

Examining the influence of adversity, family contexts, and a family-based intervention on parent and child telomere length

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ABSTRACT

Background: Exposure to adversity, trauma, and negative family environments can prematurely shorten telomeres, the protective caps at the ends of chromosomes. Conversely, some evidence indicates that positive environments and psychosocial interventions can buffer the shortening of telomere length (TL). However, most work has examined individual aspects of the family environment as predictive of TL with little work investigating multiple risk and protective factors. Further, most research has not examined parent TL relative to child TL despite its heritability.

Objective: In the current study, we examined interparental conflict, positive parenting, alcohol use, adverse childhood experiences (ACEs), and a family-based intervention as predictive of parent TL. We also examined interparental conflict, positive parenting, ACEs, and a family-based intervention as predictive of child TL.

Method: Parents and adolescents from a sample of divorced families participated in either a 10-session family-based intervention, the New Beginnings Programme (NBP), or a 2-week active control condition. Approximately six years after the intervention, a subsample of parents ($n=45$) and adolescents ($n=41$) were assessed for TL. Parents reported on interparental conflict, ACEs, and alcohol use. Children reported on interparental conflict, positive parenting, and ACEs. In separate models, these constructs and the NBP intervention condition were examined as predictors of parent TL and child TL.

Results: Findings indicated that the family-based intervention was associated with longer TL in parents. Also, positive parenting was associated with longer TL in children.

Conclusions: These findings have important implications for the role of the family and family-based preventive interventions in buffering parent and child biological stress.

Examen de la influencia de la adversidad, los contextos familiares y una intervención basada en la familia en la longitud de los telómeros de padres e hijos

Antecedentes: La exposición a la adversidad, el trauma y los entornos familiares negativos pueden acortar prematuramente los telómeros, las tapas protectoras en los extremos de los cromosomas. Por el contrario, algunas pruebas indican que los entornos positivos y las intervenciones psicosociales pueden amortiguar el acortamiento de la longitud de los telómeros (LT). Sin embargo, la mayor parte del trabajo ha examinado aspectos individuales del entorno familiar como predictivo de LT con pocos trabajos que investiguen múltiples factores de riesgo y protección. Además, la mayoría de las investigaciones no han examinado la LT de los padres en relación con la LT del niño a pesar de su heredabilidad.

Objetivo: En el estudio actual, examinamos el conflicto interparental, la crianza positiva, el consumo de alcohol, las experiencias infantiles adversas (ACE, por sus siglas en inglés) y una intervención basada en la familia como predictores de LT de los padres. También examinamos el conflicto interparental, la crianza positiva, las ACE y una intervención basada en la familia como predictores de LT infantil.

Método: Los padres y los adolescentes de una muestra de familias divorciadas participaron en una intervención familiar de 10 sesiones, *el nombre de la intervención está oculto para su revisión*, o en una condición de control activo de 2 semanas. Aproximadamente seis años después de la intervención, se evaluó la longitud de los telómeros en una submuestra de padres ($n = 45$) y adolescentes ($n = 41$). Los padres informaron sobre conflictos entre padres, ACE y consumo de alcohol. Los niños informaron sobre conflictos entre padres, crianza positiva y ACE. En modelos separados, estos constructos y la condición de

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关键词

端粒长度; 父母间冲突; 创伤; 王牌; ACE; 青少年

HIGHLIGHTS

- Across multiple indices of psychosocial functioning, we found a family-based intervention associated with longer telomere length in parents and positive parenting associated with longer telomere length in children.

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intervención *nombre oculto para su revisión* se examinaron como predictores de LT de padres y LT de niños.

Resultados: Los hallazgos indicaron que la intervención basada en la familia se asoció con una LT más prolongada en los padres. Además, la crianza positiva se asoció con una LT más prolongada en los niños.

Conclusiones: Estos hallazgos tienen implicaciones importantes para el papel de la familia y las intervenciones preventivas basadas en la familia para amortiguar el estrés biológico de padres e hijos.

考查逆境、家庭背景和基于家庭的干预对父母和儿童端粒长度的影响

背景: 暴露于逆境、创伤和消极的家庭环境会过早地缩短端粒，即染色体末端的保护帽。相反，一些证据表明，积极的环境和社会心理干预可以缓冲端粒长度 (TL) 的缩短。然而，大多数工作都将家庭环境的各个方面作为 TL 的预测因素，而很少有考查多种风险和保护因素的研究。此外，尽管具有遗传性，大多数研究未考查相较于儿童 TL 的父母 TL。

目的: 在当前研究中，我们考查了父母间冲突、积极养育、饮酒、不良童年经历 (ACE) 和基于家庭的干预作为父母 TL 的预测因素。我们还考查了父母间冲突、积极养育、ACEs 和基于家庭的干预对儿童 TL 的预测。

方法: 来自一个离婚家庭样本的父母和青少年参加了 10 次基于家庭的干预，干预名称已屏蔽以供审查，或 2 周的主动控制条件。干预后大约六年，对父母 ($n = 45$) 和青少年 ($n = 41$) 的子样本进行端粒长度评估。父母报告了父母间冲突、ACEs 和酒精使用。儿童报告了父母间冲突、积极养育和 ACE。在单独的模型中，把这些构念和为审查屏蔽干预名称的干预条件作为父母 TL 和儿童 TL 预测因素进行考查。

结果: 研究表明，基于家庭的干预与父母 TL 更长相关。此外，积极养育与儿童 TL 较长相关。

结论: 这些发现对于家庭和基于家庭的预防性干预在缓冲父母和儿童生物应激方面的作用具有重要意义。

1. Introduction

Exposure to chronic negative environments and acute traumatic experiences have a strong and lasting detrimental impact on an individual's social, emotional, and behavioural well-being as well as their biological outcomes (Gilbert et al., 2015). Accumulating evidence indicates that psychosocial stressors, exposure to traumatic events, and negative family environments in both adults and children, can contribute to the premature shortening of telomeres, the protective caps at the end of chromosomes (Hanssen, Schutte, Malouff, & Epel, 2017; Rentscher, Carroll, & Mitchell, 2020). Whereas telomeres naturally shorten with age, premature telomere length (TL) shortening is a sign of biological distress which has been associated with mental and physical health problems later in life (Price, Kao, Burgers, Carpenter, & Tyrka, 2013). Much of this research has examined TL in adulthood (e.g. Mathur et al., 2016), but more research is beginning to focus on TL in childhood and adolescence (Bürgin et al., 2019; Lang et al., 2019). Moreover, some evidence indicates that positive family environments and psychosocial interventions can buffer the shortening of child TL (Asok, Bernard, Roth, Rosen, & Dozier, 2013; Brody, Yu, Beach, & Philibert, 2015).

1.1. Stress, adversity, and TL

Over the past decade TL has increasingly been studied as a marker of biological stress. Telomeres are the protective caps at the end of chromosomes which ensure

proper DNA replication. While telomeres naturally shorten over time with cell division, psychosocial stressors have been found to accelerate TL attrition, proposedly by increasing physiological stress and in turn oxidative stress (Rentscher et al., 2020). Exposure to chronic negative environments and acute traumatic experiences have been linked to shorter TL in both children and adults (e.g. Bürgin et al., 2019; Li, He, Wang, Tang, & Chen, 2017). Adverse childhood experiences (ACEs) represent a cumulative measure of exposure to childhood trauma, often including abuse and neglect as well as indicators of household dysfunction and parental substance use (Felitti et al., 1998). Recent reviews and a meta-analysis support shortening of TL for individuals exposed to ACEs compared to those that were less exposed or not-exposed (Bürgin et al., 2019; Lang et al., 2019). Two meta-analyses and a systematic review have found exposure to chronic and pervasive psychosocial stress related to shorter TL (Hanssen et al., 2017; Mathur et al., 2016; Oliveira et al., 2016). Within this domain, several studies and a meta-analysis have also found adult substance use disorder and alcohol dependence associated with TL shortening (Chen, Pan, Chen, & Huang, 2011; Navarro-Mateu et al., 2020).

However, many studies fail to find associations between TL and psychosocial stress or adversity. In addition, some of the aforementioned meta-analyses show highly heterogeneous findings that are suggestive of publication bias (Mathur et al., 2016; Navarro-Mateu et al., 2020; Ridout et al., 2018). Finally, the majority of studies have examined family risk and

protective factors as predictors of child, but not parent, TL (Brody, Yu, & Shalev, 2017; Drury et al., 2014; Robles et al., 2016). Collectively, this highlights the need for more research on individual and family factors associated with parent and child TL.

1.2. Familial influences on telomere length

Evidence from separate studies demonstrates that marital conflict, substance use, family conflict, negative parenting, and divorce are all associated with shortened TL in caregivers and children (Navarro-Mateu et al., 2020; Rentscher et al., 2020). However, most studies have examined individual aspects of the family relationship as predictive of TL. For example, studies have found family violence and disruption (Drury et al., 2014), parent-child conflict and home chaos (Brody et al., 2017), and non-supportive parenting (Beach, Lei, Brody, Yu, & Philibert, 2014) to predict shorter TL in childhood, adolescence, and emerging adulthood. Thus, both acute trauma and chronic stress within the family environment have been associated with shorter TL. Conversely, the presence of positive parenting and family interactions has been shown to have protective effects on TL (Asok et al., 2013; Beijers et al., 2020; Robles et al., 2016). Thus, positive family influences, such as positive parenting, can serve as protective factors by buffering the impact of negative environmental influences on child TL.

Relatedly, the heritability of TL is often overlooked when examining familial influences on child TL. A meta-analysis found TL to be highly heritable, yielding an estimate of 70% (Broer et al., 2013). That is, children's TL is influenced by parent's TL as well as their family environment. To our knowledge, no study to date has examined the intergenerational transmission of parent and child TL *relative to* their respective negative family experiences. We address this gap by examining parent TL and family influences relative to child TL.

1.3. Intervention effects on telomere length

Family-based interventions that provide individual and family skills, supports, and resources are known to improve both parent and child mental and physical health and well-being (Sandler et al., 2014). Some research shows psychosocial interventions may buffer TL shortening. In particular, Brody et al. (2015) found some evidence that unsupportive parenting was associated with TL at age 22 but only in the control group of a family-based intervention which provided skills to parents and children. This suggests that the family-based intervention served as a protective factor against TL shortening. In another study, parents of adopted children participated in an

attachment and biobehavioural catch-up programme providing skills on nurturance and sensitivity; children in the programme had longer telomeres than children in the comparison and control conditions (Hoye, 2015).

Such effects are proposed to occur through the provision of parent- and child-level skills that dampen physiological and biological stress, reducing the subsequent influence on TL (Asok et al., 2013; Brody et al., 2015). Children and parents may benefit from such programmes directly by establishing skills and resources, and for children indirectly through improvements in the family environment. However, TL has never been examined relative to a family-based intervention for families exposed to marital conflict and divorce.

1.4. The current study

The current study advances the field by examining the effects of a family-based intervention on parent's and child's TL in a sample of divorced families. The current sample consists of divorcing families who participated in either a 10-session family-based intervention, the New Beginnings Programme (NBP), or an active 2-week control. The NBP is designed to improve family functioning and has shown to affect an array of parent behaviours including improved parenting (Wolchik et al., 1993, 2000), which in turn has been found to reduce child externalizing and internalizing symptoms (Bonds et al., 2010; Tein et al., 2004).

We examined multiple individual and family-level factors, including interparental conflict, positive parenting, alcohol use, and ACEs as predictive of parent and child TL. These aims followed our preregistered analysis plan (<https://osf.io/ay38s>).

In parents, we hypothesized that interparental conflict, alcohol use, and ACEs would associate with shorter TL. We also hypothesized that the family-based intervention would associate with longer parent TL. In children, we hypothesized that interparental conflict and ACEs would associate with shorter TL. Finally, we hypothesized that positive parenting and the family-based intervention would associate with longer child TL.

2. Methods

2.1. Participants

Participants for the current study were a subsample of individuals who had participated in either a 2-week active control (control condition) or a 10-week trial (intervention condition) version of the NBP (see Sandler et al., 2020). The original sample consisted of 888 divorcing families and their child, aged 2–18. Recruitment for the current study took place approximately 6 years after families were first assessed. All families with a child 13–

Table 1. Descriptive statistics and correlations for parent variables.

	1	2	3	4	5	6	7	8	9	10	11	M (SD)
1. Interparental conflict	1											.00 (.44)
2. Alcohol use	-.05	1										.00 (.48)
3. Positive parenting	-.43**	.18	1									.00 (.91)
4. ACEs	-.06	.21	-.21	1								2.74 (2.16)
5. Intervention	.13	-.24	.13	.09	1							1.53 (.50)
6. Parent gender	.25	-.50***	-.29	.06	-.10	1						1.75 (.43)
7. Parent age	-.03	-.04	.10	-.32**	-.07	-.10	1					44.39 (6.46)
8. Parent race	-.03	.13	-.35**	.23*	-.16	.08	.03	1				1.18 (.39)
9. Education	.06	.01	-.01	-.10	.15	.09	.35**	-.09	1			3.93 (1.20)
10. Income	-.27	.14	.10	-.10	.05	-.39***	.14	-.04	.33**	1		6.91 (4.45)
11. Par. TL	-.03	.09	.04	-.07	.20	-.26	-.16	-.07	-.30*	-.14	1	.00 (1.00)

Note. * $p < .05$, ** $p < .01$, *** $p < .001$. ACEs = Adverse Childhood Experiences; Par. = Parent; Intervention = 1 (2-week condition), 2 (10-week condition); Gender = 1 (Male), 2 (Female); Race = 1 (White), 2 (Other); Education = 1–11 (grade level), 12 (GED), 20 (Doctorate); Income = 1 (Less than 10k), 2 (10k to 20k), 21 (200k+). Interparental conflict, alcohol use, and parenting represent latent variable factor scores.

17 years old were invited to participate ($N = 200$). This sampling strategy was used to facilitate broader study aims focused on adolescent functioning. Of this targeted sample, parent–child dyads (45 parents and 41 children) provided saliva samples for telomere analysis. Parents and children were included if one member of the dyad opted to provide a saliva sample, leading to differences in parent and child samples sizes in the current study. Low response rates were primarily due to both parent and child refusal to provide a saliva sample or inability to recontact subjects. In the current sample parents were 75% female, an average of 45.61 years old, and 81.6% White, 2.6% African American, 1.3% American Indian, 2.6% Asian, 6.6% more than one race, and 5.3% not reported. Racial/ethnic information was not available for offspring. The median annual income was \$40,000 to \$50,000 (assessed in \$10,000 increments). Parents in the current study had been separated on average 6 years. Children were 42% female and 15.50 years old on average. Forty-seven percent of families were in the 2-week active control condition and 53% were in the 10-week intervention condition of the NBP.

2.2. Procedure

Participants of the study were contacted via phone and email and invited to participate. Participants who agreed to participate were sent saliva collection materials. Parents and their adolescents also were sent an online survey with questions assessing family functioning, adversities, and mental health. Each parent provided consent and adolescents provided assent. Upon completion of the survey, parents were compensated \$50, and adolescents were compensated \$25 for their time. The study's protocol was approved by the University's Institutional Review Board.

2.3. Measures

2.3.1. Demographics/covariates

Parents reported on their current age, race/ethnicity (coded 1 = white, 2 = non-white), age at the child's birth, education level, income, and presence of

degenerative disorders given evidence these constructs may be related to parent and offspring TL. Parents also reported on time since separation from their partner and time spent with their adolescent as this was a divorced sample. Adolescents reported on their gender and age. These variables were examined as covariates in relation to the primary variables of interest in preliminary correlations (see Tables 1 and 2).

2.3.2. New Beginnings Programme prevention trial

In the original study, parents and their children participated in a randomized prevention trial of the NBP. Information for the NBP was presented to families in a required class for divorcing or separated parents. Interested parents were contacted and screened based on the following criteria: (a) there is a minimum of one child between 3 and 17 years old in the home, (b) parents spend at least 3 h each week or at least one overnight every other week with the child, (c) parents and children understand English well enough to complete assessments themselves, and (d) not having been referred by child protective services or juvenile court. Parents were randomly assigned to either a 10-week trial of the NBP or an active 2-week control condition. The NBP targets two protective factors, parent–child relationship quality and effective discipline as well as one risk factor, exposure to interparental conflict. Parents participated in group sessions guided by programme leaders. Parents in the 10-week trial participated in goal-setting, role-play, and practicing parenting skills at home. An active 2-week active comparison condition was used to offer a credible intervention to all families. This consisted of two group sessions in which a leader didactically presented risk and protective factors for divorce and parents were encouraged to exchange their ideas and set goals. Parents were not instructed to role-play or practice parenting skills.

2.3.3. Perceptions of interparental conflict

Parents and adolescents each reported on their perceptions of interparental conflict over the past

Table 2. Descriptive statistics and correlations for adolescent variables.

	1	2	3	4	5	6	7	8	9	10	11	12	M (SD)
1. Interparental conflict	1												.00 (.38)
2. Positive parenting	-.45**	1											.00 (.91)
3. Child ACEs	.16	-.25	1										2.67 (1.70)
4. Intervention	.31*	.13	-.01	1									1.53 (.50)
5. Child gender	.25	.02	.34*	.17	1								1.42 (.50)
6. Child age	-.12	.06	-.04	-.13	-.23	1							15.50 (1.23)
7. Parent race	-.09	-.35*	.09	-.16	-.13	-.01	1						1.18 (.39)
8. Time spent w/child	.05	.03	-.39**	.05	-.19	.02	.03	1					2.20 (1.21)
9. Par. age at birth	.06	.05	-.26	-.07	-.16	.05	.06	.04	1				20.29 (6.39)
10. Par. income	.19	.10	-.12	.05	.02	-.09	-.04	.12	.19	1			6.91 (4.45)
11. Par. TL	-.13	.04	-.08	.20	-.08	-.01	-.07	.04	-.13	-.14	1		.00 (1.00)
12. Ch. TL	-.13	.15	.08	-.21	-.10	-.07	.36*	-.20	-.03	.03	-.13	1	.00 (1.00)

Note. * $p < .05$; ** $p < .01$. ACEs = Adverse Childhood Experiences; Par. = Parent, Ch. = Child; Gender = 1 (Male), 2 (Female); Intervention = 1 (2-week condition), 2 (10-week condition); Gender = 1 (Male), 2 (Female); Parent Race = 1 (White), 2 (Other); Time spent w/Parent (% of time spent with parent) = 1 (80-100%), 5 (0-19%); Race = 1 (White), 2 (Other). Income = 1 (Less than 10k), 2 (10k to 20k), 21 (200k+). Interparental conflict and parenting represent latent variable factor scores.

month using the Children's Perceptions of Interparental Conflict scale (CPIC; Grych, Seid, & Fincham, 1992). This measure has been shown to be reliable and valid for parents and their children (Grych & Fincham, 1993). Parents and adolescents each reported on the Frequency (i.e. 'In the past month you and your partner/your parents argued or disagreed a lot,' 6 items), Intensity (i.e. 'In the past month you and your partner/your parents yelled, pushed, or shoved each other,' 9 items), and Resolution (i.e. 'In the past month, if you and your partner/your parents had an argument, they usually worked it out,' 6 items). Response options for each item were 1 (True), 2 (Sort of true), or 3 (False), with lower scores reflecting more negative conflict. All subscales were calculated so that greater scores indicated greater conflicted behaviour. Alphas for each subscale were .80, .69, and .85 for parent report of frequency, intensity, and resolution respectively. Alphas for each subscale were .80, .71, and .85 for adolescent report of frequency, intensity, and resolution respectively. In both parent and child models, interparental conflict was conceptualized as a latent variable using the three subscales as indicators.

2.3.4. Experience of early adversity

Parents and adolescents each reported on their lifetime exposure to childhood trauma using the Adverse Childhood Experiences (ACEs) Questionnaire (Felitti et al., 1998). This count-based measure has good validity (Murphy et al., 2014), and includes ten questions, which participants respond yes (1) or no (0). An example item from this measure is 'Were you ever the victim of violence or witness to any violence in your neighborhood?' A sum of these ten items was generated for both parents and adolescents, where higher scores indicate more ACEs.

2.3.5. Parent alcohol use

Parents reported on their alcohol use in the past three months using items from the Alcohol Use Disorders

Identification Test (AUDIT), which has been shown to be both reliable and valid (Bush, Kivlahan, McDonnell, Fihn, & Bradley, 1998). Parents reported on their quantity, 0 (1 or 2) to 4 (10 or more), and frequency, 0 (Never) to 4 (4 or more times a week) of alcohol use in the past year, as well as how often they have six or more drinks in one occasion, 0 (Never) to 4 (daily or almost daily). These three items were used as indicators for an alcohol use latent variable.

2.3.6. Positive parenting composite

Adolescents reported on their parent's positive parenting using the Child Report of Parenting Behaviour Inventory (CRPBI), which is a reliable and valid measure of parenting in the past month (Schaefer, 1965). The subscales of the CRPBI include 16 items on acceptance ('In the last month, your (mom/dad) made you feel better after talking over your worries with (her/him)'), 16 items on rejection ('Your (mom/dad) said you were a big problem'), and eight items on consistency of discipline ('Your (mom/dad) frequently changed the rules you were supposed to follow,' all items reverse scored). All items were rated on a scale of 1 (almost never or never) to 5 (almost always or always). The internal consistency of the three scales was good ($\alpha = .92-.95$)

Adolescents also used the Child Monitoring Scale to report on positive parenting. This measure includes 12 items and is valid and reliable for child reporters (Reiss & Roth, 1994). An example item from this measure is 'How much does your (mom/dad) know about ... Your activities outside of school (e.g. sports, jobs, clubs, etc.)?' Adolescents were asked to rate each item on a scale of 1 (Nothing) to 5 (Everything). The internal consistency of this scale was good ($\alpha = .91$)

Parent-Adolescent Communication was also measured as part of positive parenting in the past month. Adolescents reported on this using the Parent-Adolescent Communication Scale (Barnes & Olson, 1985). This measure includes 10 items, such

as ‘When you asked questions, you got honest answers from your (mom/dad).’ Each item was rated on a scale of 1 (Agree a lot) to 5 (Disagree a lot). The internal consistency of this scale was good ($\alpha = .92$).

All scales were scored to indicate greater positive parenting behaviour. In both the parent and child model these five parenting scales were used as indicators of a positive parenting latent variable.

2.3.7. Telomere length

Oragene OGR-500 saliva collection kits were mailed to families for saliva collection. Participants were provided with written and video instructions for providing the saliva samples by spitting into the collection kits. DNA was extracted from saliva samples after which relative TL was assayed via MMqPCR (Cawthon, 2009; Eisenberg, Hayes, & Kuzawa, 2012). All samples, DNA standards, positive, and negative controls were assayed twice in triplicate. The T/S ratio for each sample was calculated by dividing the estimated starting quantity (SQ) of its telomere amplicon (T) by that of a single copy gene – albumin (S) (SQ T/SQ S). T/S ratio was averaged across the sample triplicate and then across assays to be included in subsequent analyses. Lower T/S ratios indicate shorter relative TLs. Intra-class coefficient (ICC) across plates was calculated rather than CV (Eisenberg, 2016). ICC1 (correlation of values measured for the same individual) = 0.93 (95% CI = 0.90, 0.95), ICC1k (correlation of average values measured for the same individual) = 0.97 (95% CI = 0.95, 0.98). Across both parents and offspring, the observed TL-age correlation was ($r = -0.279$, 95% CI = -0.461 , -0.074). TL measures were z-score transformed (Verhulst, 2020). For a full description of saliva collection and telomere analysis see supplementary information.

2.3.8. Statistical analyses

We first examined descriptive statistics and bivariate correlations among study variables separately for parents and children. Next, we examined separate models considering parent TL and child TL as outcomes. Child race was not measured so parent race was examined as a proxy in the child model and was the only covariate associated with child TL. These covariates were included in the parent and child models, respectively. In the parent model we considered interparental conflict (parent-reported), alcohol use, positive parenting, intervention condition, and parent ACEs as correlated predictors of parent TL. In the child model we considered interparental conflict (child-reported), positive parenting, intervention condition, and child ACEs as correlated predictors of child TL. Moderation of effects by intervention condition were not considered due to a lack of power. Additional sensitivity analyses examined interparental conflict and positive parenting, as well as alcohol use

in the parent model, as mediators of intervention condition and TL.

All analyses were pre-registered in the Open Science Framework (<https://osf.io/ay38s>). The present models diverged slightly from the preregistered plan in the following ways. Parenting was reconceptualized as positive parenting rather than negative parenting and one measure, parenting involvement, was not included in the parenting latent variable as it was found unrelated to the other scales in preliminary analyses. In addition, parent alcohol use was included as an additional predictor in the parent model.

Full information maximum likelihood was used to handle missing data, based upon the missing at random (MAR) assumption. Descriptive statistics were conducted in SPSS and all other analyses were conducted in Mplus Version 8.3. Post-hoc power tests in g*power for a multiple linear regression model with the current sample sizes indicate power of .80 to detect medium to large effects ($f^2 > .33$).

3. Results

Descriptive statistics and correlations for parents and children can be found in Tables 1 and 2, respectively. There were few associations among primary constructs, mostly with sociodemographic characteristics. For both parents and children, there was a negative association between interparental conflict and positive parenting (parents: $r = -.43$, $p = .006$; children: $r = -.45$, $p = .003$) but no other correlations were observed among primary constructs. In correlations, parent TL was not associated with child TL so was not included in the final child model.

For the final parent model, intervention condition ($\beta = 0.28$, $p = 0.04$) and parent education ($\beta = -0.33$, $p = 0.01$) were both associated with TL, such that parents in the 10-week intervention group had longer TL whereas increased education was associated with decreased telomere length (see Table 3). Interparental conflict, alcohol use, and ACEs were not associated with parent TL. For the final child model, positive parenting ($\beta = 0.38$, $p = 0.04$) and parent race ($\beta = 0.42$, $p = 0.01$) were both associated with child TL, such that greater positive parenting was associated with longer TL and children had longer TL if their parent was non-white (see Table 4). Interparental conflict, intervention condition, and ACEs were not associated with child TL.

In additional analyses there was no evidence of mediation in either the parent or child model (see Supplemental Materials). In the parent and child model intervention condition did not predict interparental or positive parenting, or alcohol use in the parent model. These variables predicted parent and child TL in the same pattern as in the main parent and child models.

Table 3. Predictors of parent TL.

	Parent TL	
	<i>B</i> (SE)	<i>p</i>
Interparental conflict	-.08 (.17)	.66
Alcohol use	.19 (.14)	.16
Positive parenting	-.09 (.14)	.54
ACEs	-.16 (.14)	.24
Intervention	.28 (.13)	.04
Education	-.33 (.13)	.01

Note. Estimates with *p*-values less than .05 are bolded.

Table 4. Predictors of child TL.

	Child TL	
	<i>B</i> (SE)	<i>p</i>
Interparental conflict	.13 (.19)	.48
Positive parenting	.38 (.18)	.04
ACEs	.09 (.16)	.58
Intervention	-.20 (.16)	.21
Parent race	.42 (.15)	.01

Note. Estimates with *p*-values less than .05 are bolded.

4. Discussion

This study adds to the literature in considering multiple individual and family constructs, the role of adversity, and a parenting intervention, in predicting parent and child TL. We examined this in a sample of families that had experienced divorce. Interestingly, the findings support the importance of protective factors, including the NBP intervention in parent TL and positive parenting in child TL. This complements a growing body of literature emphasizing the importance of identifying factors that promote adaptation in stressful circumstances, specifically the importance of relationships.

Previous family-based intervention effects have been observed on TL, but only in children and adolescents (Brody et al., 2015; Hoyer, 2015). Our study is the first we know of to examine family-based intervention effects on parent TL, finding the 10-week intervention condition associated with longer parent TL. However, there were no effects on child TL. This could be the result of the NBP being a parent-focused intervention for divorced families with programming on interparental conflict and parenting skills. Specifically, the NBP was designed to target key parent behaviours that follow divorce including improving parent-child relationship quality and effective discipline as well as reducing exposure to interparental conflict. Participation in the NBP could have reduced family and parent stress related to divorce or single parenting through more effective parenting practices, and/or reduced interparental conflict. This reduction in stress could have had possible long-term effects on mental health and physiological stress, all collectively contributing to longer TL. These effects may occur, in-part, due to the extended nature of the NBP which is in-line with previous interventions on TL (Brody et al., 2015; Hoyer, 2015). Thus, extended interventions may

be needed to achieve biological effects via both increases in adaptive abilities and reduced physiological stress. Although we examined indirect effects of the intervention on parent TL via interparental conflict, parenting, or alcohol use, we did not find any significant indirect effects. Future studies should consider intervention length, intervention effects on adult physiological functioning, and pre/post assessment of TL.

In children, the buffering effect of positive parenting is interesting and in-line with the few studies examining positive parenting (Asok et al., 2013; Brody et al., 2015). These studies theorize that positive parenting may contribute to slower TL shortening via reductions in physiological and psychological stress in children. Although our results suggest that there is a buffering effect of positive parenting on child TL, we did not find intervention effects on child TL mediated by parenting or interparental conflict. Future studies should consider examining these effects in larger, more diverse samples.

We found that children whose parent were non-white had longer TL, although this finding should be interpreted with caution given that less than 20% of parents in this sample were non-white. This association has been shown in young adults (e.g. Lynch et al., 2016), however, the opposite pattern has been observed in adulthood, specifically shorter TL in non-white populations such as African Americans (Coimbra et al., 2020). This may be due to increased exposure to social stress related to discrimination and social inequality across the lifespan, accelerating cellular aging and shortening TL (Coimbra et al., 2020). In addition, the finding that greater educational level was associated with shorter parent TL should also be interpreted with caution as this is contrary to most evidence. Some research has found negative associations between education level and TL in older men (see Murkey, Watkins, Vieira, & Boden-Albala, 2022), with speculation that greater educational attainment may be linked to shorter TL due to less healthy lifestyles involving greater job stress, less physical activity, and greater alcohol use (Woo, Suen, Leung, Tang, & Ebrahim, 2009). Collectively, emerging research finds nuanced interactive patterns among employment, discrimination, and educational attainment which are beyond the scope of the present study, but which future research should pursue (Thomas, Sohail, Mendez, Márquez-Magaña, & Allen, 2021).

The lack of effects for interparental conflict in both parents and children may be due to the long average length of time that had passed between parental separation and the current study. We also did not detect an association between alcohol use and parent TL. This may be because the current measure was of normative alcohol use and did not capture alcohol dependence or substance use disorder which has previously been associated with TL (Maugeri et al., 2021; Navarro-

Mateu et al., 2021). Finally, the lack of effect of ACEs on TL in either parents or children is interesting and may be that our measure of ACEs was not specific enough. More broadly, heterogeneity in associations between ACEs and TL are proposed to vary based on timing, severity, and chronicity of exposure to risk factors, variation in measurement of the environment, and variation in measurement of TL (Hanssen et al., 2017), as well as publication bias (Ridout et al., 2018). Complementary to these explanations, it is also likely that with the current small sample size we were unable to detect the aforementioned effects, particularly if they were small in size. Conversely, despite the small sample size there was good reproducibility across TL assay runs, increasing confidence in TL measurement. Further, our measurement of interparental conflict and parenting leveraged latent variables representing multiple measures/scales. Using this approach, we detected an effect of the NBP intervention on parent TL and positive parenting on child TL. It should be noted that both findings emerged when testing our defined pre-registered analysis plan.

Limitations should be considered, primarily that the current study had a small sample size. This precluded testing for possible interactive effects on TL. Also, a wide range of factors are associated with TL and we were not able to include other possible individual and environmental factors previously associated with TL such as diet, physical health, exercise, smoking, exposure to carcinogens, or other possible confounders. Relatedly, child race/ethnicity was not assessed so parent race/ethnicity was examined as a proxy which we acknowledge is imprecise. Future research is needed to better understand the role of race/ethnicity in child TL. Also, parents in this sample separated on average 6 years prior to the current assessment and this is also when the intervention took place. This makes interparental conflict less salient during the current assessment. This also introduces the possibility that other individual, family, and environmental factors may have arisen during this intervening period, however, these were outside the scope of the current study. The final limitation was sample type. Though salivary DNA is primarily composed of leukocytes and shows strong to moderate associations with blood, it is more cellularly heterogeneous (Rej et al., 2021; Theall, Brett, Shirtcliff, Dunn, & Drury, 2013). These limitations are in light of some notable strengths. An important contribution of this study was examination of an array of individual and family predictors of parent and child TL in the context of a psychosocial intervention.

5. Conclusion

The current findings have implications for prevention, namely supporting the importance of psychosocial

interventions and positive parenting especially for those families most at risk, as well as the impact that extended psychosocial intervention can have at the biological level. Prevention science is beginning to focus on a dual generation approach, which recognizes the importance of simultaneous support for both parents and children. The benefits of these programmes are gained both through the recognition of the importance of strengthening the whole family, but also from the coordination of different service agencies. Supporting family relationships may be especially important in minimizing adversity and effects on biological functioning.

Data availability statement

Data are not publicly available due to privacy and confidentiality of participants. Restricted data are available upon reasonable request from the PIs.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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