impact their children's growth, and thus there may

be a socioemotional pathway through which marital harmony or discord influences anthropometric outcomes. For example, among the Bondongo, marital discord was not found to be associated with energetic status but did predict increased stress response in children of fathers whose marriages had more conflict (Boyette et al., 2018; Gettler et al., 2019). The social and cognitive domains of development and well-being, and their potential relationships with biological health and growth, are areas of future interest for our ongoing work at the site.

In contrast to these results from the BaYaka, in Boyette et al. (2018), we reported that Bondongo children were in better health when their fathers more strongly fit the local cultural model of fatherhood. Broadly characterized, the two cultural domains in question diverge in the attention they have typically received in studies of fathering in small-scale societies, with men's provisioning being more commonly studied and emphasized whereas fathers' direct caregiving has received far less attention (Gettler, 2010; Hill & Hurtado, 2009; Kaplan et al., 2000; Winking et al., 2009). Bondongo society is "communal" within kin networks in the sense that extended families are seen as important units of production and reproduction, and interfamily relationships can be highly competitive. For example, accusations of witchcraft are common expressions of jealousy leveled at others who are perceived to be doing well or getting ahead, while one's own family is experiencing sickness, death, or poor luck in the food quest (eg, Hewlett, Mongosso, King, & Lehmann, 2013). In this context, children were in healthier energetic condition when their fathers were seen as having better abilities as providers and direct caregivers, respectively. We note that these two dimensions of father care—provisioning and direct care—were statistically uncorrelated, suggesting they are conceptually distinct and have independent associations with children's health (Table S2). Complementing those prior findings, here we found that there was significantly greater variance in Bondongo children's energetic measures, relative to their BaYaka peers. We suggest that these results are potentially reflective of the hierarchical nature of Bondongo society, yielding social inequality that is manifest in children's growth outcomes and energetic status in this society (Krieger, 1999). While we cannot be certain of the causes of the difference in variance, we expect any combination of increased parasite loads, poorer nutrition, and more chronic activation of the body's stress systems could contribute to the gradient in health visible among the Bondongo (Krieger, 1999; McDade, 2005; Sapolsky, 2004; Urlacher et al., 2018). We suggest that these results are complementary to the expanding literature linking relative social inequality to health disparities within the context of small-scale societies (Gurven, Jaeggi, von Rueden,

Hooper, & Kaplan, 2015; Mattison, Smith, Shenk, & Cochrane, 2016; Reyes-García et al., 2008, 2009; C. R. von Rueden et al., 2014).

In our ranking measure, we included a question of how healthy fathers' thought their peers' children were. Parallel to our anthropometric measurements, BaYaka men reported little perceived variation, with all reporting that the children were largely in good health (Tables 1 and 2). We interpret these results to reflect men's accurate assessment of other men's children's health and further validation that our peer-ranking method adequately captured men's relatively accurate knowledge of their community. An alternative explanation is that men were not sensitive to the real variation in other men's children's health. However, during the interviews in which these data were collected, many of our informants consistently noted that several specific children had had symptoms of a respiratory infection but had recovered and were currently in good health. We were able to later confirm that there had been an outbreak of a respiratory illness not long before our field work began from which the children had recovered. Additionally, while few men distinguished their peers by their children's health (visible in the incalculable Cronbach's α noted in Table 1 and the small range in Table 2), those who did provide a ranking commonly noted one father whose child was particularly sickly at the time. We determined that his wife was pregnant and had weaned their youngest daughter early, leading to her being relatively malnourished. The girl also was concurrently suffering from a bad malaria infection as well. Together, this ethnographic evidence supports our interpretation that men's knowledge was accurate. Accordingly, we also interpret the negative or lack of an association between the average of men's peer ranking scores for this qualitative measure of children's health and the anthropometric measures to reflect the generally minimal impact of variation in fathering quality on children's health among the BaYaka.

A major limitation of this study is that we cannot rule out a potential genetic origin of the reduced variance in anthropometric measures among the BaYaka compared to the Bondongo. The generally short stature and body shape of Congo Basin forest foragers, or so-called "Pygmies", has been tied to their unique genetic history (Becker et al., 2011; Bergey et al., 2018; Jarvis et al., 2012). However, the BaYaka in this study share a close genetic ancestry to the Baka (Verdu et al., 2009), whose growth pattern has been shown to vary from a French reference population only during the first 2 years, during which they have a slower growth velocity and after which they resume a pattern parallel to that of the French, though remaining smaller (Rozzi, Koudou, Froment, Le Bouc, & Botton, 2015). Furthermore, there are no studies

that we are aware of demonstrating a population-level reduction in variance in growth among “pygmies” that could explain our results in terms of genetic differences between the two groups in our study, and there is not a strong rationale for thinking that the selective pressures for smaller average body size among BaYaka would constrain the extent to which children might downregulate growth in response to adverse early life energetic conditions. Thus, we are confident that the comparatively reduced individual differences in energetic status among the BaYaka children demonstrated here are likely to result from children's common developmental experiences, such as shared caregiving and support across families within the community, as compared to that of the Bondongo (ie, largely within-family support, with children experiencing differences across families), and not due to a genetic-based restriction in the ranges of BaYaka growth dimensions. It is an additional limitation that a number of our interpretations are based on null results, and one must be cautious in analyzing the implications of nonsignificant results. While we acknowledge this as a concern, we note that the effect sizes linking BaYaka fathering quality to children's energetic markers are small, in addition to being nonsignificant. This suggests that our null results do not reflect lack of statistical power. That point is further underscored by the fact that we observed statistically significant, biologically meaningful effect sizes in our related analyses among the Bondongo (Boyette et al., 2018), despite a smaller overall sample size.

5 | CONCLUSION

An evolutionary perspective emphasizes that all parents face trade-offs in deciding how best to care for their offspring in relation to the costs and benefits they perceive in their socioecological context. That context typically includes many potential avenues for parents to contribute to their children's well-being, as well as other individuals who may also provide care. In this article, focusing on fathers, we integrated evolutionary and biocultural perspectives and argued that the cultural context in which parents care for children defines the values and practices that guide parental roles and decisions (Super & Harkness, 2002). Moreover, we argued that the relative effects of individual differences in parents' abilities or willingness to meet their culturally defined role on children's health and well-being are enmeshed within broader cultural systems, values, and institutions. Specifically, shortcomings in parental care and their potential influences on child health may be attenuated when family systems are embedded in cultural contexts emphasizing social equality, as is the case among the BaYaka.

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AUTHOR CONTRIBUTIONS

A.B. and L.G. conceived of the study and wrote the article. A.B. analyzed the data with regular discussion with L.G. A.B., S.L.-L., M.S., and M.V. collected the data. S.L.-L. provided critical comments on the manuscript.

ORCID

Adam H. Boyette  <https://orcid.org/0000-0003-0306-6841>

Lee T. Gettler  <https://orcid.org/0000-0001-7325-8852>

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