# Longitudinal Association Between Participation in Organized Sport and Psychosocial Development in Early Childhood

Ross D. Neville, PhD[1], Ye Guo, MPhil[2], Colin A. Boreham, PhD[1], and Kimberley D. Lakes, PhD[3]

**Objective** To explore whether the associations between developmental delays in the first year of life and psychosocial outcomes in preschool children are affected by participation in organized sport.

**Study design** Data were obtained from the infant cohort of the Growing Up in Ireland project. Parents reported on child development (Ages and Stages Questionnaire) at age 1 year, psychosocial characteristics (Strengths and Difficulties Questionnaire) at ages 3 and 5 years, and engagement in organized sport at age 5 years. Data were analyzed using mixed models.

**Results** At age 1 year, 15% of the cohort was classified as having developmental delays. These children exhibited more behavioral difficulties (0.55, ±0.27; mean difference, ±95% confidence limits [CL]) ($P < .0001$) and fewer prosocial behaviors (−0.54, ±0.11) ($P < .0001$) at age 3 years. For boys in this group, engagement in sport was associated with a significant decrease in behavioral difficulties between ages 3 and 5 years (−0.44, ±0.39) ($P = .03$). Compared with those classified as lacking regular engagement (ie, never engaging, or engaging <1 hour/week), the relative effect of sport on changes in behavioral difficulties for boys with developmental delays was statistically significant (0.70, ±0.59) ($P = .02$). Participation in sport was not associated with significant changes in behavioral difficulties for girls, or a significant change in prosocial behaviors for boys or girls.

**Conclusions** Regular participation in sport by boys could attenuate some of the behavioral difficulties associated with early development. Lack of opportunities for engaging in sport could negatively affect boys' behavioral regulation in the preschool period. *(J Pediatr 2021;230:152-60)*.

If developmental delays in key areas are not identified and targeted within early childhood, a crucial window of opportunity for intervention can be missed.[1] For example, psychosocial development in early childhood is a strong predictor of wide-ranging socioeconomic, social-emotional, behavioral-regulatory, and health-related outcomes later in life. Moffitt et al have shown that early childhood is 1 of the 2 critical periods to target psychosocial development, not only improving a child's developmental trajectory over time but also even reducing the substantial societal costs that have been shown to be associated with poor self-control.[2]

The first 5 years of life provide a unique opportunity to impact a child's developmental trajectory.[3,4] Early interventions now often focus on the establishment of healthy lifestyle habits, such as increasing the child's level of physical activity by engaging routinely in organized sports. The American Academy of Pediatrics advocates for such structured forms of physical activity and engagement in sport as "universally beneficial" for all children, regardless of ability status.[5] Physical activity is associated with benefits in multiple domains of child development, including cognition and academic achievement[6] and emotional and behavioral regulation.[7] Regular participation in organized sport provides a structured, routinized, and therefore reliable way of achieving the recommended daily amounts of physical activity.[8] Participation in organized sport also latently exposes children to higher-order psychosocial demands such as goal-setting and -striving, respect for authority, rule-following and -reinforcing, practice, teamwork, and mastery, coping with adversity, role-playing, fair play, and moral reasoning.[9]

Research on active lifestyles in the context of developmental delays is still limited,[10] and the evidence base requires larger sample sizes and longitudinal follow-up.[11-13] A systematic review[12] of short-term (≤6 months) and small-scale (n ≤ 60) intervention studies in this population suggested that physical activity can be beneficial in the context of behavioral regulation and reduced stereotyped behaviors—both of which are common and chronic among children with developmental delays.[12,14] Despite the known health benefits, and the opportunities physical activity presents for the development and refinement of adaptive skills,[15] children with developmental delays are less likely to be physically active and more likely to be excluded from sports than

| | |
|---|---|
| ASQ | Ages and Stages Questionnaire |
| CL | Confidence limits |
| SDQ | Strengths and Difficulties Questionnaire |

From the [1]School of Public Health, Physiotherapy and Sports Science, University College Dublin, Dublin, Ireland; [2]School of Physical Education, Guangzhou University, Guangzhou, Guangdong, China; and [3]Department of Psychiatry and Neuroscience, School of Medicine, University of California, Riverside, CA

Contribution to this study from Y.G. was supported by the China National Social Science Fund (14CTY023). .The funder had no role in: the design and conduct of the study; collection, management, analysis, and interpretation of the data; preparation, review, drafting, or final approval of the manuscript; and the decision to submit the manuscript for publication in this journal. The authors declare no conflicts of interest.


https://doi.org/10.1016/j.jpeds.2020.10.077

their typically developing peers.[16-20] Moreover, parents of children with developmental delays may be less likely to perceive such activities as beneficial.[21,22]

Using a nationally representative prospective cohort of Irish children recruited at birth and followed up at ages 1, 3, and 5 years, we explored the association between developmental delays in the first year of life and social–emotional and behavioral outcomes in preschool children and the extent to which this association was moderated by participation in organized sport. Specifically, we sought to understand the extent to which early childhood difficulties were ameliorated, and prosocial behaviors enhanced, by regularity of engagement in organized sport. We explored these associations separately for boys and girls, because research has shown that their psychosocial development and levels of engagement in different forms of physical activities differ in the early childhood years.[23,24]

## Methods

Data were derived from the infant cohort of the Growing Up in Ireland project, which is a nationally representative longitudinal study focusing on determinants of wellbeing in early childhood. The infant cohort represents a simple random sample of 11 194 children who were born in Ireland between December 2007 and June 2008.[25] A prospective panel design was used, and data about the sampled children were collected from primary caregivers in their homes by trained researchers from the Irish Central Statistics Office. Data for use in this specific study were collected at 3 separate time points: when the child was age 1 year, which commenced in September 2008 and comprised data from the original (n = 11 194) cohort; age 3 years, which was undertaken between December 2010 and July 2011 (n = 9793); and age 5 years, which took place between March and September 2013 (n = 9001). Given the nature of the design and representativeness of the sample, no exclusion criteria were applied to children with specific congenital abnormalities, syndromes, diseases, or disorders. Data analyses for this particular study were conducted in August 2019. Community-, socioeconomic-, household-, and parent-level factors for the cohort are summarized in **Table I**. Child-level characteristics are summarized for boys and girls separately in **Table II**. Ethical approval for the study was granted by an independent research ethics committee convened by the Irish Department of Children and Youth Affairs. Primary caregivers received no incentive to participate in the study and provided written informed consent.

**Table I. Community, socioeconomic, household-, and parent-level characteristics of the sample**

| Characteristics | Value |
|---|---|
| Community-level factors | |
| Urban, n | 4942 (45) |
| Sense of community, mean (SD) (1-4) | 1.79 (0.51) |
| Community safety, mean (SD) (1-4) | 2.77 (0.37) |
| Community facilities, mean (SD) (1-4) | 2.05 (0.68) |
| Socioeconomic factors | |
| Ethnicity, n (%) | |
| White Irish | 8810 (79) |
| White non-Irish | 1533 (14) |
| Black/African | 377 (3) |
| Asian | 315 (3) |
| Mixed/other | 55 (<1) |
| Maternal education, n (%) | |
| No formal education | 37 (<1) |
| Primary school education | 244 (2) |
| Secondary school education | 3158 (28) |
| Technical or vocational education | 1500 (14) |
| College or university diploma | 2154 (19) |
| College or university degree | 2539 (23) |
| Completed postgraduate studies | 1492 (13) |
| Equivalized household income, n (%) | |
| Q1 (<$13 917) | 2219 (20) |
| Q2 ($13 917-$19 792) | 1925 (17) |
| Q3 ($19 792-$26 610) | 1970 (18) |
| Q4 ($26 610-$37 315) | 2204 (20) |
| Q5 (>$37 315) | 1952 (17) |
| Missing | 864 (8) |
| Household-level factors | |
| Single parent, n (%) | 1359 (12) |
| Family-size, mean (SD) | 4.06 (1.16) |
| PCG-level factors | |
| PCG parenting style, mean (SD) (1-5) | |
| Warmth | 4.72 (0.40) |
| Hostility | 1.80 (0.49) |
| Consistency | 4.08 (0.70) |
| PCG stress, mean (SD) (6-30) | 11.75 (4.07) |

*PCG*, primary caregiver, *Q*, quintile.

### Outcome Variable

**Psychosocial Development.** Social, emotional, and behavioral outcomes were assessed using the parent-report version of the Strengths and Difficulties Questionnaire (SDQ).[26] The SDQ comprises 25 items subdivided into 5 behavioral scales: emotional symptoms; conduct problems; inattention problems; peer problems; and prosocial behaviors. Example items include: "nervous or clingy in new situations…" (emotional symptoms); "often fights with other children" (conduct problems); "easily distracted, concentration wanders" (inattention problems); "generally liked by other children" (reverse coded) (peer problems); "often volunteers to help others…" (prosocial behaviors). Scores within each item (0 = "not true, 1 = "somewhat true", and 2 = "certainly true") were added to derive a total, ranging from 0 to 10. SDQ produces 2 factors: prosocial behaviors (combining 5 items that range from 0 to 10) and behavioral difficulties (combining the remaining 4 × 5 items that range from 0 to 40). The psychometric properties of SDQ exhibit a high level of construct validity.[26] Research has shown that the SDQ is sensitive to change among children,[27] and that it is at least as effective as semistructured interviewing at detecting social, emotional, and behavioral problems.[28] These factors combine to make SDQ a particularly effective tool in longitudinal studies.[29]

### Independent Variables

**Developmental Delays.** Developmental delays were assessed using the parent-report version of the Ages and Stages Questionnaire (ASQ).[30] The ASQ is a highly reliable and cross-

**Table II. Child-level characteristics, by ASQ group**

| Characteristics | Low (n = 1654) | Mid (n = 6021) | High (n = 3459) | Total (n = 11134) |
|---|---|---|---|---|
| Independent variables | | | | |
| Girls, n (%) | 733 (13) | 2998 (55) | 1724 (32) | 5455 (100) |
| Boys, n (%) | 921 (16) | 3023 (53) | 1735 (31) | 5679 (100) |
| Regularity of engagement in organized sport, n (%) | | | | |
| Irregular participation | 724 (16) | 2535 (55) | 1327 (29) | 4586 (100) |
| Weekly participation | 631 (14) | 2405 (55) | 1379 (31) | 4415 (100) |
| Covariates | | | | |
| BMI at age 5 y, mean (SD) | 16.11 (1.86) | 16.18 (1.79) | 16.24 (1.75) | 16.19 (1.79) |
| Total daily sleep, min, at age 5 y, mean (SD) | 710 (59) | 705 (60) | 707 (62) | 707 (61) |
| Daily screen time, h, at age 5 y, mean (SD) | 1.44 (0.79) | 1.51 (0.74) | 1.50 (0.74) | 1.51 (0.75) |
| PA at age 5 y, (0-7) | 3.79 (0.73) | 3.91 (0.67) | 3.98 (0.65) | 3.91 (0.68) |
| Dependent variables | | | | |
| Prosocial behaviors at age 3 y, mean (SD) (0-10) | 7.52 (2.01) | 7.92 (1.74) | 8.20 (1.61) | 7.95 (1.76) |
| Prosocial behaviors at age 5 y, mean (SD) (0-10) | 8.03 (1.96) | 8.42 (1.65) | 8.60 (1.50) | 8.42 (1.66) |
| Behavioral difficulties at age 3 y, mean (SD) (0-40) | 8.25 (4.76) | 7.73 (4.53) | 7.69 (4.51) | 7.79 (4.56) |
| Behavioral difficulties at age 5 y, mean (SD) (0-40) | 7.55 (4.91) | 7.14 (4.72) | 7.10 (4.73) | 7.19 (4.76) |

*BMI*, body mass index; *PA*, physical activity.

culturally valid[31] screening tool that comprises 30 items subdivided into 5 developmental areas: personal–social; gross motor; fine motor; problem-solving; and communication. Items are scored between 0 and 10, generating an outcome for each developmental area of 0 to 60. Outcomes were assessed against the widely established cut-off score of 2 SDs below the mean, which was used to designate for the child a pass or fail in that particular developmental area. A fail indicated that the child may be at risk of delayed development in that particular area. Following the recommendations outlined in the ASQ user guide,[32] we categorized developmental status into three distinct groups. A fail in more than 2 developmental areas was indicative of a broad developmental delay; a pass in all 5 areas was indicative of strong development; and the remaining pass-fail combinations were indicative of typical early childhood development, with one or two areas of potential concern.[32] For the purposes of analysis, we refer to these 3 categories representing as low-, mid-, and high-ASQ groups.

**Participation in Organized Sport.** At age 5 years, parents were asked about their child's participation in organized sport over the course of the previous 12 months: "Does <child> attend a sports club or a sports group?" Parents responded on a 1 to 5 visual analog scale coded as follows: 1 = "never"; 2 = twice a month"; 3 = "regularly, 1 hour per week"; 4 = "regularly, 2 hours per week"; 5 = "regularly, more than 2 hours per week." After initial data screening, which revealed that <90 of children sampled (ie, <2%) were reported as attending a sports club or group "twice a month"; this item was dichotomized to reflect "irregular" (≤2 on the visual analog scale) and "weekly" (≥3) participation in organized sport. Very much consistent with international participation data from other anglosphere and European countries,[33] in Ireland,[34] the predominant sporting activities undertaken by children are organized team-based activities, such as the national Gaelic Games (Gaelic Football, Hurling, and Camogie), Association Football, or "Soccer," rugby, and basketball. Broadly speaking, these activities fall into either or both of the "football code" and "invasion games" categories of sporting rules, competence, and mastery.[35] Invasion games represent the most complex game form within which players work together to enter the opposition team's territory with an object (usually, though not always, a ball) to score or reach a goal. Playing such games requires interaction with peers, communication, teamwork, cooperation, role-playing, shared goal-striving, tactical knowledge, awareness of strategy, trust, understanding of fair play, among other things, all of which are known to contribute to psychosocial development and to the development of transferable skills.[35]

**Additional Covariates.** There is an "ecology" of factors that affect psychosocial development and engagement in organized sport.[9] Therefore, in our analyses, we have controlled for a broad range of known regional, community-, socioeconomic-, household-, parent-, and child-level covariates. The geographical location of the household was coded as rural or urban. Primary caregivers were also asked a range of Likert-style questions about the community within which their household was located. Primary caregivers were asked 16 questions in total on a scale of 1 (strongly agree) to 4 (strongly disagree), and principal components analysis confirmed the factorial independence of these items as: "sense of community" (5 items), "access to facilities" (5 items), and "community safety" (6 items). Ethnicity was classified as "white Irish," "white non-Irish," "black or African," "Asian," or "mixed/other." Primary caregivers' level of educational attainment was ranked from 1 (no formal education) to 7 (completed postgraduate studies). Equalized household income was calculated and coded into quintiles. Family size, whether or not the child was living in a single- or dual-parent household, primary caregiver self-reported parenting style (along 3 dimensions—"warmth," "hostility," and "consistency"—validated for the Longitudinal Study of Australian Children,[25] and primary caregiver self-reported stress (according to the Parental Stress Scale[25]) was also reported. As for the child-level factors, sex was categorized as boy and girl; height and weight were measured by trained researchers from the Irish Central Statistics Office at ages 3 and 5 years; height was measured in centimeters using a Leicester Portable Measure, and weight in kilograms was measured using a reliable digital scale (model 385; SECA); body mass index was calculated using the formula weight in kg/height in $m^2$. The child's usual bedtime and

waking up times also were reported by primary caregivers. These were used to calculate an average value for the child's night time sleep, which was thereafter combined with their daytime sleep in minutes to estimate a value for total daily sleep for each child. Finally, to more precisely estimate the effect of weekly participation in organized sport, we controlled for the effects of daily screen time and engagement in unstructured physical activities. To assess screen time, primary caregivers reported the time (in hours per day) that their children spent watching television and using electronic devices at age 5 years. Also at age 5 years, to assess levels of physical activity, primary caregivers were also asked a series of questions about their child's regularity of engagement in different types of unstructured physical activities: "Can you tell me how often <your child>:" "…participates in sport or physical activities," "…climbs on trees, climbing frames, wall bars, etc," "…plays with a ball," "…plays chasing," "…rides a bike, tricycle, or scooter." In respect of these activities, primary caregivers responded on a 1 to 5 scale, where 1 = "never" and 5 = "every day." Principal components analysis confirmed the factorial independence of these items when compared against a range of general playing items that were more passive (eg, painting and drawing, and listening to music) or sedentary (playing make believe or pretend games) in nature.

### Statistical Analyses

A subsample of 7831 (70%) children had complete records for each of the variables of interest. We recognized the issues that can arise from complete case analysis or simple mean substitution when there are substantial missing data and clear missing data patterns. Therefore, we used multiple imputation to produce unbiased estimates of the effect of sport on the association between developmental delays (at age 1 year) and later psychosocial development (between the ages of 3 and 5 years). Imputed data were analyzed in SAS (SAS Studio, University Edition; SAS Institute, Inc). Imputed datasets were analyzed using the linear mixed model program (PROC MIXED). The fixed factors in the model were derived from the interaction between developmental status (3 levels: low-, mid-, and high-ASQ groups), sex (2 levels: boys and girls), and regularity of engagement in organized sport (2 levels: irregular and weekly engagement). The random factor statement in PROC MIXED was specified to allow for different residual errors (SD of change scores) in each of these 12 comparison groups. The final model estimated least squares mean changes (age 5 minus 3 years) in the dependent variables across each of these 12 groups whilst adjusting for baseline differences between groups and with the change score as the dependent variable. The precise effect of participation in sport was derived using least squares means estimates in the PROC MIXED program. The effects therefore represent differences in the adjusted mean changes between the comparison groups: for example, the difference in mean changes in behavioral difficulties for boys with developmental delays with irregular and with weekly participation in organized sport. The final models were also adjusted for potential confounders by holding the additional covariates constant at their mean. Separate models were used for evaluating behavioral difficulties and prosocial behaviors. The Bonferroni correction was used in each of the models to adjust for multiple comparisons. In light of ongoing debates about the sole use of statistical significance testing and *P* values without considering the level of uncertainty in an estimate or effect, the results that follow are also interpreted in terms of their magnitude and respective 95% confidence limits (CLs).

## Results

### Sample Characteristics

Subject characteristics for 11 134 children are shown in Table II, by ASQ group. At age 1 year, 15% were classified as exhibiting developmental delays (low-ASQ). The proportions of children with typical (mid-ASQ) and strong development (high-ASQ) were 54% and 31%, respectively. There was a no difference in the proportions of boys and girls in these ASQ groups (0.91,×/÷1.06; proportion ratio, ×/÷95% CL), and there was also no practical difference in the proportions of boys and girls engaged in organized sport on a weekly basis (1.05, ×/÷1.03; proportion ratio, ×/÷95% CL).

Table II also shows descriptive statistics for dependent variables and additional child-level covariates, by ASQ group. There was a non-significant difference in body mass index between the low-ASQ group and their typically developing peers combined in the mid- and high-ASQ groups ($t_{[1830]} = -1.81$, $P = .07$: −0.10, ±0.10; mean difference, ±95% CL). Total daily sleep in minutes ($t_{[2075]} = 1.97$, $P = .05$: 3.38, ±3.36; mean difference, ±95% CL) and screen time in hours ($t_{[1837]} = 1.27$, $P = .20$: 0.03, ±0.05; mean difference, ±95% CL) did not differ significantly in the low-ASQ group. There were significant differences in regularity of engagement in unstructured physical activities and in the dependent variables across ASQ groups, however. Children in the low-ASQ group were reported by their primary caregivers as engaging in less physical activity than their typically developing peers ($t_{[1803]} = -7.38$, $P < .0001$: −0.16, ±0.04; mean difference in days per week, ±95% CL). Children in the low-ASQ group were also reported as exhibiting more behavioral difficulties at ages 3 ($t_{[1976]} = 3.99$, $P < .0001$: 0.54, ±0.27; mean difference, ±95% CL) and 5 years ($t_{[1865]} = 2.92$, $P = .003$: 0.43, ±0.28; mean difference, ±95% CL) and fewer prosocial behaviors at ages 3 ($t_{[1846]} = -9.58$, $P < .0001$: −0.54, ±0.11; mean difference, ±95% CL) and 5 years ($t_{[1693]} = -8.62$, $P < .0001$: −0.49, ±0.11; mean difference, ±95% CL) than their typically developing peers.

### Primary Analysis

Figure 1 illustrates mean changes in prosocial behaviors and behavioral difficulties between ages 3 and 5 years. Figure 1 shows that there were practically no differences in the changes in prosocial behaviors over time across developmental levels (mid–low ASQ: $t_{[600]} = -2.32$,

$P$ = .02: −0.11, ±0.10; difference in least squares mean changes, ±95% CL) (high–low ASQ: $t_{[600]}$ = −2.50, $P$ = .01: −0.13, ±0.11; difference in least squares mean changes, ±95% CL). There were meaningful differences in the changes in prosocial behaviors between boys and girls without regard for developmental status ($t_{[600]}$ = 9.03, $P$ < .0001: 0.33, ±0.07; difference in least squares mean changes, ±95% CL). Regularity of participation in organized sport was not associated with a substantial sized change in prosocial behaviors between groups ($t_{[600]}$ = −2.53, $P$ = .01: −0.10, ±0.07; difference in least squares mean changes, ±95% CL).

Girls with developmental delays exhibited a significant decrease in behavioral difficulties over time ($t_{[205]}$ = −5.63, $P$ < .0001: −0.83, ±0.29; least squares mean change, ±95% CL) (Figure 1). No significance was detected from a pairwise comparison of girls with irregular and weekly sport participation in relation to changes in behavioral difficulties over time ($t_{[292]}$ = 0.36, $P$ = .72: 0.10, ±0.55; difference in least squares mean changes, ±95% CL). There was a nonsignificant change in behavioral difficulties for boys who did not regularly participate in sport ($t_{[330]}$ = 1.19, $P$ = .23: 0.26, ±0.43; difference in least squares mean changes, ±95% CL). And, when compared with the significant decrease in behavioral difficulties for boys with weekly participation in sport ($t_{[215]}$ = −2.18, $P$ = .03: −0.44, ±0.39; difference in least squares mean changes, ±95% CL), the relative effect of participating in sport on changes in behavioral difficulties for boys with developmental delays was statistically significant with a larger effect magnitude ($t_{[232]}$ = 2.31, $P$ = .02: 0.70, ±0.59; difference in least squares mean changes, ±95% CL).

### Post Hoc Analysis of Covariates

Table III (available at www.jpeds.com) summarizes the confounding effects of the additional covariates. Clearly, primary caregivers' self-reported levels of stress ($t_{[334]}$ = 21.32, $P$ < .0001: 1.96, ±0.18; standardized beta coefficient, ±95% CL), as well as evidence (from the parental styles inventory) of primary caregivers' hostility towards the child ($t_{[307]}$ = 20.74, $P$ < .0001: 1.97, ±0.19 standardized beta coefficient, ±95% CL), represent large confounding effects. These estimates indicate that a 2SD difference in primary caregivers' levels of stress and hostility toward their child is associated with an approximate 2 unit increase in behavioral difficulties. Relevant normative data for the present cohort (available from https://www.sdqinfo.org/norms/UK3yearNorm.html) indicate that a 1-unit change in behavioral difficulties on the SDQ scale represents a substantial magnitude. This begs the question of the extent to which the effects of sport on changes in behavioral difficulties for boys with developmental delays differ according to levels of primary caregivers' stress and hostility.

**Effect of Primary Caregiver Stress.** The extent to which primary caregivers' stress moderated the effect of sport on changes in behavioral difficulties for boys with developmental delays between ages 3 and 5 years is summarized in Figure 2. Weekly participation in organized sport is associated with a statistically significant relative reduction in behavioral difficulties for boys with developmental delays whose primary caregiver self-reported high levels of stress ($t_{[263]}$ = −2.03, $P$ = .04: −1.20, ±1.16; difference in least squares mean changes, ±95% CL). No significance was detected for the 2 leftmost data points, which represent the corresponding pairwise comparison for primary caregivers with low levels of self-reported stress ($t_{[173]}$ = −0.60, $P$ = .55: −0.30, ±0.99; difference in least squares mean changes, ±95% CL).

### Effect of Primary Caregivers' Hostility

Weekly participation in organized sport is associated with a statistically significant relative reduction in behavioral difficulties for boys with developmental delays whose primary caregiver reported low levels of hostility ($t_{[405]}$ = −2.79, $P$ = .006: −1.27, ±0.89; difference in least squares mean changes, ±95% CL) (Figure 2). No significance was detected in corresponding pairwise comparison for primary caregivers reporting high levels of hostility ($t_{[226]}$ = −0.73, $P$ = .47: −0.40, ±1.08; difference in least squares mean changes, ±95% CL). These findings suggest that the potentially beneficial developmental effect of sport on preschool boys' behavioral regulation is accentuated and diminished in households with low and high primary caregiver hostility, respectively.

## Discussion

We explored the extent to which the association between developmental delays in the first year of life and social–emotional and behavioral outcomes in preschool children are moderated by engagement in organized sport. By age 3 years, children with developmental delays exhibited more behavioral difficulties and fewer prosocial behaviors than their typically developing peers. For boys with developmental delays, regular participation in sport by age 5 years was associated with a substantial relative decrease in behavioral difficulties between the ages of 3 and 5 years. This positive association was accentuated for boys living in households in which primary caregivers reported high levels of stress but diminished in households in which there was evidence of hostility in the primary caregiver–child relationship. Our data suggest that the beneficial effects of such interventions could be moderated by the degree to which the primary caregiver exhibits self-oriented and other-directed negative affect (eg, anxiety, depression, fear, or distress vs irritability, hostility, anger, and aggression).[36]

Our results reaffirm at a population level what is known about the association between developmental delays and behavioral difficulties from smaller studies, ie, children exhibiting early childhood delays are at a greater risk of suboptimal development in the preschool period.[1] Early childhood delays predict cognitive delays such as lower IQ by age 5 years,[37] thereby highlighting how early screening can be an important factor in a child's readiness and ability to succeed academically at school. We have shown early childhood

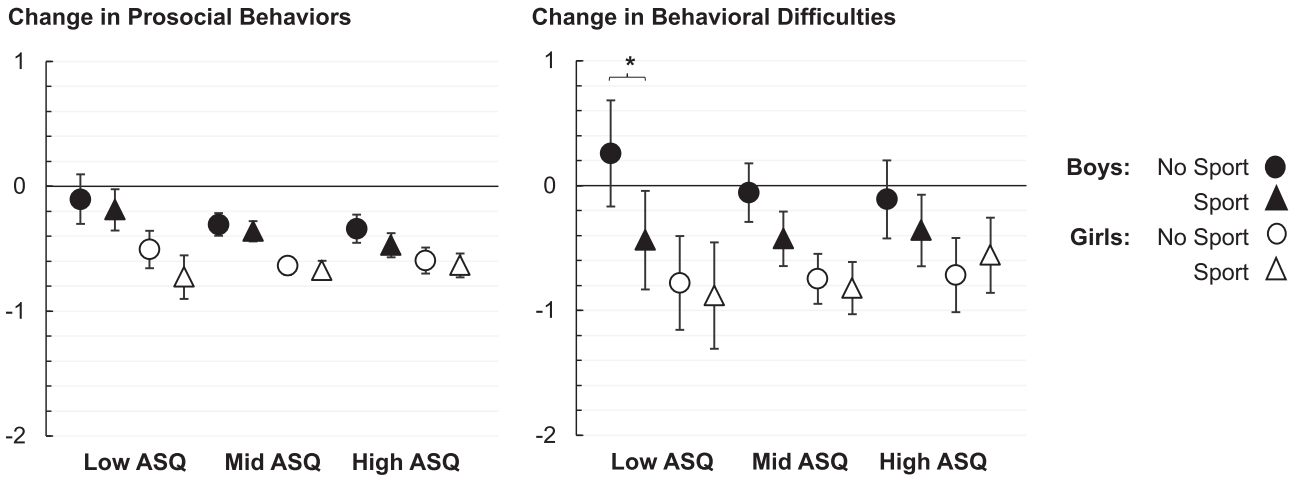


**Figure 1.** Data are changes in prosocial behaviors (*left*) and behavioral difficulties (*right*) between the age of 3 and 5 years, by the child's developmental level, sex, and regularity of engagement in organized sport. *Error bars* represent 95% CLs. *Asterisks* represent statistically significant differences between levels (*$P < .05$).

delays are associated with greater behavioral difficulties and fewer prosocial behaviors by age 3 years. Such behavioral deficits, if could be early indicators of a lack of readiness for engagement in more meaningful and structured interpersonal activities at school, namely learning.

Our study also provides further evidence to support the belief that age 3-5 years is a critical period for interventions to impact a child's developmental trajectory. However, we would speculate that interventions focusing on reducing behavioral difficulties are more appropriate at this age, as our analysis showed that there were non-significant changes in prosocial behaviors across all children comparing ages 3 and 5 years. When considered alongside evidence from other recent international longitudinal studies,[29,38-40] our findings suggest that later childhood (eg, Key Stages 1 and 2 at school) could be a more appropriate period for interventions focusing on prosocial learning,[23,39] for example, during Piaget pre-operational (age 4-7 years) and operational (age 8-11 years) stages.[41] The transfer of learning across contexts that would be required to enhance prosocial behaviors is particularly open to intervention within the operational stage of child development.[42]

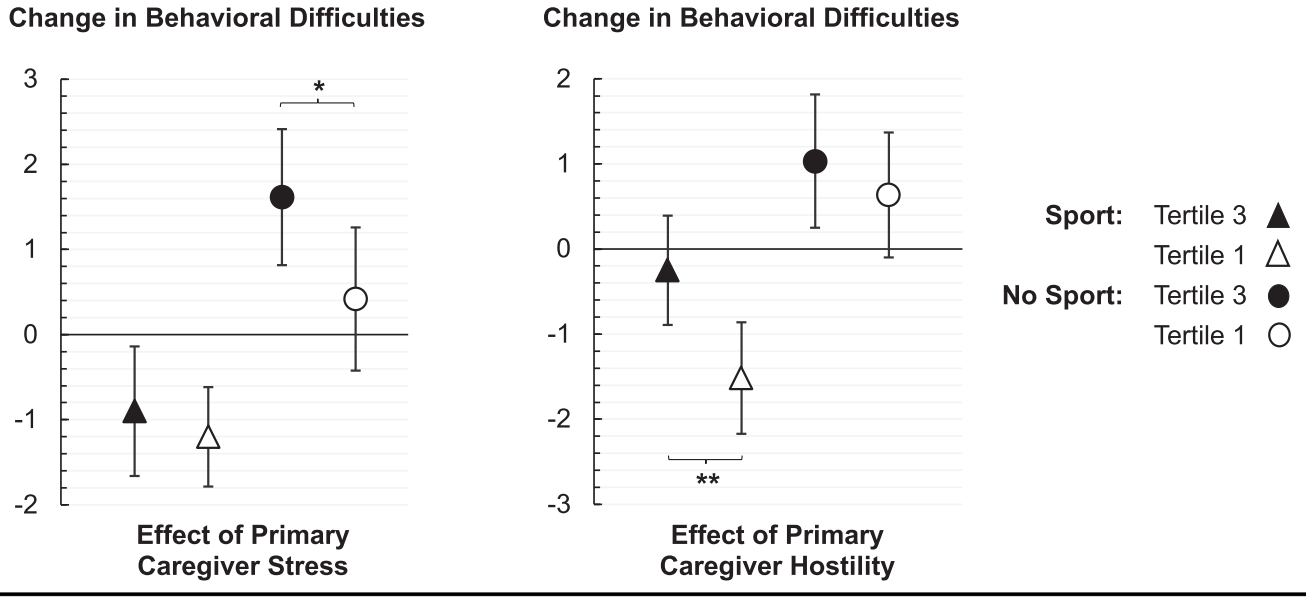


**Figure 2.** Data are changes in behavioral difficulties between the age of 3 and 5 years, by the child's developmental level, sex, and regularity of engagement in organized sport. *Error bars* represent 95% CLs. Tertile 3 and 1 represent high and low levels of primary caregiver stress (*left*) and hostility (*right*), respectively. *Asterisks* represent statistically significant differences between levels (*$P < .05$, **$P < .01$).

Recent studies have shown that moderate-to-vigorous physical activity is associated with conduct and hyperactivity problems in early- and mid-childhood.[43] This suggests that physical activity might not be a reliable predictor of self-control, which is a crucial component of development in early childhood and a strong predictor of social-emotional, behavioral, and health-related outcomes later in life.[2] We suspect that the structured, routinized, role-based, rule-governed, and goal-oriented nature of sporting activities make them particularly suitable for promoting beneficial developmental outcomes, including behavioral regulation, in the early years. Such an association between participation in organized sport and behavioral regulation is suggested in studies of school-age children in the Sport Education literature, and in pedagogical models that proffer the benefits of sports-based physical education in school for reinforcing educative values such as cooperation, patience, empathy, self-discipline, resilience, and fair play.[35] Emerging lines of developmental science research posit that qualitative rather than quantitative characteristics of physical activity determine its effect on executive functioning, which is a known precursor of behavioral regulation in early childhood.[6,7,44]

Our study contributes to the already equivocal nature of research on physical activity and sex differences in preschool children.[24] Typical development includes an increase in behavioral regulation from toddlerhood to school entry, and it may be the case that girls develop behavioral regulation at an earlier stage, or at a faster rate, than boys.[45-48] A focus on different predictors of externalizing behaviors in girls and boys may be more useful than a focus on differences in sex in behavior or developmental trajectories.[45] Boys and girls exhibit externalizing behavior problems to a similar degree from ages 2 to 5 years, and there are differences in sex in the contextual risk factors associated with behavioral profiles.[44,49] Different types of early intervention activities may be needed to target differences in risk factors for behavioral problems.[45]

Girls are more negatively affected by increased sedentary time (than they are positively affected by increased moderate-to-vigorous physical activity)[23]; thus, other movement-based activities—such as dance- or arts-based education—may provide girls with more meaningful opportunities for the development of behavioral regulation. Many of these activities share similarities with organized sports in that they are structured, routinized, role-based, rule-governed, and goal-oriented.[9,35] They also provide opportunities for social interaction, feeling a sense of belonging, and personal enjoyment.[45] Physical activity, sports, and the arts affect development through common executive processes,[50] we speculate that different types of activities benefit boys and girls to the degree that they are cognitively engaging[44] and promote sufficient time on task to lead to learning and skill acquisition.[50]

Unfortunately, more nuanced data on engagement in different types of activities were not collected as a routine part of the Growing Up in Ireland project.[25] In future large-scale cohort studies, assessment of time on task for a broader range of children's activities (ie, sports, music, reading, gaming, dance, the arts) is warranted to further our understanding of whether and how different types of enrichment activities can have a different impact on developmental outcomes.

Several limitations should be acknowledged. The use of parent reporting is a possible limitation, because an over-reliance runs the risk of misclassification of early delays in childhood. Moreover, parent reporting is often associated with issues relating to recall and social desirability bias. To mitigate these issues, widely validated and reliable measures of child development and psychosocial outcomes were used and the Growing Up in Ireland project also used trained researchers from the Irish Central Statistics Office.[25]

Our operant of measure of activity in this study was parental report of children's frequency of engagement in organization sports. Lack of objective measurement of physical activity is therefore another possible limitation; as is the lack of randomization of children to such organized sports participation (which ultimately precludes inferences regarding causality). A design that can parse out sport-related physical activity from total daily physical activity would enable a greater understanding of whether it is the nature of the sporting activities themselves that is beneficially affecting behavioral outcomes. Moreover, a design (eg, compositional analysis[51]) that could estimate the relative effects of different types of sporting activities based on differences in their Frequency, Intensity, Time, and Type (ie, based on the 'F.I.T.T.' principle[52]) would provide additional clinical relevance. The emerging research evidence on the importance of both "qualitative" and "quantitative" beneficial aspects of physical activity[44] provides a concrete rationale for future studies. For example, it is also likely that the type of sport (individual vs team-based), nature of the activity (object manipulation vs locomotor, or both), level of physicality (noncontact vs contact vs collision), intensity of the activity (light vs moderate-to-vigorous), frequency of engagement (daily vs weekly), social climate (parent-vs peer-initiated), and motivational climate (task-vs ego-oriented) within which the activities take place are all further moderators of developmental outcomes.

These findings are clinically important because they suggest that structured forms of physical activity can provide enrichment opportunities for young boys to practice precursor skills for developing self-regulation during this critical developmental time period. ■

*We thank the Irish Social Science Data Archive for granting permissions to access the Growing Up in Ireland dataset. Data were accessed via the Irish Social Science Data Archive at: www.ucd.ie/issda.*

Submitted for publication Apr 19, 2020; last revision received Oct 27, 2020; accepted Oct 30, 2020.

Reprint requests: Ross D. Neville, School of Public Health, Physiotherapy and Sports Science, University College Dublin, Dublin, Ireland. E-mail: ross.neville@ucd.ie

## References

1. Boyle CA, Boulet S, Schieve LA, Cohen RA, Blumberg SJ, Yeargin-Allsopp, et al. Trends in the prevalence of developmental disabilities in US children, 1997-2008. Pediatrics 2011;127:1034-42.

2. Moffitt TE, Arseneault L, Belsky D, Dickson N, Hancox RJ, Harrington HL, et al. A gradient of childhood self-control predicts health, wealth, and public safety. Proc Natl Acad Sci USA 2011;108:2693-8.
3. Zwaigenbaum L, Bauman ML, Choueiri R, Kasari C, Carter A, Granpeesheh D, et al. Early intervention for children with autism spectrum disorder under 3 years of age: recommendations for practice and research. Pediatrics 2015;136(suppl 1):S60-81.
4. Talbott MR, Miller MR. Future directions for infant identification and intervention for autism spectrum disorder from a transdiagnostic perspective. J Clin Child Adolesc Psychol 2020;49:688-700.
5. Murphy NA, Carbone PS. Promoting the participation of children with disabilities in sports, recreation, and physical activities. Pediatrics 2008;121:1057-61.
6. Donnelly JE, Hillman CH, Castelli S, Etnier JL, Lee S, Tomporowski P, et al. Physical activity, fitness, cognitive function, and academic achievement in children: a systematic review. Med Sci Sports Exerc 2016;48:1197-222.
7. Guerrero MD, Barnes JD, Walsh JJ, Chaput JP, Tremblay MS, Goldfield GS. 24-hour movement behaviors and impulsivity. Pediatrics 2019;144:e20190187.
8. Logan K, Cuff S , AAP Council on Sports Medicine and Fitness. Organized sports for children, preadolescents, and adolescents. Pediatrics 2019;143:e20190997.
9. Bailey R, Hillman C, Arent S, Petitpas A. Physical activity: an underestimated investment in human capital? J Phys Act Health 2013;10:289-308.
10. Srinivasan SM, Pescatello LS, Bhat AN. Current perspectives on physical activity and exercise recommendations for children and adolescents with autism spectrum disorders. Phys Ther 2014;94:875-89.
11. Ash T, Bowling A, Davison K, Garcia J. Physical activity interventions for children with social, emotional, and behavioral disabilities—a systematic review. J Dev Behav Pediatr 2017;38:431-45.
12. Bremer E, Crozier M, Lloyd M. A systematic review of the behavioural outcomes following exercise interventions for children and youth with autism spectrum disorder. Autism 2016;20:899-915.
13. Ruggeri A, Dancel A, Johnson R, Sargent B. The effect of motor and physical activity intervention on motor outcomes of children with autism spectrum disorder: a systematic review. Autism 2020;24:544-68.
14. Schmitz SO, Mcfadden BA, Golem DL, Pellegrino JK, Walker AJ, Sanders DJ, et al. The effects of exercise dose on stereotypical behavior in children with autism. Med Sci Sports Exerc 2017;49:983-90.
15. Bremer E, Cairney J. Adaptive behavior moderates health-related pathways in children with Autism Spectrum Disorder. J Autism Dev Disord 2020;50:491-9.
16. Rimmer JA, Rowland JL. Physical activity for youth with disabilities: a critical need in an underserved population. Dev Neurorehabil 2008;11:141-8.
17. Healy S, Aigner CJ, Haegele JA, Patterson F. Meeting the 24-hr movement guidelines: an update on US youth with autism spectrum disorder from the 2016 National Survey of Children's Health. Autism Res 2019;12:941-51.
18. Liang X, Li R, Wong SH, Sum RK, Sit CH. Accelerometer-measured physical activity levels in children and adolescents with autism spectrum disorder: a systematic review. Prev Med Rep 2020;19:101147.
19. McCoy SM, Jakicic JM, Gibbs BB. Comparison of obesity, physical activity, and sedentary behaviors between adolescents with autism spectrum disorders and without. J Autism Dev Disord 2016;46:2317-26.
20. Must A, Curtin C, Hubbard K, Sikich L, Bedford J, Bandini L. Obesity prevention for children with developmental disabilities. Curr Obes Rep 2014;3:156-70.
21. Lakes KD, Abdullah MM, Youssef J, Donnelly JH, Talyor-Lucas C, Goldberg WA, et al. Assessing parent perceptions of physical activity in families of toddlers with neurodevelopmental disorders: the parent perceptions of physical activity scale (PPPAS). Pediatr Exerc Sci 2017;29:396-407.
22. Lakes KD, Vaughan J, Radom-Aizik S, Taylor-Lucas C, Stehli A, Cooper D. Development of the Parent Perceptions of Physical Activity Scale (PPPAS): results from two studies with parents of infants and toddlers. PLoS One 2019;14:e0213570.
23. Hinkley T, Teychenne M, Downing KL, Ball K, Salmon J, Hesketh KD. Early childhood physical activity, sedentary behaviors and psychosocial well-being: a systematic review. Prev Med 2014;62:182-92.
24. McNeill J, Howard SJ, Vella SA, Santos R, Cliff DP. Physical activity and modified organized sport among preschool children: associations with cognitive and psychosocial health. Ment Health Phys Act 2018;15:45-52.
25. *Growing Up in Ireland* [webpage on the Internet]. Dublin: Growing Up In Ireland; c1994-2020 [updated 2020 July 28; cited 2020 Aug 8]. Economic and Social Research Institute. Accessed October 25, 2018. https://www.growingup.ie/information-for-researchers/
26. Goodman R. The Strengths and Difficulties Questionnaire: a research note. J Child Psychol Psychiatry 1997;38:581-6.
27. Glazebrook C, Hollis C, Heussler H, Goodman R, Coates L. Detecting emotional and behavioural problems in paediatric clinics. Child Care Health Dev 2003;29:141-9.
28. Goodman R, Scott S. Comparing the Strengths and Difficulties Questionnaire and the Child Behavior Checklist: is small beautiful? J Abnormal Child Psychol 1999;27:17-24.
29. Vella SA, Swann C, Allen MS, Schweickle MJ, Magee CA. Bidirectional associations between sport involvement and mental health in adolescence. Med Sci Sports Exerc 2017;49:687-94.
30. Squires J, Potter L, Bricker D. The ASQ user's guide for the ages and stages questionnaires: a parent-completed monitoring system. Baltimore (MD): Brookes Publishing Co; 1999.
31. Hornman J, Kerstjens JM, de Winter AF, Bos AF, Reijneveld SA. Validity and internal consistency of the Ages and Stages Questionnaire 60-month version and the effect of three scoring methods. Early Hum Dev 2013;89:1011-5.
32. Squires J, Twombly E, Bricker D, Potter L. ASQ-3: user's guide. Baltimore (MD): Paul H. Brookes; 2009.
33. Hulteen RM, Smith JJ, Morgan PJ, Barnett LM, Hallal PC, Colyvas K, et al. Global participation in sport and leisure-time physical activities: a systematic review and meta-analysis. Prev Med 2017;95:14-25.
34. Woods CB, Powell C, Saunders JA, O'Brien W, Murphy MH, Duff C, et al. The Children's Sport Participation and Physical Activity Study 2018 (CSPPA 2018). Department of Physical Education and Sport Sciences, University of Limerick, Limerick, Ireland, Sport Ireland, and Healthy Ireland, Dublin, Ireland and Sport Northern Ireland, Belfast, Northern Ireland. [Internet]. 2018. Accessed October 13, 2020. https://www.sportireland.ie/sites/default/files/2019-10/csppa-2018-final-report_1.pdf
35. Dyson B, Griffin LL, Hastie P. Sport education, tactical games, and cooperative learning: theoretical and pedagogical considerations. Quest 2004;56:226-40.
36. Watson D, Clark LA, Tellegen A. Development and validation of brief measures of positive and negative affect: the PANAS scales. J Pers Soc Psychol 1988;54:1063-70.
37. Charkaluk ML, Rousseau J, Calderon J, Bernard JY, Forhan A, Heude B, et al. Ages and Stages Questionnaire at 3 years for predicting IQ at 5–6 years. Pediatrics 2017;139:e20162798.
38. Griffiths LJ, Dowda M, Dezateux C, Pate R. Associations between sport and screen-entertainment with mental health problems in 5-year-old children. Int J Behav Nutr Phys Act 2010;7:30.
39. Hinkley T, Timperio A, Salmon J, Hesketh K. Does preschool physical activity and electronic media use predict later social and emotional skills at 6 to 8 years? A cohort study. J Phys Act Health 2017;14:308-16.
40. Vella SA, Cliff DP, Magee CA, Okely AD. Associations between sports participation and psychological difficulties during childhood: a two-year follow up. J Sci Med Sport 2015;18:304-9.
41. Munroe-Chandler KJ, Hall CR, Fishburne GJ, Strachan L. Where, when, and why young athletes use imagery: an examination of developmental differences. Res Q Exerc Sport 2007;78:103-16.
42. Hepach R, Warneken F. Editorial overview: early development of prosocial behavior: revealing the foundation of human prosociality. Curr Opin Psychol 2018;20:iv-viii.
43. Ahn JV, Sera F, Cummins S, Flouri E. Associations between objectively measured physical activity and later mental health outcomes in children:

findings from the UK Millennium Cohort Study. J Epidemiol Commun H 2018;72:94-100.
44. Vazou S, Pesce C, Lakes K, Smiley-Oyen A. More than one road leads to Rome: a narrative review and meta-analysis of physical activity intervention effects on cognition in youth. Int J Sport Exerc Psychol 2019;17:153-78.
45. Else-Quest NM, Hyde JS, Goldsmith HH, Van Hulle CA. Gender differences in temperament: a meta-analysis. Psychol Bull 2006;132:33-72.
46. Nolen-Hoeksema S. Emotion regulation and psychopathology: the role of gender. Annu Rev Clin Psychol 2012;8:161-87.
47. Wanless SB, McClelland MM, Lan X, Son SH, Cameron CE, Morrison FJ, et al. Gender differences in behavioral regulation in four societies: the United States, Taiwan, South Korea, and China. Early Child Res Q 2013;28:621-33.
48. Veijalainen J, Reunamo J, Heikkilä M. Early gender differences in emotional expressions and self-regulation in settings of early childhood education and care. 2020. Early Child Dev Care. 2020. https://doi.org/10.1080/03004430.2019.1611045
49. Hill A, Degnan K, Calkins SD, Keane SP. Profiles of externalizing behavior problems for boys and girls across preschool: the roles of emotion regulation and inattention. Dev Psychol 2006;42:913-28.
50. Tomporowski PD, Pesce C. Exercise, sports, and performance arts benefit cognition via a common process. Psychol Bull 2019;145:929-51.
51. Chastin SF, Palarea-Albaladejo J, Dontje ML, Skelton DA. Combined effects of time spent in physical activity, sedentary behaviors and sleep on obesity and cardio-metabolic health markers: a novel compositional data analysis approach. PLoS One 2015;10:e0139984.
52. Barisic A, Leatherdale ST, Kreiger N. Importance of frequency, intensity, time and type (FITT) in physical activity assessment for epidemiological research. Can J Public Health 2011;102:174-5.

## 50 Years Ago in *The Journal of Pediatrics*

# Therapy of Hemolytic Uremic Syndrome, a 50-Year Update

Kaplan BS, Katz J, Krawitz S, Lurie A, Path F. An Analysis of the Results of Therapy in 67 Cases of the Hemolytic-Uremic Syndrome. J Pediatr 1971;78:420-5.

An unknown syndrome of microangiopathy characterized by a triad of hemolytic anemia, thrombocytopenia, and acute kidney injury was described for the first time by Gasser et al in 1955, named the "hemolytic-uremic syndrome" (HUS). In the 1970s, the etiology and pathogenesis remained unclear. A postulated mechanism of renal injury was a consumption coagulopathy, suggesting that heparin could be useful, although it had no apparent effect on immediate survival and is no longer advised. Survival was better in patients treated with early peritoneal dialysis and now is seldom required because its indications are similar to other forms of acute kidney injury.[1]

In 1983, Karmali et al identified the etiologic toxin produced by the *Escherichia coli* serotype O157:H7, a critical discovery for future therapy, owing to the growing knowledge regarding its pathogenesis and complement interaction. Approximately 90% of cases in children are produced by the Shiga toxin-producing *E coli*, associated with a prodrome of diarrhea known as "hemorrhagic colitis." This toxin damages the cellular glycosphingolipid, increasing thrombin and fibrin levels, activating an inflammatory response responsible of extensive microangiopathic intravascular thrombosis and multiorgan failure particularly targeting the kidneys. The toxin has a high affinity for the membrane receptor in the glomerular endothelium and tubular cells, making dialysis a needed therapy in 50%-70% of cases.[2]

Antibiotic use for this disorder is controversial. Current recommendations suggest against antibiotic use, owing to a paradoxical increase in Shiga toxin production. The cornerstone of management for HUS is supportive care such as fluids and blood transfusion, including platelets when active bleeding takes place. Eculizumab, a humanized monoclonal antibody, blocks factor C5 activation and has a promising effect in complement-associated HUS.[3]

HUS is one of the most common causes of acute kidney injury in children. Overall mortality has decreased from 60% to less than 5% in the last half-century. Its proper identification is still essential to provide prompt supportive care.

**Cynthia A. Salinas Silva, MD**
**Sara E. Ortega Alonzo, MD**
Division of Pediatrics
Tecnologico de Monterrey
School of Medicine and Health Sciences
Monterrey, Mexico

## References

1. O'Brien AD, Lively TA, Chang TW, Gorbach SL. Purification of Shigella dysenteriae 1 (Shiga)-like toxin from Escherichia coli 0157:H7 strains associated with haemorrhagic colitis. Lancet 1983;1:573.
2. Karmali MA, Steele BT, Petric M, Lim C. Sporadic cases of haemolytic-uraemic syndrome associated with faecal cytotoxin and cytotoxin-producing Escherichia coli in stools. Lancet 1983;I:619-20.
3. Sheerin NS, Glover E. Haemolytic uremic syndrome: diagnosis and management. F1000Research 2019;8:1690.

**Table III. Effects of additional covariates on changes in behavioral difficulties between the ages of 3 and 5 years**

| Covariates | Effect,* ±95% CL | *P* value |
|---|---|---|
| Community-level factors | | |
| Geographic location (urban–rural) | 0.22, ±0.17 | .009 |
| Sense of community | 0.18, ±0.17 | .038 |
| Community safety | −0.33, ±0.16 | <.0001 |
| Community facilities | 0.19, ±0.17 | .028 |
| Socioeconomic factors | | |
| Ethnicity (Irish–non-Irish) | 0.51, ±0.21 | <.0001 |
| Maternal education | −0.62, ±0.18 | <.0001 |
| Equivalized household income | −0.21, ±0.19 | .035 |
| Household-level factors | | |
| Single parent (single–dual parent) | −0.59, ±0.28 | <.0001 |
| Family-size | −0.25, ±0.17 | .004 |
| PCG-level factors | | |
| Warmth | −0.03, ±0.17 | .71 |
| Hostility | 1.97, ±0.17 | <.0001 |
| Consistency | −0.53, ±0.20 | .0001 |
| Stress | 1.96, ±0.18 | .0001 |
| Child-level factors | | |
| BMI | 0.06, ±0.16 | .47 |
| Sleep | 0.01, ±0.17 | .94 |
| Screen time | 0.27, ±0.16 | .0009 |
| PA | 0.25, ±0.17 | .003 |

*BMI*, body mass index; *PA*, physical activity; *PCG*, primary caregiver.
*Effects for numeric covariates are standardized beta coefficients that represent the changes in behavioral difficulties associated with a 2-SD change in the predictor. Effects for categorical covariates represent differences in the changes in behavioral difficulties between the levels specified.