Published in final edited form as:

Early Child Dev Care. 2020 ; 190(4): 570–579. doi:10.1080/03004430.2018.1485670.

The relationship of gross motor and physical activity environments in child care settings with early learning outcomes

Pooja Tandon, MD MPH^{1,2}, Nail Hassairi, PhD³, Janet Soderberg, PhD³, Gail Joseph, PhD³

¹University of Washington School of Medicine, Seattle, WA

²Seattle Children's Research Institute, Center for Child Health, Behavior & Development, M/S CW8-6, PO Box 5371, Seattle, WA 98145

³Cultivate Learning, College of Education, University of WA, 5001 25th Ave NE Suite 201E, Seattle, Washington 98105

Abstract

Gross motor and physical activity opportunities in early childhood are important for promoting health and development. We conducted two studies with the following aims: 1) to describe the quality of gross motor/physical activity early learning environments in Washington (WA) state, USA and 2) to study the relationship between the quality of gross motor/physical activity environments and various early learning outcomes. We used state-wide classroom quality measures related to gross motor activities from the Early Childhood Environment Rating Scale-Revised (N=1335 centers). For Aim 2, individual early learning assessments were conducted on 495 children from 72 centers in the fall and spring. We found considerable room for improvement in the space, equipment, schedule and supervision related to gross motor activities in child care centers. The quality of the gross motor environments was found to be related to desirable early learning outcomes including preschoolers' executive functions and behavior.

Introduction

Physical activity is important for numerous aspects of children's health and development. (Janssen & LeBlanc, 2010; Trost, 2007) Physical activity in the early childhood years promotes the development of gross motor and fundamental movement skills, which are the building blocks for the confidence and skills needed for active lifestyles later in life. (Fisher, Reilly, & Kelly, 2005; Lubans, Morgan, Cliff, Barnett, & Okely, 2010) Furthermore, there is evidence to support both short and long-term cognitive benefits of physical activity in the early childhood years. (Carson et al., 2015; Pooja S. Tandon et al., 2016) Given that the majority of U.S. preschoolers spend considerable time in child care settings (Iruka, Carver, & National Center for Education, 2006), the physical activity environments and opportunities for physical activity in those settings could have considerable ramifications for child health and early learning. (Story, Kaphingst, & French, 2006)

The Physical Activity Guidelines for Americans Midcourse Report:

Strategies to Increase Physical Activity Among Youth specifically identified the need for researchers to examine strategies to promote physical activity in preschool settings. (Physical Activity Guidelines for Americans Midcourse Report Subcommittee of the President's Council on Fitness, Sports & Nutrition. Physical Activity Guidelines for Americans Midcourse Report: Strategies to Increase Physical Activity Among Youth, 2012) Since preschoolers' physical activity has been found to be highly correlated with their preschool environment (one study found that the preschool environment explained 27% of the variance in physical activity levels and accounted for more variance than did age, gender and race/ethnicity (Pate, McIver, Dowda, Brown, & Addy, 2008)) this setting provides an effective venue for intervention. (D. S. Ward, 2010) Increasing children's physical activity in early childhood education settings is critical given that approximately 60 percent of US children 5 years old and under attend preschools or structured child care programs, with the average child spending over 30 hours/week in this care; and low income children spending approximately 40 hours/week. (Child Care and Development Fund (CCDF) Data Statistics, 2014) Strategies to increase preschoolers' physical activity should be informed by research on which modifications would have the greatest benefit.

Research suggests that most U.S. preschoolers do not meet recommended guidelines for daily physical activity and one study found that for 88% of child care time, children were not presented opportunities for active play and that more than 70% of child care time was sedentary. (Pooja S. Tandon, Saelens, & Christakis, 2015) A 2013 survey of Washington state child care programs found that there was considerable room for improvement in licensed child care settings to meet best-practice standards for young children's outdoor and physically active time. (P. S. Tandon, Walters, Igoe, Payne, & Johnson, 2017) These findings highlight the continued disconnect between physical activity recommendations and actual practices in early childhood education settings, which results in undesirable levels of sedentary behavior and physical activity in children. A suggested barrier to increasing physical activity in early learning settings has been the idea of competing priorities; that parents, child care providers, and/or policy makers may not recognize the potential benefits of active play for cognitive development and therefore deprioritize it as a learning activity in preschool. (Copeland, Sherman, Kendeigh, Kalkwarf, & Saelens, 2012)

Recent literature reviews have found that gross motor skills and physical activity are positively associated with cognitive performance in early childhood. (Carson et al., 2015; Pooja S. Tandon et al., 2016) Both acute and longer term exposures to physical activity were associated with positive findings related to executive function (including self-regulation, attention, and memory) and academic tasks (including early math and literacy). The generally small sample sizes and correlative nature of most of the studies included in the reviews do not allow for examination of directionality or causation. Also, the measurement tools varied widely between studies, making comparison difficult, but 11 of the 12 studies from one review reported evidence suggesting that physical activity or gross motor skills are related to cognition or early learning. (Pooja S. Tandon et al., 2016) In addition, some have noted a decline in preschoolers' motor skills over the past decade that may be reflective of fewer physical activity opportunities. (Hardy, Barnett, Espinel, & Okely, 2013; Roth et al.,

2010) We sought to study the relationship between gross motor/active play and early learning prospectively, to begin to evaluate causality.

We conducted two studies with the following aims: Study 1) describe the quality of Washington (WA) state's early learning environments with respect to space and equipment available for gross motor and physically active play and Study 2) study the relationship between the quality of gross motor and physical activity environments and early learning outcomes.

Methods

Data collection was done in accordance with the requirements of the <blinded> Institutional Review Board.

For Study 1, we used state-wide classroom quality measures collected using the Early Childhood Environment Rating Scale (ECERS-R) as part of the Early Achievers quality rating process between 2012 and 2017. There are approximately 3400 childcare programs enrolled in Early Achievers, and approximately 7,000 licensed childcare programs in the state. Until 2016, participation in Early Achievers was voluntary and childcare sites could apply for a rating at no cost. Observations were conducted by data collectors employed by the <blinded> and funded by the state's Department of Early Learning as part of the Quality Rating and Improvement System (QRIS) in WA state. Data collectors were trained by authorized (or anchor) trainers and deemed reliable on the ECERS-R. The data collectors' reliability with an anchor trainer is assessed every 10th observation and needs to be at 80% or above.

The ECERS-R 43-item observation tool is a widely used assessment of child care classroom quality. Each item has numerous indicators that are scored as met or not met, based on observation or interview, on a scale of one to seven. Observers score until an indicator is not met so that a quality level score is assigned for that item. Subscales covered by this tool include: Space & Furnishings, Personal Care Routines, Language-Reasoning, Activities, Interaction, Program Structure and Parents & Staff.

Using the literature on best practices for physical activity in early childhood education settings, we focused on the ECERS-R items that would have a theoretical basis for being related to children's gross motor activities and physical activity opportunities and behaviors. The recommended practices and standards are based on evidence-based national health performance standards for early care and education programs and are aimed at promoting health and preventing childhood obesity in these settings. (American Academy of Pediatrics, 2012; D. Ward et al., 2008) While these items do not exactly map to best practices recommendations for physical activity in early learning, we were able to use them to select our ECERS-R indicators. We included the following ECERS-R items in this analysis: 1) Space for gross motor play 2) Gross motor equipment 3) Program schedule and 4) Supervision of Gross Motor activities.

For Study 2, we used data from a study that explores the relationship between levels of classroom quality and child outcomes for three to five year old preschool children.

Classroom quality measures include the Early Childhood Environment Rating Scale (ECERS-R), collected by trained observers in the winter of the 2014–2015 school year by the same cadre of staff who worked on the data collection for Study 1. Reliability checks were completed with observers on average every tenth visit, and data collectors achieved 92.7% agreement. In this study, observers were instructed to score all the indicators for each ECERS-R item even beyond an indicator that was not met (i.e. a stop rule was not used). This was done to gain additional information on program strengths and areas of improvement and provides more detailed information than we have from the data set for Study 1, described above.

In addition to the classroom quality observations, Study 2 also included individual child assessments conducted by research study staff in the fall and spring of the same academic year. Children participating in this study (N=495) were randomly selected from 72 classrooms. Up to four boys and four girls were selected and assessed by external assessors during an individual session lasting approximately 30 minutes. The early learning domains were assessed using the same techniques and tools at both time points. Not all children with fall assessment data were available to participate in the spring battery, which resulted in a retention rate of approximately 80%. The tools used and domains assessed are described in Table 1. The difference in scores from spring to fall, were used as the outcome measure in analysis. An increase in score from fall to spring would be desirable for all domains except social-emotional (CBCL). An increase in the CBCL score would represent increased behavioral challenges; therefore a decreased score would be desirable. Demographic information, including child's age, gender and whether they qualified for a subsidy for child care (as a proxy for socioeconomic status), was collected from the parents.

Analysis:

Continuous measures were summarized using means and standard deviations, and categorical variables using frequencies and proportions. For Study 2, since children were nested within classrooms, we examined the relationship between ECERS-R indicators and the early learning outcomes using a hierarchical linear model (HLM). (Raudenbush & Bryk, 2001) Separate HLM models were created to examine each ECERS-R indicator with spring-to-fall changes in each early learning outcome, controlling for age, gender, subsidy, classroom size, and the child's score in the fall. Since there were missing values for many of the variables of interest, we estimated data so that we could control for important family covariates using Multivariate Imputation in Chained Equations (MICE) multiple imputation. (van Buuren & Groothuis-Oudshoorn, 2011). MICE was also employed to address the issue of sample selection bias from missing spring scores of the children dropping out from the sample. (Lewin, Brondeel, Benmarhnia, Thomas, & Chaix, 2018)

Results:

Study 1 results from 1335 centers are presented in Table 2, which represent 39% of the programs enrolled in the QRIS (Early Achievers). On a scale of 1 to 7, with 7 being the indicator of highest quality, child care centers scores in the four domains assessed ranged from 1.88 (Space for gross motor play) to 3.78 (Schedule).

For Study 2, children were, on average, 4.2 years old, approximately half were female, and 35% received a child care subsidy. See Table 3 for additional demographics.

Table 4 contains the proportion of classrooms from the second study that met the various physical activity-related ECERS-R indicators examined in this study. These indicators are grouped based on physical activity best-practices recommendations related to space/equipment, schedule and staff supervision. More than 80% of centers were observed to be meeting each of the following indicators: 1) structuring the day so that a substantial portion of day is spent in play, 2) having at least one indoor and one outdoor play session daily, and 3) having some gross motor equipment available to children for at least one hour per day. Less than 3/4 of classrooms met the various other indicators related to gross motor space, equipment and staff supervision. In the last column of this table, we identify the early learning outcomes that were statistically significantly associated with each ECERS-R indicator. Statistically significant associations were found between child care quality and children's performance on tasks assessing executive functions (HTKS), early science (LENS) and social-emotional outcomes (CBCL). Specifically, having a variety of gross motor equipment and staff resources to set up and enhance gross motor play was associated with a decrease in behavioral problems from fall to spring. A child care schedule with at least an hour of gross motor play and having daily indoor and outdoor gross motor play opportunities was associated with gains in executive functions, as measured by HTKS. Having a substantial portion of the day for play activities was associated with gains in early science outcomes but an increase in behavioral problems. Finally, programs where staff were found to talk with children about their play saw a decline in early receptive language scores.

Discussion:

Our study found that there is considerable room for improvement in the space, equipment, schedule and supervision related to gross motor activities for young children in child care centers. In addition, we found that certain indicators of quality in these gross motor domains are positively associated with early learning outcomes. Previous research suggests that there is a positive association between the quality of children's early care environments and their academic and cognitive outcomes (Sammons, et al., 2003a). Our study furthers that concept to specifically highlight the importance of the quality of gross motor environments in promoting early childhood development and education. Studying this relationship between gross motor/active play and early learning could support earlier opportunities for physical activity interventions, which could confer a range of benefits to children's health, development, and well-being.

For our first study, using a large sample of child care centers, the average ratings for four ECERS-R indicators related to gross motor activities were all less than 4 (on a scale of 1 to 7, with 7 indicating highest quality). In particular, the "space for gross motor play" rated the lowest. In the state-wide assessments, the stop-rule for ECERS-R was used, which means that once a condition on the rating scale was not met, the scoring was stopped. Our findings from the sub-sample, where all indicators were scored, suggest that centers may actually be doing better than the ECERS-R score suggests. In fact, other researchers and practitioners have raised concerns about the stop-rule use in the ECERS-R. Gordon et al recommend that

that all indicators in the ECERS-R be scored since that provides more information than does stop-scoring about what centers are currently doing well and where they need to improve. (Gordon, Fujimoto, Kaestner, Korenman, & Abner, 2013) Regardless, there remains a need for centers to consider ways to improve their space, equipment, schedules and supervision of gross motor activities.

In the second study, we found some promising results with regard to centers meeting some of the quality standards that loosely align with physical activity best practices. Over 85% were found to have some gross motor equipment that was accessible to all children for at least one hour daily and at least one indoor and one outdoor play period occurs daily. A high number of centers were noted to have a substantial portion of the day used for play activities. In fact, indicators related to schedule had the most associations with early learning outcomes, which is promising because they are likely the most policy-sensitive. The indicators with lower proportions of compliance were related to equipment and teacher practices. These areas may be less policy-sensitive and require other strategies to improve these areas to the level of best practices recommendations. Most Quality Rating and Improvement Systems (QRIS), including the Early Achievers program in WA, use a coaching model for quality improvement. One strategy to support best practices in physical activity could be to have Early Achievers coaches include a focus on health behaviors such as physical activity as part of their work with child care centers.

Our findings would be of interest to those involved with QRIS initiatives because we did find positive associations between quality metrics related to gross motor environments and measures of early learning at the child level. Of note, in our sample, time allocated for physically active play was associated with executive function gains in preschoolers. Executive functions refer to mental processes important for planning, organizing, and paying attention to details, and this function is critical to children's academic, social-emotional and behavioral long-term outcomes. There are at least three general pathways by which physical activity may facilitate executive functions in children: (1) the cognitive demands inherent in the structure of goal-directed and engaging exercise, (2) the cognitive engagement required to execute complex motor movements, and (3) the physiological changes in the brain induced by aerobic exercise. (Best, 2010) There is compelling evidence in school-aged children (Educating the Student Body: Taking Physical Activity and Physical Education to School, 2013) and emerging evidence in preschoolers (Carson et al., 2015; Pooja S. Tandon et al., 2016) that physical activity enhances cognitive performance, especially executive functioning. Our findings highlight the importance of focusing on gross motor and physical activity environments in early learning settings.

Another notable area of findings was related to those from the Child Behavior Checklist. Behavioral concerns are prominent for child care providers. The two indicators associated with a decrease in behavioral problems from fall to spring were 1) having a variety of stimulating gross motor equipment and 2) staff that engage in the gross motor play. Each of these indicators are only being met by 50% of centers. This finding has implications for staff training around interactions with children and resources dedicated to creating a stimulating gross motor environment. Recognizing that higher quality gross motor environments and practices may be associated with improved behavioral outcomes could support efforts to

discourage teachers from restricting active play opportunities as punishment for bad behavior. Numerous organizations and expert groups now oppose withholding physical activity as a form of punishment and/or behavior management.(Centers for Disease & Prevention, 2011; “Physical activity used as punishment and/or behavior management. Position statement,.” 2009) Additional research on the potential benefits of using movement in the classroom and physical activity breaks in preschoolers could further garner support for this idea. We also found a positive association of a substantial portion of the day used for play and science outcomes but a negative association with behavior, which may be related to less structure and possibly supervision. We saw a surprising negative association between staff talking with children about their gross motor play and their receptive language gains, which would need replication and further study to explore.

There are several limitations to this study that need to be acknowledged. First, the ECERS-R has been critiqued as a measure of child care quality and found, by some, to only have weak associations to early learning outcomes.(Brunsek et al., 2017) Therefore, we are limited to the information collected using the ECERS-R tool. Second, we did not have any individual child assessment measures to assess their gross motor skills or physical activity, but future studies should pursue this. Third, there may be unobserved factors that influence both the choice of child care and the child-level outcomes that could bias our estimates. Fourth, Finally, there is the issue of multiple inferences given that we conducted several statistical tests on the same data set.

Preschooler’s physical activity does not usually occur as a planned, structured activity and they typically engage in it through active play.(Pelligrini & Smith, 1998) However, the American Academy of Pediatrics and other experts have cautioned that many children today, from those living in poverty to those with abundant resources but hurried lifestyles, do not have sufficient opportunities for play.(Milteer et al., 2012) For many children from low SES families, active play opportunities during school may be their only ones, yet there is some evidence to suggest that these children who need the in-school active playtime the most actually get the least.(Carlson et al., 2014) In fact, one early childhood development expert has stated that “in a misguided effort to close the achievement gap, we are creating a new kind of inequality” where poor and minority children are subject to early learning environments with less resources, more tests and less play.(Strauss, 2016) Our findings suggest that the quality of the gross motor environments in early childhood education settings are important components of the measures of overall child care quality and are related to early learning outcomes.

Acknowledgements:

We would like to thank Dr. Robert Abbott for his review of the manuscript. We are grateful for the child care center staff, families and children who participated. Dr. Tandon’s time was supported by a career development award from the NIH (K23 HL112950-01A1).

Abbreviations:

ECERS-R	Early Childhood Environment Rating Scale- Revised
QRIS	Quality Rating and Improvement System

WA

Washington

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Table 1.**Study 2: Early learning domains and assessments used**

Early learning domain	Assessment used
Early reading	The Woodcock– Johnson III Tests of Achievement (WJ III) Letter-Word Identification subtest assesses a child's ability to identify letters and words.(Woodcock, Mather, McGrew, Woodcock, & Riverside Publishing, 2001) The WJ III is a standardized measure with a mean of 100 and a standard deviation of 15.
Early science	The Lens on Science (LENS) is an adaptive computer-based instrument that assesses preschoolers' content and processing skill knowledge in science.(Greenfield & Penfield, 2009) The LENS measure has a mean of 0 and a standard deviation of 1.
Early writing	The Early Writing Assessment (EWA) is an adapted tool that measures early writing development and asks preschoolers to write their names (EWA Name) as well as two consonant-vowel-consonant words (EWA Word) from dictation.(Puranik, Lonigan, & Kim, 2011) The EWA Name task yields raw scores between 0 and 8. The range of possible raw scores on the EWA Word is 0–18.
Executive function	The Head Toes Knees and Shoulders (HTKS), measures preschoolers' behavior regulation and effortful control. Effortful control is the ability to stop doing something (inhibit a response) and do something else instead.(McClelland, Cameron, & Duncan, 2014) The HTKS is a three part activity that yields raw scores up to 60.
Early math	The Tools for Early Assessment in Math (TEAM) assesses preschoolers' early math knowledge and skills. Children participated in a short form version of the TEAM, which included 20 questions and a stop rule.(Clements & Sarama, 2011) The TEAM yields raw scores up to 20.
Receptive language	The Peabody Picture Vocabulary Test, Fourth edition (PPVT-4) measures receptive vocabulary of preschool children.(Dunn & Dunn, 2007) The PPVT-4 is a standardized measure with a mean of 100 and a standard deviation of 15.
Social-emotional	The Child Behavior Checklist (CBCL) yields Internalizing, Externalizing, and Total Problems scales as reported by teachers/providers.(Achenbach & Ruffle, 2000) The CBCL is a standardized measure with a mean of 50 and a standard deviation of 10. Note that higher scores indicate more problem behaviors.

Table 2 –

Study 1: WA state-wide child care center level ECERS-R data on items relevant to gross motor activities (scale 1–7)

Item (n=1335)	Mean (SD)
Overall ECERS-R Score	3.90 (0.77)
Space for gross motor play	1.88 (0.75)
Gross motor equipment	3.21 (1.88)
Schedule	3.78 (1.65)
Supervision of gross motor play	3.61 (1.68)

Table 3 –

Study 2: Descriptive data about child participants (n=495 children from 72 classrooms)

Characteristic (n)	Mean (SD) or %
Age (n= 495)	4.2 (0.8)
Female gender (n= 495)	51%
Race/Ethnicity (n= 400)	
White	52%
Black	6%
Hispanic	13%
Asian	6%
Other	23%
Primary Language (n= 494)	
English	83%
Spanish	7%
Other	10%
Child care subsidy (n= 416)	35%
Classroom size (n = 444)	14.53 (4.4)

Table 4.

Study 2: Fall and spring early learning outcomes on children (n=495 children)

Early Learning Characteristic	Timepoint	mean	SD	n
Social-emotional (CBCL)	Fall	45.9	10	364
	Spring	46.5	10.1	226
Early Writing -Name (EWA-N)	Fall	4.86	2.82	491
	Spring	5.61	2.37	403
Early Writing -Word (EWA-W)	Fall	6.08	4.21	491
	Spring	7.6	4.74	399
Executive Function (HTKS)	Fall	10.9	15.6	474
	Spring	19.2	18.1	394
Early Science (LENS)	Fall	0.743	1.11	229
	Spring	1.27	1.1	308
Receptive Language (PPVT)	Fall	101	17.2	478
	Spring	103	14.6	401
Early Math (TEAM)	Fall	7	4.21	484
	Spring	8.89	3.85	395
Early Reading (WJIII)	Fall	102	15.7	484
	Spring	103	15.1	403

Table 5 –

Study 2: Proportion of classrooms meeting gross motor/ active play indicators and indicators associated with early learning outcomes

ECERS-R Indicator	Description	Proportion meeting indicator, mean (SD)	Associated early learning outcome* (β coefficient)
Space for Gross Motor Play <i>PA Best Practices</i> <ul style="list-style-type: none"> • Outdoor play space should include open, grassy areas and a track/path for wheeled toys. • Make indoor play space available for all activities, including running. 			
Space GM 5.1	Adequate space outdoors and some space indoors for gross motor play	0.72 (0.45)	
Space GM 5.3	GM space is organized so that different types of activities do not interfere with one another	0.65 (0.48)	
Space GM 7.1	Outdoor gross motor space has a variety of surfaces	0.78 (0.41)	
Space GM 7.2	Outdoor area has some protection from elements	0.67 (0.48)	
Gross Motor Equipment <i>PA Best Practices</i> <ul style="list-style-type: none"> • Make a wide variety of fixed play equipment available that accommodate the needs of all children. • Make a large variety of portable play equipment available for children to use at the same time. • Make outdoor portable play equipment freely available to all children at all times. 			
GM Equip 3.3	Most of the equipment is appropriate for the age and ability of the children	.59 (.49)	
GM Equip 5.1	There is enough GM equipment so that children have access without a long wait	0.63 (0.49)	
GM Equip 5.2	Equipment stimulates a variety of skills (balancing, climbing, ball play, etc)	0.43 (0.50)	CBCL ^I (β = -3.47)
GM Equip 5.3	Adaptations provided for children with disabilities	NA	
GM Equip 7.1	Both stationary and portable GM equipment are used	0.75 (0.44)	
GM Equip 7.2	GM equipment stimulates skills on different levels	0.42 (0.50)	
Schedule <i>PA Best Practices</i> <ul style="list-style-type: none"> • Provide children with at least 120 minutes of active play time each day. • Provide teacher-led physical activity to children 2 or more times per day. • Provide outdoor active play time 2 or more times per day. 			
GM Equip 3.1	Some GM equipment accessible to all children at least one hour daily	0.86 (0.35)	HTKS (β = 5.20)
Schedule 3.3	At least one indoor and one outdoor play period occurs daily	0.90 (0.30)	HTKS (β = 7.32)
Schedule 5.2	A variety of play activities occur each day, some teacher directed and some child initiated	0.96 (0.19)	
Schedule 5.3	A substantial portion of the day is used for play activities	0.90 (0.30)	LENS (β = 0.57) CBCL ^I (β = 4.79)
Supervision of Gross Motor Play <i>PA Best Practices</i> <ul style="list-style-type: none"> • Encourage children to be active and join children in active play. • Provide physical activity education for children through a standardized curriculum 1x per week or more. 			
Supervise GM 5.3	Staff assist children to develop skills needed to use GM equipment (pump a swing, pedal a tricycle)	0.67 (0.48)	

ECERS-R Indicator	Description	Proportion meeting indicator, mean (SD)	Associated early learning outcome* (β coefficient)
Supervise GM 7.1	Staff talk with children about ideas related to their play (fast –slow; tell about building)	0.49 (0.50)	PPVT ($\beta = -2.87$)
Supervise GM 7.2	Staff help with resources to enhance play (set up obstacle course for tricycles)	0.51 (0.50)	CBCL ^I ($\beta = -4.52$)
Supervise GM 7.3	Staff help children develop positive social interactions related to gross motor activities	0.82 (0.39)	

* $p < 0.05$, Adjusted for age, gender, subsidy, fall performance on the same task.

^I For the Child Behavior Checklist, a positive β -coefficient suggests an increase in behavioral problems from fall to spring. A negative association would be desirable.