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POPULATION STUDY ARTICLE

Sports participation and preterm birth: a nationwide birth cohort in Japan

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BACKGROUND: Children born preterm may be less physically active than children born term because of neurocognitive problems, reduced lung function, and poor physical fitness. We evaluated sports participation of children and adolescents who had been born preterm (<37 weeks) and early term (37–38 weeks) in 2001.
METHODS: Data from a nationwide longitudinal survey ($n = 47{,}015$, including 2375 children born preterm) were analyzed. As indicators of sports participation, we used responses to questions about participation in sports clubs at 7 and 10 years old and in extracurricular school sports at 15 years old.
RESULTS: Children born very preterm (25–31 weeks) and moderately to late preterm (32–36 weeks) were less likely to participate in sports clubs at 7, 10, and 15 years old than children born full term (39–41 weeks). Compared with children born full term, the adjusted risk ratios for participation in extracurricular school sports at 15 years old were 0.86 (95% confidence interval: 0.75–0.98) for children born very preterm, 0.92 (0.88–0.97) for children born moderately to late preterm, and 1.00 (0.98–1.02) for children born early term.
CONCLUSIONS: Our findings suggest that preterm birth is associated with less participation in organized sports during childhood and adolescence than full-term birth.

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IMPACT:

- Research investigating associations between preterm birth and physical activity among children born in the 2000s is limited.
- This study shows that preterm birth was associated with less participation in organized sports during childhood and adolescence than full-term birth, especially in boys, and the participation in organized sports of children born preterm decreased as gestation shortened.
- During childhood, boys born early term were also less likely to participate in organized sports than boys born full term, suggesting a continuum with preterm births.
- These findings offer important additional insights into the limited evidence available for predicting future health outcomes for preterm infants.

INTRODUCTION

Recent advances in perinatal care have resulted in lower mortality and morbidity for infants born preterm.[1–3] The assessment of long-term outcomes for infants born preterm has become increasingly important. Children born preterm are at higher risk for neurocognitive problems, motor problems, reduced lung function, poor physical fitness, and behavior problems.[4–13] Moreover, previous studies have reported that children born early term (i.e., 37–38 gestational weeks) were at higher risk for long-term cognitive problems and respiratory morbidity.[14,15] These morbidities may negatively affect their future participation in physical activities.

Physical inactivity is a risk factor for obesity, cardiovascular disease, type 2 diabetes, metabolic syndrome, and mortality.[16–18] Additionally, physical inactivity during childhood is associated with future impaired health, including obesity and cardiovascular disease.[19,20] Although several studies have examined the association between prematurity and physical activity of children born from the 1980s to 1990s, their results were inconsistent: some studies reported that preterm birth was associated with lower rates of physical activity,[21–24] while others found no differences in the physical activities of children born preterm and those born at term.[25–29] Importantly, only a limited number of studies that assessed associations between preterm birth and physical activity included children born in the 2000s, during which time neonatal care for preterm births advanced markedly by the widespread use of antenatal corticosteroids and surfactant replacement therapy,

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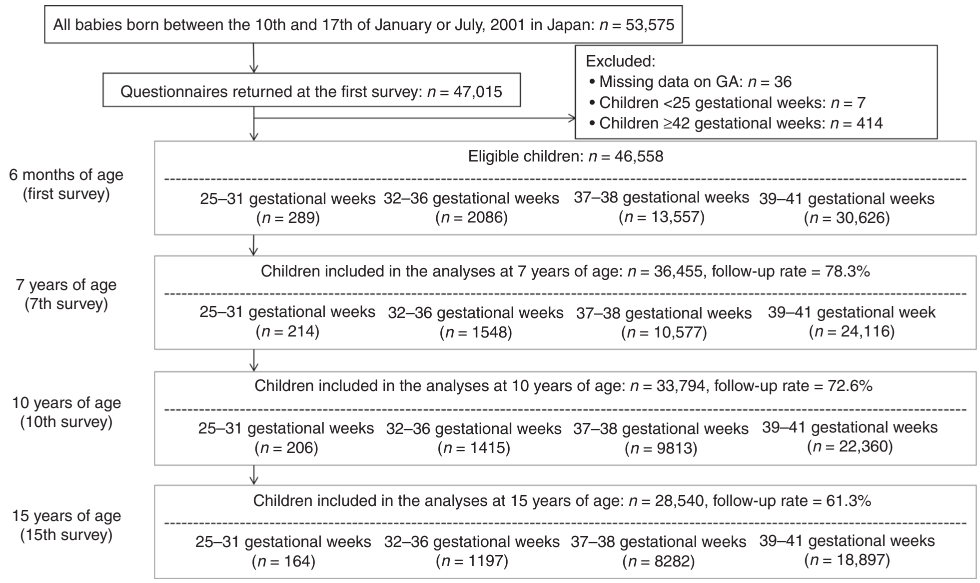

Fig. 1 Study participant flow chart. The Japanese Ministry of Health, Labour and Welfare has conducted a nationally representative longitudinal survey since 2001. Follow-up rates were 78.3%, 72.6%, and 61.3% at 7, 10, and 15 years old, respectively.

and improvements in ventilators.[30] Moreover, a few studies have distinguished between different levels of prematurity such as very, moderately, and late preterm. The millennium cohort study in the United Kingdom, for example, used accelerometers with 14-year-olds born between 2000 and 2002 and showed that those who had been born very, moderately, and late preterm were as physically active as their term-born peers.[25] However, the number of studies is limited, and, to our knowledge, none have investigated the physical activity of children born early term.

The present study evaluated sports participation of children and adolescents who had been born very preterm (25–31 weeks), moderately to late preterm (32–36 weeks), and early term (37–38 weeks) in the 2000s, using a large nationwide longitudinal questionnaire survey in Japan.

METHODS

Study participants

The Japanese Ministry of Health, Labour and Welfare has conducted a nationally representative longitudinal survey since 2001 to follow infants born across the country between January 10 and 17 or between July 10 and 17, 2001; it is called the Longitudinal Survey of Newborns in the 21st Century (2001 Cohort).[31–36] Baseline questionnaires were sent to families when their infants, born during the study period, were 6 months old. Of the 53,575 questionnaires posted, 47,015 were completed and returned (88% response rate). Follow-up questionnaires were sent yearly to all participants who initially responded (at 18, 30, and 42 months, and so on). The 15th survey was completed in 2016. For each child included in this survey, we also obtained birth-record data from the Vital Statistics system: birth weight, gestational age, singleton or multiple births, sex, parity, and parental age at delivery.

Children were excluded if their information did not include gestational age ($n = 36$). In the present study, we excluded children born at 22–24 weeks' gestation ($n = 7$) and children born post term ($n = 414$), resulting in the inclusion of 46,558 children in the descriptive analysis. Follow-up rates were 78.3%, 72.6%, and 61.3% at 7, 10, and 15 years old, respectively (Fig. 1). As a result, for example, 36,455 7-year-olds were analyzed in the regression analysis.

Gestational age

We obtained each infant's gestational age from their birth records. Gestational age ranged from 25 to 41 weeks. We created four groups according to gestational weeks: 25–31 weeks, very preterm ($n = 289$, including extremely preterm births); 32–36 weeks, moderately to late preterm ($n = 2,086$); 37–38 weeks, early term ($n = 13,557$); and 39–41 weeks, full-term ($n = 30,626$). Although it would have been preferable to have divided the 32–36 weeks group into moderately preterm (32–33 weeks) and late-preterm (34–36 weeks) groups, we chose to combine these two groups because of the small number of infants born at 32–33 gestational weeks.

Sports participation

To examine the impact of preterm birth on sports participation, we used responses to questions about participation in sports clubs during childhood and in extracurricular sports clubs at school during adolescence. The survey obtained information on whether the child had participated in sports clubs (e.g., gymnastics, swimming, baseball, soccer, tennis, martial arts, or dancing, which are popular for elementary school children in Japan) from the age of 7–12 years, and in extracurricular sports clubs at school (without details of kinds of sports activities) from the age of 13–15 years. We then focused on participation in sports activities at 7, 10, and 15 years of age for the present study. The questions used to assess sports participation did not include information on frequency, intensity, or duration of organized sports or other opportunities for sports activity.

Statistical analysis

We first conducted a descriptive analysis of children categorized by gestational weeks: very preterm, moderately to late preterm, early term, and full term. Subsequently, we conducted a log-binomial regression analysis to investigate the association between gestational age categories as defined above and sports participation at 7, 10, and 15 years of age. We estimated the risk ratio (RR) and 95% confidence interval (CI) for the main outcomes using the full-term category (i.e., 39–41 weeks) as a reference and adjusted for child and parental factors.

We selected the potential confounders on the basis of previous studies.[31–36] The child factors included sex (dichotomous), singleton or multiple births (dichotomous), parity including delivery of the child (1, 2, or ≥3; categorical), birth weight for gestational age (small [birth weight <10 percentile], appropriate [10–90 percentile], or large [≥90 percentile] for gestational age; categorical), daycare attendance at 18 months old (dichotomous), and breastfeeding status during infancy (formula feeding only, partial breastfeeding, or exclusive breastfeeding at 6–7 months of age; categorical). Parental factors included maternal age at delivery (<25, 25–30, 30–35, and ≥35; categorical), maternal smoking status (dichotomous), maternal educational level (categorical), paternal age at delivery (<25, 25–30, 30–35, and ≥35; categorical), paternal educational level (categorical), and place of birth and residence (ward, city, and town or village; categorical). Data for infant sex, singleton or multiple births, parity, birthweight for gestational age, parental age at delivery, and place of birth and residence were obtained from birth records. Maternal smoking status and breastfeeding status during infancy were obtained from the first

Table 1. Demographic characteristics of eligible children, separated by gestational week category ($n = 46{,}558$).

	Total children ($n = 46{,}558$)	Gestational week category			
		25–31 weeks ($n = 289$)	32–36 weeks ($n = 2086$)	37–38 weeks ($n = 13{,}557$)	39–41 weeks ($n = 30{,}626$)
Characteristics of children					
Sex, *n* (%)[a]					
Males	24,187 (52.0)	163 (56.4)	1251 (60.0)	7514 (55.4)	15,259 (49.8)
Females	22,371 (48.0)	126 (43.6)	835 (40.0)	6043 (44.6)	15,367 (50.2)
Birth weight for gestational age, *n* (%)[a]					
Appropriate for gestational age	37,465 (80.6)	187 (65.4)	1629 (78.2)	11,010 (81.3)	24,639 (80.6)
Small for gestational age	3738 (8.0)	60 (21.0)	275 (13.2)	991 (7.3)	2412 (7.9)
Large for gestational age	5295 (11.4)	39 (13.6)	180 (8.6)	1545 (11.4)	3531 (11.5)
Singleton birth or not, *n* (%)[a]					
Singleton birth	45,582 (97.9)	235 (81.3)	1652 (79.2)	13,132 (96.9)	30,563 (99.8)
Multiple births	976 (2.1)	54 (18.7)	434 (20.8)	425 (3.1)	63 (0.2)
Parity, *n* (%)[a]					
1 (no older siblings)	22,642 (48.6)	111 (38.4)	901 (43.2)	5538 (40.9)	16,092 (52.5)
2	17,039 (36.6)	114 (39.4)	785 (37.6)	5614 (41.4)	10,526 (34.4)
≥3	6877 (14.8)	64 (22.2)	400 (19.2)	2405 (17.7)	4008 (13.1)
Daycare attendance, *n* (%)[c]					
No	36,368 (78.1)	238 (82.4)	1599 (76.7)	10,561 (77.9)	23,970 (78.3)
Yes	7076 (15.2)	25 (8.7)	306 (14.7)	2072 (15.3)	4673 (15.3)
Missing	3114 (6.7)	26 (9.0)	181 (8.7)	924 (6.8)	1983 (6.5)
Breastfeeding status during infancy, *n* (%)[b]					
Formula feeding only	778 (1.7)	12 (4.2)	72 (3.5)	283 (2.1)	411 (1.4)
Partial breastfeeding	35,677 (77.3)	254 (88.2)	1770 (85.5)	10,557 (78.6)	23,096 (76.0)
Exclusive breastfeeding at 6–7 months old	9709 (21.0)	22 (7.6)	228 (11.0)	2596 (19.3)	6863 (22.6)
Parental characteristics					
Maternal age at delivery, *n* (%)[a]					
<25	6096 (13.1)	32 (11.1)	264 (12.7)	1545 (11.4)	4255 (13.9)
25–30	17,662 (37.9)	93 (32.2)	697 (33.4)	4782 (35.3)	12,090 (39.5)
30–35	16,584 (35.6)	105 (36.3)	780 (37.4)	5057 (37.3)	10,642 (34.7)
≥35	6216 (13.4)	59 (20.4)	345 (16.5)	2173 (16.0)	3639 (11.9)
Maternal smoking status, *n* (%)[b]					
Non-smoker	38,196 (82.0)	230 (79.6)	1665 (79.8)	11,120 (82.0)	25,181 (82.2)
Smoker	8039 (17.3)	57 (19.7)	404 (19.4)	2327 (17.2)	5251 (17.1)
Missing	323 (0.7)	2 (0.7)	17 (0.8)	110 (0.8)	194 (0.6)
Maternal educational attainment, *n* (%)[c]					
University or higher	5965 (12.8)	29 (10.0)	247 (11.8)	1676 (12.4)	4013 (13.1)
Junior college	17,873 (38.4)	108 (37.4)	755 (36.2)	5135 (37.9)	11,875 (38.8)
High school	17,008 (36.5)	98 (33.9)	782 (37.5)	5086 (37.5)	11,042 (36.1)
Junior high school or others	2421 (5.2)	27 (9.3)	111 (5.3)	685 (5.1)	1598 (5.2)
Missing	3291 (7.1)	27 (9.3)	191 (9.2)	975 (7.2)	2098 (6.9)
Paternal age at delivery, *n* (%)[a]					
<25	3901 (8.4)	20 (6.9)	164 (7.9)	953 (7.0)	2764 (9.0)
25–30	13,132 (28.2)	71 (24.6)	535 (25.6)	3473 (25.6)	9053 (29.6)
30–35	16,101 (34.6)	94 (32.5)	720 (34.5)	4827 (35.6)	10,460 (34.2)
≥35	12,822 (27.5)	97 (33.6)	632 (30.3)	4134 (30.5)	7959 (26.0)
Missing	602 (1.3)	7 (2.4)	35 (1.7)	170 (1.3)	390 (1.3)

Table 1 continued

	Total children ($n = 46,558$)	Gestational week category			
		25–31 weeks ($n = 289$)	32–36 weeks ($n = 2086$)	37–38 weeks ($n = 13,557$)	39–41 weeks ($n = 30,626$)
Paternal educational attainment, *n* (%)[c]					
University or higher	15,474 (36.2)	80 (31.0)	671 (35.8)	4557 (36.6)	10,166 (36.0)
Junior college	6699 (15.7)	39 (15.1)	275 (14.7)	1901 (15.3)	4484 (15.9)
High school	17,014 (39.8)	110 (42.6)	742 (39.6)	4977 (40.0)	11,185 (39.6)
Junior high school or others	3597 (8.4)	29 (11.2)	184 (9.8)	1007 (8.1)	2377 (8.4)
Residential area, *n* (%)[a]					
Wards	10,199 (21.9)	55 (19.0)	438 (21.0)	2870 (21.2)	6836 (22.3)
Cities	27,430 (58.9)	175 (60.6)	1252 (60.0)	7954 (58.7)	18,049 (58.9)
Towns and villages	8929 (19.2)	59 (20.4)	396 (19.0)	2733 (20.2)	5741 (18.7)

[a]Obtained from the birth record.
[b]Obtained from the first survey (at the age of 6 months).
[c]Obtained from the second survey (at the age of 18 months).

survey (at infant age of 6 months). Parental educational level and daycare attendance at 18 months old were obtained from the second survey (at child age of 18 months). We classified the original eight categories of educational level into four categories as follows: junior high school or others, high school, junior college (2 years) or vocational school, and university (4 years) or higher. We excluded missing cases and conducted our analyses with complete cases only.

Furthermore, we conducted a restricted cubic spline analysis to evaluate the relationship between gestational age and sports participation. We inserted four knots and controlled for the same covariates as the original categorical analyses. From the spline analyses, we obtained the adjusted RR and 95% CI for each gestational week, ranging from 25 to 41 weeks, using 39 gestational weeks as a reference.

Stata SE version 16 statistical software (StataCorp., College Station, TX) was used for all analyses. This study was approved by the Okayama University Graduate School of Medicine, Dentistry and Pharmaceutical Sciences Institutional Review Board (No. 1506-073).

RESULTS

The baseline characteristics of the eligible children and their parents are shown in Table 1. Compared with children born at term, children born preterm were more likely to be associated with male-infant sex, multiple births, older mothers, smoking mothers, and less-educated parents. The characteristics of the participants at 7, 10, and 15 years of age are also shown in Supplementary Table 1. Children with younger parents, smoking mothers, and less-educated parents tended to be lost to follow-up.

Table 2 shows the association between preterm birth and participation in organized sports at 7, 10, and 15 years of age. Compared with children born full-term, children born very preterm and moderately to late preterm were less likely to participate in organized sports at 7, 10, and 15 years of age. Children born early term were as physically active as children born full term. For example, compared with children born full term, the adjusted RRs for participation in organized sports at 15 years old were 0.86 (95% CI: 0.75–0.98) for children born very preterm, 0.92 (0.88–0.97) for children born moderately to late preterm, and 1.00 (0.98–1.02) for children born early term.

The results from the restricted cubic function are shown in Fig. 2. Before 39 gestational weeks, we observed a linear relationship between shorter duration of gestation and less participation in organized sports at 7, 10, and 15 years of age, which was consistent with the original categorical analysis.

Table 3 shows the association between preterm birth and participation in organized sports at 7, 10, and 15 years old, separated by sex. There were no differences in sports participation for girls by gestational age categories. However, at 7, 10, and 15 years old, boys born very preterm and moderately to late preterm were less likely to participate in organized sports than boys born full term. Additionally, at 7 and 10 years old, boys born early term were less likely to participate in organized sports than boys born full term. For example, compared with boys born full-term, the adjusted RRs for participation in organized sports at 10 years of age were 0.77 (95% CI: 0.65–0.92), 0.92 (0.87–0.97), 0.97 (0.95–0.99) for boys born very preterm, moderately to late preterm, and early term, respectively.

DISCUSSION

The purpose of the present study was to examine the association between preterm birth and sports participation during childhood and adolescence, using a nationwide survey in Japan. Children born preterm were less likely to participate in sports activities than children born full term, and sports participation decreased as gestation shortened. The spline analyses supported the findings. Although there were no differences in sports participation for girls by gestational age categories, sports participation of boys born preterm decreased as gestation shortened. Additionally, during

Table 2. Unadjusted RRs and adjusted[a] RRs with 95% CIs for associations between gestational week category and participation in organized sports.

	Ncase/*N* (%)	Crude model		Adjusted model[a]	
		RR	(95% CI)	RR	(95% CI)
Participation in organized sports at 7 years old					
25–31 weeks	78/214 (36.4)	0.73	(0.61–0.87)	0.75	(0.63–0.89)
32–36 weeks	737/1548 (47.6)	0.95	(0.90–1.00)	0.94	(0.89–0.99)
37–38 weeks	5206/10,577 (49.2)	0.98	(0.96–1.00)	0.98	(0.96–1.00)
39–41 weeks	12,083/24,116 (50.1)	1.00	(reference)	1.00	(reference)
Participation in organized sports at 10 years old					
25–31 weeks	87/206 (42.2)	0.76	(0.64–0.89)	0.80	(0.69–0.93)
32–36 weeks	787/1415 (55.6)	0.99	(0.95–1.04)	0.96	(0.92–1.00)
37–38 weeks	5526/9813 (56.3)	1.01	(0.99–1.03)	0.99	(0.97–1.01)
39–41 weeks	12,501/22,360 (55.9)	1.00	(reference)	1.00	(reference)
Participation in organized sports at 15 years old					
25–31 weeks	91/164 (55.5)	0.86	(0.75–0.99)	0.86	(0.75–0.98)
32–36 weeks	743/1197 (62.1)	0.97	(0.92–1.01)	0.92	(0.88–0.97)
37–38 weeks	5415/8282 (65.4)	1.02	(1.00–1.04)	1.00	(0.98–1.02)
39–41 weeks	12,129/18,897 (64.2)	1.00	(reference)	1.00	(reference)

RR risk ratio, *CI* confidence interval.
[a]Adjusted for neonatal factors (sex, singleton birth or not, birthweight for gestational age, parity, breastfeeding status during infancy, and daycare attendance), and family factors (maternal and paternal age, maternal smoking status, maternal and paternal educational attainment, and place of birth and residence). There were 1463, 1278, and 963 cases missing on potential confounders at 7, 10, and 15 years of age, respectively.

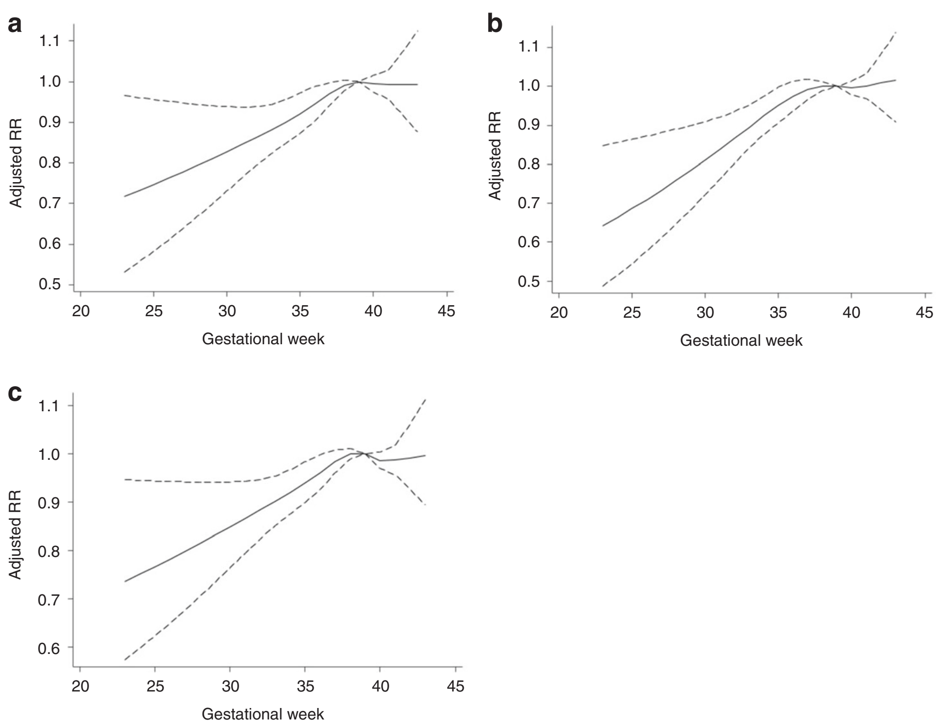

Fig. 2 The restricted cubic spline analysis. Adjusted RRs (solid lines) and 95% CIs (dotted lines) for the associations between gestational weeks and participation in organized sports at **a** 7 years of age, **b** 10 years of age, and **c** 15 years of age.

childhood, boys born early term were also less likely to participate in sports activities than boys born full term. These findings could be associated with future impaired health, including obesity and cardiovascular disease.

Although several studies have examined the association between prematurity and physical activity, their results were inconsistent. Moreover, only a few studies have investigated the physical activity of preterm children born in the 2000s. A large population-based cohort study in the United Kingdom, which examined adolescents born between 1991 and 1992, showed that physical activity levels, measured objectively using accelerometers, were similar for different gestational groups.[27] A birth cohort study in Denmark reported that moderately to late preterm children born from 1989 to 1991 participated in sports activities as often as children who had been born full term.[26] However, some case–control studies using survey data for children born around 1990 showed that preterm birth was associated with physical inactivity.[21–24] The millennium cohort study in the United K

Table 3. Adjusted[a] RRs with 95% CIs for associations between gestational week category and participation in organized sports, stratified by sex.

	Males			Females		
	Ncase/*N* (%)	RR	(95% CI)[a]	Ncase/*N* (%)	RR	(95% CI)[a]
Participation in organized sports at 7 years old						
25–31 weeks	42/115 (36.5)	0.64	(0.50–0.82)	36/99 (36.4)	0.97	(0.76–1.25)
32–36 weeks	464/935 (49.6)	0.89	(0.83–0.95)	273/613 (44.5)	1.07	(0.98–1.17)
37–38 weeks	3187/5859 (54.4)	0.97	(0.94–0.99)	2019/4718 (42.8)	0.99	(0.96–1.03)
39–41 weeks	6824/12,009 (56.8)	1.00	(reference)	5259/12,107 (43.4)	1.00	(reference)
Participation in organized sports at 10 years old						
25–31 weeks	57/111 (51.4)	0.77	(0.65–0.92)	30/95 (31.6)	0.85	(0.64–1.13)
32–36 weeks	542/859 (63.1)	0.92	(0.87–0.97)	245/556 (44.1)	1.12	(1.02–1.24)
37–38 weeks	3599/5420 (66.4)	0.97	(0.95–0.99)	1927/4393 (43.9)	1.04	(0.99–1.08)
39–41 weeks	7690/11,153 (69.0)	1.00	(reference)	4811/11,207 (42.9)	1.00	(reference)
Participation in organized sports at 15 years old						
25–31 weeks	55/90 (61.1)	0.83	(0.70–0.98)	36/74 (48.6)	0.91	(0.72–1.16)
32–36 weeks	490/718 (68.2)	0.90	(0.86–0.95)	253/479 (52.8)	1.00	(0.91–1.10)
37–38 weeks	3478/4540 (76.6)	1.01	(0.99–1.03)	1937/3742 (51.8)	0.97	(0.94–1.01)
39–41 weeks	7038/9314 (75.6)	1.00	(reference)	5091/9583 (53.1)	1.00	(reference)

RR risk ratio, *CI* confidence interval.
[a]Adjusted for neonatal factors (singleton birth or not, birthweight for gestational age, parity, breastfeeding status during infancy, and daycare attendance), and family factors (maternal and paternal age, maternal smoking status, maternal and paternal educational attainment, and place of birth and residence). There were 1463, 1278, and 963 cases missing on potential confounders at 7, 10, and 15 years of age, respectively.

investigated associations between prematurity and the physical activity levels (measured with accelerometers) of children born in the 2000s and reported that children 14 years old who had been born very, moderately, and late preterm were as physically active as their term-born peers.[25] However, the researchers found differences in moderate-to-vigorous physical activity at 14 years old between gestational age groups when they evaluated the activity by questionnaire responses (i.e., 19% of term-born, 17% of late preterm-born, 12% of moderately preterm-born, and 11% of very preterm-born adolescents reported daily moderate-to-vigorous physical activity of 60 min).[25] Studies using subjective methods have often reported less physical activity in children born preterm than term, while those using objective methods have shown modest differences in physical activities between children born preterm and term. Therefore, disparities in results may be explained by the timing of the period during which the participants were recruited and/or by differences in the methods used to assess their physical activities.

A few studies have investigated associations between preterm birth and physical activity, separated by sex. The millennium cohort study in the United Kingdom, for example, showed that boys born at ≤32 weeks' gestation had statistically significant reductions in objectively measured moderate-to-vigorous physical activity at 7 years of age when compared to term controls, but there was no association between gestational age and any measure of physical activity for girls at 7 years of age.[37] Similarly, in a prospective cohort study in Sweden, boys born extremely preterm (<27 gestational weeks) spent less time per day in objectively measured moderate-to-vigorous physical activity at 6.5 years of age than boys born at term, while there were no differences observed between girls born extremely preterm and term.[38] By contrast, a large population-based study in the United Kingdom reported no differences in the objectively measured physical activities of both boys and girls at 11 and 15 years old between the different gestation groups.[27] Boys born preterm are at higher risk for poor neurological and respiratory outcomes than girls born preterm.[39] Additionally, developmental coordination disorder is reported to be associated with male sex, preterm birth, and decreased participation in sports.[40] A large population-based study showed that boys with developmental coordination disorder were less physically active than boys without developmental coordination disorder, while there was no difference in the physical activities of girls with or without developmental coordination disorder.[41] These findings may show that boys born preterm may be more vulnerable with respect to physical activity than girls born preterm. Irrespective of preterm births and ages, the percentages of sports participation for girls were lower than those for boys in our data. Previous studies have also reported that girls were less likely, in general, to participate in sports activities than boys.[42,43] The relative inactivity of girls might be another reason for sex differences in the present study.

Recently, children born early term (i.e., 37–38 gestational weeks) are increasingly acknowledged to have greater long-term morbidities (e.g., childhood respiratory morbidity, cognitive deficits, and behavioral problems) than children born full term.[14,15] These morbidities may negatively influence physical activity. However, to our knowledge, no studies have investigated the physical activity of children born early term. We observed that, during childhood, boys born early term were less physically active than boys born full term, providing further insights into the limited evidence.

The present study showed that the percentages of participation in organized sports increased with age, while most previous studies indicate that physical activity decreases with age.[27,44,45] The millennium cohort study in the United Kingdom, which used questionnaires, reported that the frequencies of participation in organized physical activities (in sports clubs or classes) increased with age, which is consistent with the present study, while those in unorganized physical activities (with siblings and friends) decreased with age.[25] Although participation in only organized sports does not predict all physical activity, participation in organized sports is thought to be an important role in the improvement of physical activity.[46,47]

The present study's strengths include the large sample size, which allowed us to estimate the impact of specific preterm birth categories on sports participation, and the very high response rate at baseline (88.1%), which reinforced the validity of our findings.

Some limitations of this study should be acknowledged. First, we relied on subjective questionnaire data to quantify participation in sports activities. Second, we could not assess the frequency, intensity, or duration of organized sports or other opportunities for sports activity. However, popular sports clubs at junior high schools in Japan are baseball, soccer, basketball, volleyball, tennis, table tennis, athletics, martial arts, and swimming, all of which entail intensities that are consistent with moderate-to-vigorous physical activity.[48] Furthermore, a survey conducted by the Japan Sports Agency reported that 94% of 25,092 junior high school students who engaged in extracurricular sports clubs at school spent more than 420 min per week on extracurricular sports activities.[48] Third, the follow-up rate was low, especially in 15 years of age (61.3%). Furthermore, data for some children born very preterm or moderately to late preterm were unavailable in follow-up surveys owing to attrition (Fig. 1), which may have caused an underestimation of the adverse effects of preterm birth. Finally, children born very preterm were uncommon, and thus statistical power was limited for that group even in this large cohort.

CONCLUSIONS

We found that preterm birth was associated with less participation in organized sports during childhood and adolescence than full-term birth, especially in boys, and the participation in organized sports of children born preterm decreased as gestation shortened. During childhood, boys born early term were also less likely to participate in organized sports than boys born full term, suggesting a continuum with preterm births. Further studies are needed to examine the association between less participation in sports activity among children born preterm and early term and future impaired health, including obesity and cardiovascular disease.

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K.T. contributed to the study design, data interpretation, and writing the first draft and revision of the manuscript. N.M. contributed to the study design, acquisition of the data, data analysis and interpretation, and revision of the manuscript. A.T., M.N., K.N., M.K., Y.W., and H.T. contributed to the study design, providing important intellectual content, and revision of the manuscript. T.Y. contributed to the study design, providing important intellectual content, revision of the manuscript, and study supervision. All the authors mentioned above approved the final manuscript.

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