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Health-related quality of life as a longitudinal mediator of the relationship between participation in organised sports and adiposity among young people

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ABSTRACT

The objective of this study was to investigate potential mediating effects of health-related quality of life between children's participation in organised sports and measures of adiposity. The sample consisted of 4116 children derived from the Longitudinal Study of Australian Children. Participants were aged 10.32 ($SD = 0.47$) years at baseline (2010), and followed up 24 and 48 months later. Participation in organised sports was assessed using child-completed time-use diary. Health-related quality of life and demographic data were reported by each child's primary parent. Measures of body mass index, body fat, and waist circumference were also taken at each Wave. Sport was indirectly associated with measures of body fat (β = −0.002, 95%CI −0.004, 0.000, $p = .039$) and waist circumference (β = −0.001, 95%CI −0.003, 0.000, $p = .039$) through the mediating effects of social functioning. Sport was also associated with body fat via physical functioning (β = −0.01, 95%CI −0.02, −0.003, $p = .038$), however, this was not replicated with other measures of adiposity. No other mediating effects were evident. Sport participation may enable children and adolescents to function well in groups and access social support which in turn promote health behaviours and influence adiposity. This may be one of multiple pathways through which sports participation is associated with adiposity. Replication and extension of these novel findings is warranted, as is a focus on the design and implementation of sports programs to maximise health benefits.

1. Participation in organised sports, social and emotional functioning, and adiposity during childhood: a mediational model

Participation in organised sports during childhood is associated with the development of many important indicators of good health. For example, children involved in organised sports show more favourable cardiometabolic profiles including thinner carotid intima-media thickness, greater levels of physical activity, and greater health-related quality of life (HRQOL) (Drake et al., 2012; Idris et al., 2015; Vella et al., 2013a; Nelson et al., 2011). Children who participate in organised sports also show higher levels of social and emotional skills, including self-esteem, greater social skills, and reduced risk for mental health problems (Eime et al., 2013a; Vella et al., 2015). Importantly, findings suggest that the psychosocial benefits of sports participation are independent of those that could be attributable to physical activity (Eime et al., 2013a; Vella et al., 2015).

Despite well-documented health benefits, the relationship between participation in organised sports during childhood and measures of adiposity is equivocal (Vella et al., 2013a; Nelson et al., 2011). The causal mechanisms which underpin these equivocal results are largely unknown. Results vary by type of sport and by various subpopulations with no clear pattern emerging (Nelson et al., 2011). One causal pathway that could potentially account for equivocal findings in the relationship between participation in organised sports and adiposity is the mediating role of HRQOL. Sport participation is associated with greater HRQOL over time during childhood (Eime et al., 2013b; Vella

Abbreviations: Health-related quality of life, (HRQOL); Body mass index, (BMI); Longitudinal study of Australian Children, (LSAC); Time-use diary, (TUD); Pediatric Quality of Life Scale, (PEDSQL); Socio-economic position, (SEP)

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et al., 2014). In turn, all components of HRQOL have been associated with body mass index (BMI) during childhood and adolescence. For example, social and emotional functioning are strongly inversely associated with measures of adiposity (Tsiros et al., 2009; Incledon et al., 2013). Further, there is some evidence that aspects of HRQOL predict change in BMI over time. Lower emotional awareness predicts greater increases in BMI over time during childhood (Whalen et al., 2015), and greater school functioning predicts 4-year change in BMI in overweight and obese children (Incledon et al., 2013). However, a robust understanding of causal pathways and directionality in the relationship between HRQOL and adiposity is lacking. Nonetheless, it is plausible that sports participation may indirectly be linked with adiposity through components of HRQOL by equipping children with the skills necessary to maintain a healthy body weight over time.

The aim of this paper was to provide evidence on the potential mediating effect of components of HRQOL between children's participation in organised sports and measures of adiposity in a sample of Australian children over a 4-year time period extending into early adolescence. Specifically, we tested the indirect effect of time spent participating in organised sports at age 10 on subsequent measures of body fat, waist circumference, and body mass index (BMI) at age 14 through the components of HRQOL at age 12, as measured by the Pediatric Quality of Life Scale (Varni et al., 2003; Varni et al., 2002).

2. Methods

2.1. Participants and procedures

The Longitudinal Study of Australian Children (LSAC) collects data about children's health and development from the age of 4–5 years (K-cohort), with follow-up data collected every two years. Beginning in 2004, LSAC randomly selected families from the nation's largest database (the Medicare database) to participate. The initial response rate was approximately 50%, with 4983 children included in the K-Cohort at Wave 1. Data were collected by trained data collectors, using face-to-face interviews with the child's primary parent (the mother in 96% of cases), parental self-report questionnaires, and child-reported time-use diaries (TUDs). This study utilised data collected from Wave 4 (10 or 11 years of age), Wave 5 (12 or 13 years of age) and Wave 6 (14 or 15 years of age). For clarity, we refer to these ages as 10, 12, and 14 years of age across Waves 4–6, respectively. The number and demographics of participant over each Wave is provided in Table 1. The research methodology and survey content of Growing Up in Australia is reviewed and approved by the Australian Institute of Family Studies Ethics Committee, which is a Human Research Ethics Committee registered with the National Health and Medical Research Council. Informed consent was obtained from all participants.

2.2. Measures

2.2.1. Sport participation

The duration of time spent in organised sports was calculated from the time-use diary (TUD) instrument which was completed by children at 10 years of age. An open-ended paper diary was mailed to children to complete over a 24-hour period on the day before their interview (Corey et al., 2014). Interviewers then transposed these diaries according to a predetermined coding framework during the home interviews (Corey et al., 2014). Interviewers were also trained to prompt the child for further information to fill gaps in the diary. The time-use-diary measured time spent in all activities during the day of completion, of which organised sports participation was only one potential activity. In the present study, two activity codes were combined to measure sports participation: "Organised team sports and training" and "Organised individual sports and training" (Corey et al., 2014). The duration of time spent in these activity codes was extracted in a series of steps performed by one researcher (BK). The duration of each activity was firstly calculated as the difference between the start time of the activity and the start time of the next activity in sequence for each child. The last activity of each child's day was assumed to end at the child's bed time. The total duration of organised sports over the 24-hour period was then aggregated for each participant. A similar process was also used to calculate a dummy variable for school attendance (yes/no) based on the activity code "School lessons". Finally, although the TUD allowed children to record up to six activities concurrently, sport participation was based on the primary activity selected at any one time. Unlike other activities such as walking or listening to music, organised sport is less plausible as a concurrent activity.

2.2.2. Adiposity

BMI *z*-scores, waist circumference, and body fat percentage were used as measures of adiposity. Each child had their height and weight measured by trained professionals and these data were used to calculate BMI (kg/m^2). BMI *z*-scores were used to account for differences in BMI by sex and age, and were calculated based on the 2000 US Centers for Disease Control growth charts (Kuczmarski et al., 2000). Height was measured using a portable laser stadiometer (Invicta Plastics, Leicester, UK) and the average of two measurements was taken. Both weight and percentage body fat were measured using digital scales. Body fat percentage was measured using bioelectrical impedance analysis (Tanita Body Fat Scales, Kewdale, Western Australia). Weight was measured to the nearest 0.05 kg. Waist circumference was measured using the average of two measures taken by placing a non-stretch dressmakers tape horizontally over the navel. If measurements differed by more than 0.5 cm a third measure was taken and the average of the two closest measures was used.

2.2.3. HRQOL

Pediatric health-related quality of life was assessed using the parent-report version of Pediatric Quality of Life Scale (PedsQL) 4.0 (Varni

Table 1
Unadjusted mean adiposity and HRQOL data over the total sample and by sex for each Wave.

		Adiposity [*M* (*SD*)]			PedsQL Subscale Score [*M* (*SD*)]				
	N (%)	BMI-*z*	Body fat (%)	Waist (cm)	Physical	Social	Emotional	School	Psycho-social
Age 10 total	4116	0.36 (1.03)	19.63 (13.14)	66.60 (9.86)	79.18 (19.18)	80.18 (18.60)	73.95 (16.49)	85.40 (16.61)	76.60 (14.31)
Males	2104 (51.1)	0.43 (1.02)	17.93 (12.04)	67.43 (9.72)	79.35 (19.43)	79.80 (19.46)	73.68 (16.71)	85.30 (16.61)	75.52 (14.75)
Females	2012 (48.9)	0.30 (1.04)	21.42 (14.00)	65.73 (9.93)	79.00 (18.92)	80.58 (17.66)	74.24 (16.26)	85.51 (16.63)	77.72 (13.75)
Age 12 total	3767	0.35 (1.04)	21.13 (9.66)	71.88 (10.30)	82.86 (16.07)	82.42 (17.98)	75.59 (17.13)	84.39 (17.35)	77.36 (14.60)
Males	1928 (51.1)	0.32 (1.07)	17.77 (9.09)	72.75 (10.67)	83.14 (15.95)	82.31 (18.72)	75.98 (17.50)	84.31 (17.35)	76.52 (15.04)
Females	1839 (48.9)	0.37 (1.00)	24.65 (8.97)	70.90 (9.71)	82.60 (16.16)	82.56 (17.17)	75.11 (16.74)	84.63 (17.23)	78.26 (14.10)
Age 14 total	3208	0.36 (1.15)	20.91 (10.05)	75.11 (10.18)	–	–	–	–	–
Males	1647 (51.3)	0.29 (1.27)	16.27 (8.82)	76.96 (10.68)	–	–	–	–	–
Females	1561 (48.7)	0.45 (1.00)	25.99 (8.77)	73.19 (9.24)	–	–	–	–	–

et al., 2003; Varni et al., 2002). The PedsQL consists of 23 items measuring four distinct dimensions of HRQOL (physical functioning, emotional functioning, social functioning, and school functioning). Scores were computed for each of the four dimensions, as well as a psychosocial health summary score which was the mean item score over the emotional, social, and school functioning scales. All items are preceded by the stem "In the past one month, how often has your child had a problem with". Example items include "feeling sad or blue" (emotional functioning), "getting along with other kids" (social functioning), "keeping up with school work" (school functioning) and "walking more than one block" (physical functioning). Items are scored on a 5-point Likert scale from 0 (*never*) to 4 (*almost always*). When computing subscale scores, responses are assigned weightings, where 0 is equal to 100, 1 is equal to 75, 3 is equal to 50, and 4 is equal to 25. For each subscale a mean item score is computed, with possible scores ranging from 25 to 100 and higher scores representing greater HRQOL. The PedsQL has shown to be associated with weight status and BMI change among Australian children (Incledon et al., 2013; Williams et al., 2005). The parent-report version of the PedsQL has a high level of internal consistency in childhood (Varni et al., 2003), and has been shown to result in almost identical scores to the child self-report version in an Australian sample (Williams et al., 2005). However, there is some evidence to suggest that parents tend to underreport HRQOL when compared with self-reports (Bakas et al., 2012).

2.2.4. Covariates

Covariates were assessed at Wave 4 when children were aged 10 years, and included child sex and neighbourhood socioeconomic position (SEP). Neighbourhood SEP was determined according to the Socio-Economic Indexes for Areas Index of Relative Socio-Economic Disadvantage (Kuczmarski et al., 2000) using the child's home postcode. In addition, day of the week and school attendance (yes/no) were used as covariates for the sport participation variable measured by TUD.

2.3. Statistical analysis

Lagged panel mediation modelling was used to explore the longitudinal relationships between sports participation, pediatric health-related quality of life (physical functioning, emotional functioning, social functioning, school functioning, and overall psychosocial health), and physical health (BMI *z*-scores, body fat, and waist circumference). This involved modelling sports participation at 10 years of age as the independent variable, the pediatric quality of life dimensions at 12 years of age as potential moderators, with physical health indicators at 14 years of age as the dependent variables (see Fig. 1). The models controlled for child's sex, household income, day of the week, and whether the child attended school that day by adding them to the model as covariates at age 10 years. Results are presented as unstandardised β coefficients. The significance of each indirect effect was determined using bootstrapping with 5000 resamples and significance also set at $p < .05$.

Table 2
Results of the lagged panel mediation model linking sport participation at age 10 to BMI z-scores at age 14.

	β	95% CI
a paths		
$Sport_{10}$ → physical $functioning_{12}$	0.02*	0.01, 0.04
$Sport_{10}$ → emotional $functioning_{12}$	0.29	0.19, 0.77
$Sport_{10}$ → social $functioning_{12}$	0.03*	0.01, 0.05
$Sport_{10}$ → school $functioning_{12}$	0.01	−0.01, 0.03
$Sport_{10}$ → psychosocial $health_{12}$	0.02*	0.01, 0.03
b paths		
Physical $functioning_{12}$ → BMI-z_{14}	−0.01	−0.03, 0.01
Emotional $functioning_{12}$ → BMI-z_{14}	−2.78	−4.38, −1.14
Social $functioning_{12}$ → BMI-z_{14}	−0.01	−0.03, 0.02
School $functioning_{12}$ → BMI-z_{14}	−0.01	−0.02, 0.01
Psychosocial $health_{12}$ → BMI-z_{14}	0.001	−0.02, 0.03
Indirect effect		
$Sport_{10}$ → physical $functioning_{12}$ → BMI-z_{14}	0.00	−0.001, 0.000
$Sport_{10}$ → emotional $functioning_{12}$ → BMI-z_{14}	−0.82	−2.71, 0.34
$Sport_{10}$ → social $functioning_{12}$ → BMI-z_{14}	0.000	−0.001, 0.000
$Sport_{10}$ → school $functioning_{12}$ → BMI-z_{14}	0.000	−0.001, 0.000
$Sport_{10}$ → psychosocial $health_{12}$ → BMI-z_{14}	0.000	0.000, 0.001

Note. *Significant as per 95% bias-corrected confidence intervals estimated through 5000 bootstrapped resamples; subscript numerals indicate child age; adjusted for all covariates.

3. Results

3.1. Participants

Table 1 presents mean adiposity and HRQOL data over the total sample and by sex for each Wave. Mean sports participation at age 10 was 25.86 (*SD* = 53.89) min.

3.2. Lagged panel mediation

3.2.1. BMI z-score

Table 2 gives the unstandardized results of the lagged panel mediation model linking sport participation to BMI *z*-scores. This model indicated that sports participation at 10 years of age was positively associated with physical functioning, social functioning, and overall psychosocial health at 12 years of age, but not emotional functioning or school functioning. None of the pediatric quality of life dimensions at 12 years of age were associated with BMI *z*-scores at 14 years of age, and there were no significant indirect relationships.

3.2.2. Body fat

The unstandardized results of the lagged panel mediation model linking sport participation to body fat are shown in Table 3. Sport participation at 10 years of age was positively associated with physical

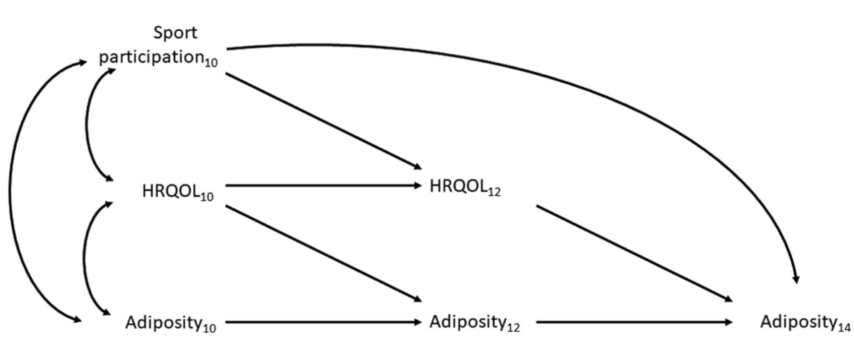

Fig. 1. Lagged panel mediation model linking sport participation at age 10 to physical health at age 14. Separate indirect effects were tested for each of the dimensions of pediatric health-related quality of life, as well as the measures of adiposity (BMI-*z*, body fat, waist circumference).

Table 3
Results of the lagged panel mediation model linking sport participation at age 10 to body fat at age 14.

	β	95% CI
a paths		
$Sport_{10}$ → physical $functioning_{12}$	0.02*	0.01, 0.04
$Sport_{10}$ → emotional $functioning_{12}$	0.33	−0.15, 0.80
$Sport_{10}$ → social $functioning_{12}$	0.03*	0.01, 0.05
$Sport_{10}$ → school $functioning_{12}$	0.01	−0.01, 0.03
$Sport_{10}$ → psychosocial $health_{12}$	0.09	−0.32, 0.11
b paths		
Physical $functioning_{12}$ → body fat_{14}	−0.43*	−0.66, −0.20
Emotional $functioning_{12}$ → body fat_{14}	−4.43*	−6.33, −2.59
Social $functioning_{12}$ → body fat_{14}	−0.01*	−0.10, −0.03
School $functioning_{12}$ → body fat_{14}	−0.34*	−0.55, −0.15
Psychosocial $health_{12}$ → body fat_{14}	−0.31	−1.29, 0.60
Indirect effect		
$Sport_{10}$ → physical $functioning_{12}$ → body fat_{14}	−0.01*	−0.02, −0.003
$Sport_{10}$ → emotional $functioning_{12}$ → body fat_{14}	−1.46	−4.10, 0.49
$Sport_{10}$ → social $functioning_{12}$ → body fat_{14}	−0.002*	−0.004, 0.000
$Sport_{10}$ → school $functioning_{12}$ → body fat_{14}	−0.004	−0.01, 0.002
$Sport_{10}$ → psychosocial $health_{12}$ → body fat_{14}	0.03	−0.05, 0.34

Note. *Significant as per 95% bias-corrected confidence intervals estimated through 5000 bootstrapped resamples, and $p < .05$; subscript numerals indicate child age; adjusted for all covariates.

functioning and social functioning at 12 years of age, but not emotional functioning, school functioning, or overall psychosocial health. Physical functioning, emotional functioning, social functioning, and school functioning were inversely associated with body fat at 14 years of age. Inspection of the indirect paths indicated that both physical functioning at age 12 ($p = .038$) and social functioning at age 12 ($p = .036$) significantly mediated the longitudinal relationship between sport participation and body fat. None of the other indirect paths were significant.

3.2.3. *Waist circumference*

Table 4 shows the unstandardized results of the lagged panel mediation model linking sport participation to waist circumference. This model indicated that sport participation at 10 years of age was positively associated with physical functioning and social functioning At 12 years of age, but not emotional functioning, school functioning, or overall psychosocial health. Social functioning at 12 years of age was inversely associated with waist circumference at 14 years of age; however, emotional functioning and overall psychosocial health were positively associated with waist circumference at 14 years of age. Social functioning at age 12 significantly mediated the longitudinal relationship between sport participation at age 10 and waist circumference at age 14 ($p = .039$). None of the other indirect paths were significant.

Table 4
Results of the lagged panel mediation model linking sport participation at age 10 to waist circumference at age 14.

	β	95% CI
a paths		
$Sport_{10}$ → physical $functioning_{12}$	0.02*	0.004, 0.04
$Sport_{10}$ → emotional $functioning_{12}$	0.32	−0.14, 0.78
$Sport_{10}$ → social $functioning_{12}$	0.03*	0.01, 0.04
$Sport_{10}$ → school $functioning_{12}$	0.01	−0.01, 0.03
$Sport_{10}$ → psychosocial $health_{12}$	−0.03	−0.32, 0.11
b paths		
Physical $functioning_{12}$ → $waist_{14}$	−0.02	−0.06, 0.02
Emotional $functioning_{12}$ → $waist_{14}$	0.03*	0.01, 0.05
Social $functioning_{12}$ → $waist_{14}$	−0.05*	−0.08, −0.02
School $functioning_{12}$ → $waist_{14}$	0.02	−0.14, 0.15
Psychosocial $health_{12}$ → $waist_{14}$	0.13*	0.08, 0.19
Indirect effect		
$Sport_{10}$ → physical $functioning_{12}$ → $waist_{14}$	0.000	−0.002, 0.000
$Sport_{10}$ → emotional $functioning_{12}$ → $waist_{14}$	0.01	−0.002, 0.03
$Sport_{10}$ → social $functioning_{12}$ → $waist_{14}$	−0.001*	−0.003, 0.000
$Sport_{10}$ → school $functioning_{12}$ → $waist_{14}$	0.000	−0.002, 0.004
$Sport_{10}$ → psychosocial $health_{12}$ → $waist_{14}$	−0.01	−0.05, 0.01

Note. *Significant as per 95% bias-corrected confidence intervals estimated through 5000 bootstrapped resamples, and $p < .05$; subscript numerals indicate child age; adjusted for all covariates.

4. Discussion

This study investigated the potential mediating effects of HRQOL between children's participation in organised sports and measures of adiposity. Results suggest that sport may influence adiposity through the mediating effects of social functioning. However, the effects were not strong. Sport was also associated with body fat via physical functioning, however, this was not replicated with other measures of adiposity. No other mediating effects were evident. It is plausible that sport influences adiposity by enabling children and adolescents to function well in groups and access social support which underpin health behaviours and consequently adiposity. This may be one of multiple pathways through which sports participation is associated with adiposity. Other indirect pathways may include behaviours such as physical activity, sedentary behaviours, and dietary behaviours, or cognitive variables such as motivation for physical activity or perceived competence.

While the mediating effect of social functioning is a novel finding, it is not unexpected. In the absence of clear associations between participation in organised sports and adiposity (Nelson et al., 2011) there is a significant body of literature to demonstrate associations between sports participation and social functioning (Eime et al., 2013b), and associations between social functioning and adiposity (Tsiros et al., 2009). Sports participation during childhood and adolescence has been positively associated with measures of social functioning including social interaction, social skills, social wellbeing, and lesser social anxiety (Eime et al., 2013b). In turn, social functioning is associated with weight status and strongly inversely associated with BMI among children and adolescents (Tsiros et al., 2009; Williams et al., 2005; Swallen et al., 2005). Both of these findings were replicated in the current study (*a* and *b* paths) for body fat percentage and waist circumference, which may be more reliable indicators of adiposity than BMI *z*-scores when considering the influence of sport participation due to the confounding influence of muscle mass. It is possible that participation in organised sports leads to the acquisition of social skills and provides social support, which make children and adolescents more likely to continue in sport (Balish et al., 2014), or more likely to be physically active (Van Der Horst et al., 2007), and in turn leads to lower levels of adiposity. Nonetheless, the effect was relatively small, with an hour of sport participation associated with a reduction of 0.12% in body fat and 0.06 cm in waist circumference due to the mediating effect of social functioning.

Associations between physical functioning and measures of adiposity are well established (Williams et al., 2005; Swallen et al., 2005). The results of this study suggest that sport participation may be associated with body fat percentage through its effect on physical functioning. However, this finding was not replicated over measures of BMI *z*-score or waist circumference, and the effect was relatively small. There also exists some ambiguity around the nature and directionality of the relationships between sport participation, physical functioning, and adiposity. It seems plausible that there exists bi-directionality in the relationships between sports participation and physical functioning, as well as physical functioning and adiposity. It is unclear in the current study, given the design and equivocal results, whether sports participation is causally linked to lower levels of adiposity through an effect on physical functioning. Experimental research is necessary and warranted to elucidate causal relationships.

While the sample size is a strength of the current study, its cohort design precludes assertions regarding causality and potentially ameliorates the true strength of associations. The indirect effects demonstrated here are novel and provide some preliminary evidence on one potential pathway between sports participation and measures of health among multiple possible pathways. It may be beneficial to explore multiple pathways simultaneously in future research in order to ascertain whether each contributes independently of the other. For example, it is unclear whether the indirect effect demonstrated here would persist if physical activity, sedentary behaviours, and dietary behaviours were considered. Further, the measurement of sports participation via a time-use diary has some limitations in that it can potentially miss some sports participants by virtue of sampling on a day that does not include organised sports participation. We have attempted to ameliorate this concern by adjusting for day of the week. It would also be beneficial to include child-reported measures of quality of life in future studies.

An indirect effect of sports participation on measures of adiposity through social and physical functioning during late childhood and early adolescence is a novel finding. Although the longitudinal cohort design limits assertions regarding causality, this study provides preliminary evidence on one pathway through which sports participation might be beneficial for health. If similar effects were replicated using stronger designs it would be important to consider the design and implementation of sports programs to maximise health benefits. Future studies may extend on the previous findings to include variables such as coaching behaviours and the quality of the coach-athlete relationship which have demonstrated associations with the acquisition of developmental assets such as social and emotional skills (Vella et al., 2013b). Future research should aim to replicate these results using stronger designs and accounting for multiple potential pathways including physical activity and dietary behaviours.

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Conflicts of interest

The authors declare no conflicts of interest.

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