Early Intervention to Encourage Physical Activity in Infants and Toddlers: A Randomized Controlled Trial

CHRIS MOIR[1], KIM MEREDITH-JONES[2], BARRY J. TAYLOR[1], ANDREW GRAY[3], ANNE-LOUISE M. HEATH[4], KELLY DALE[1], BARBARA GALLAND[1], JULIE LAWRENCE[1], RACHEL M. SAYERS[1], and RACHAEL W. TAYLOR[2]

[1]Department of Women's and Children's Health, University of Otago, Dunedin, NEW ZEALAND; [2]Department of Medicine, University of Otago, Dunedin, NEW ZEALAND; [3]Department of Preventive and Social Medicine, University of Otago, Dunedin, NEW ZEALAND; and [4]Department of Human Nutrition, University of Otago, Dunedin, NEW ZEALAND

ABSTRACT

MOIR, C., K. MEREDITH-JONES, B. J. TAYLOR, A. GRAY, A.-L. M. HEATH, K. DALE, B. GALLAND, J. LAWRENCE, R. M. SAYERS, and R. W. TAYLOR. Early Intervention to Encourage Physical Activity in Infants and Toddlers: A Randomized Controlled Trial. *Med. Sci. Sports Exerc.*, Vol. 48, No. 12, pp. 2446–2453, 2016. **Introduction**: Few physical activity interventions have been undertaken in infants and toddlers, despite concerns that they are insufficiently active. The Prevention of Overweight in Infancy trial encouraged parents to be physically active with their child from birth, including prone-based play ("tummy time"), while reducing time spent restrained in car seats and "strollers." **Methods**: A total of 802 women, recruited in late pregnancy, were randomized to a physical activity intervention, which provided information antenatally, and active group sessions with their infant at 3, 9, and 18 months of age. Questionnaires were completed at multiple time points, and toddlers wore Actical accelerometers for 5 d at 24 months of age. **Results**: Attendance at intervention sessions was high in infancy but declined by 18 months to 66%. Almost all parents placed their infant prone to play at least once a day (90%–95%, overall median 25 min·d^{-1}), with no intervention differences observed (P = 0.445 and P = 0.350 at 4 and 6 months, respectively). Few differences were observed in other measures of restraint or parental activity at any time point. At 2 yr, children spent approximately 8 h·d^{-1} in sedentary time while awake and 3.6 h in light-to-vigorous activity. However, no group differences were apparent in counts per minute (P = 0.759) or time in light-to-vigorous activity (P = 0.960). **Conclusion**: An early life intervention targeting improvements in child and parent physical activity as part of a wider obesity prevention initiative had little effect on physical activity at 2 yr of age. **Key Words:** PHYSICAL ACTIVITY, INFANT, TODDLER, ACCELEROMETER, SEDENTARY TIME

Physical activity is important for health across the life cycle and may be an effective obesity prevention tool given that physical activity tracks reasonably well from childhood to young adulthood (33). Broadly comparable physical activity guidelines have now been developed for infants and toddlers in many countries (2,9,34). Opportunities for physical activity should be provided several times a day for infants less than 1 yr of age, including floor-based interactive play ("tummy time") and activities, which promote reaching and grasping of objects (34). Such activity allows flexion and extension of the muscles involved in holding up the upper torso and head and plays a role in the achievement of motor milestones, although it is possible that these effects are only transient (28). Toddlers (1–2 yr) and preschoolers (3–4 yr) should accumulate at least 3 h of physical activity each day (9,34) at any intensity (e.g., light, moderate, and vigorous) by including a variety of activities in different environments that develop movement skills (e.g., playing with balloons, chasing balls, moving to music, walking to places).

Whether young children are meeting these guidelines is unclear, as estimates range from 5% to 90% in older preschool-age children (3–6 yr) (14,36), with similar variability in the under 2-yr age-group (15,40). Unfortunately, some of this discrepancy is attributed to variation in accelerometer cut points denoting various intensities of physical activity, which markedly affects adherence to guidelines (26). Given these uncertainties, it is difficult to conclude whether young children are indeed sufficiently active, requiring further examination of this issue.

Some countries also include recommendations to specifically limit the amount of time children spend restrained, or kept inactive, for more than 1 h at a time (except for sleeping) (9). Restraint devices may be intended to entertain children, such as "jolly jumpers" (the infant sits suspended in a harness hanging from a spring that recoils when they jump), or to contain the child for safety purposes, such as car seats. The use of "walkers" (the infant sits suspended in a frame that

Address for correspondence: Rachael Taylor, Ph.D., Department of Medicine, University of Otago, PO Box 56, Dunedin 9054, New Zealand; E-mail: rachael.taylor@otago.ac.nz.
Submitted for publication January 2016.
Accepted for publication July 2016.

0195-9131/16/4812-2446/0
MEDICINE & SCIENCE IN SPORTS & EXERCISE®

DOI: 10.1249/MSS.0000000000001055

they can roll around on wheels) has been shown to result in motor skill delays, but the effect of other infant equipment devices has been examined infrequently (28). Whether their use directly affects physical activity in infants is unknown, but greater time spent unrestrained in infancy has been associated with more favorable growth patterns (30). Furthermore, restricting sedentary time is a major public health target for all age-groups (20).

Relatively few interventions have examined whether physical activity can be increased in children younger than 2 yr of age (8,12,15,37), although improvements in "tummy time" have been observed in a single study (38). Other studies have incorporated the approaches suggested in the various international guidelines (2,9,34) through a variety of initiatives to increase physical activity in the home (8,12), child care center (37), or community group (15) environments. However, findings to date have been disappointing, with all studies failing to find a significant increase in activity in intervention groups.

The relative paucity of intervention research in infants and toddlers means that further work is required to determine whether interventions encouraging activity during the first few years of life can make a difference. Therefore, the aims of this study were to examine whether an intervention encouraging parents to be active with their child from birth influenced the use of "tummy time," the use of restraints such as car seats, and the extent of parental and toddler activity at 2 yr of age.

METHODS

This study uses data from the Prevention of Overweight in Infancy (POI) study, a 2-yr randomized controlled trial investigating early life approaches to obesity prevention. As a protocol paper is available (31), the methods will only be outlined briefly here. Ethical approval was granted by the New Zealand Lower South Regional Ethics Committee (LRS/08/12/063), and all women gave written informed consent. A total of 802 women from one city in New Zealand (Dunedin, population 120,000) were recruited in late pregnancy from the single maternity hospital servicing the region (58% participation rate). Eligibility criteria were the mother: being at least 16 yr of age, booked into hospital before 34 wk gestation, able to communicate in English or Te Reo Maori (indigenous language of New Zealand), and planning to live locally for at least 2 yr. Exclusion criteria applied after birth were prematurity (baby born before 36.5 wk gestation) or diagnosis of any medical condition likely to affect feeding, physical activity, or growth (Fig. 1).

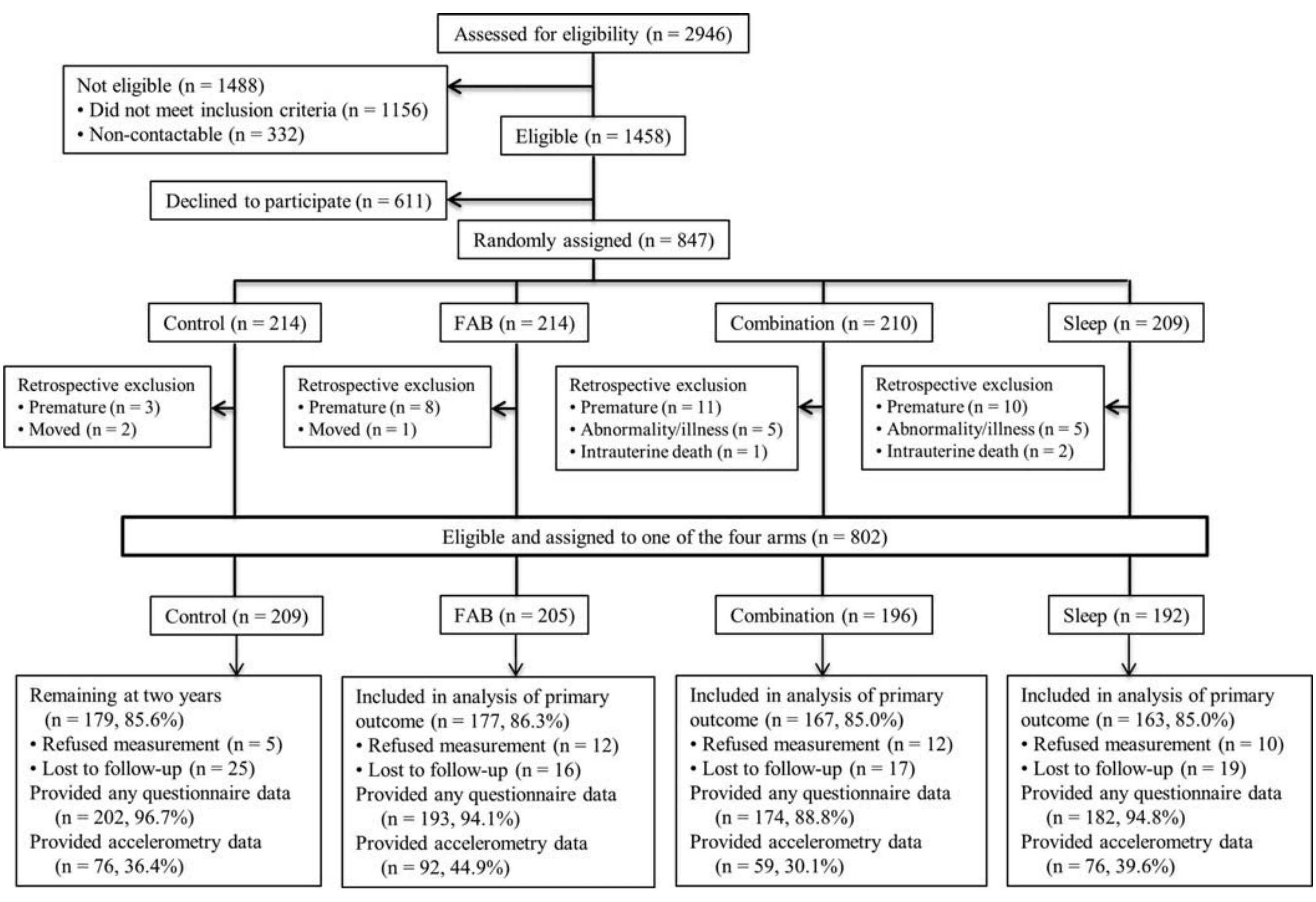

FIGURE 1—Flow of participants through the study.

APPLIED SCIENCES

Eligible participants were randomized (computer generated random numbers) after stratification for maternal parity (1 vs 2 or more) and family socioeconomic status (low, medium, and high) to one of four arms: 1) control; 2) food, activity, and breastfeeding (FAB); 3) sleep; and 4) combination (FAB and sleep) with groups described as follows:

1. Control participants received usual care from the government-funded "Well Child" care service, which typically includes seven visits beginning from 2 to 4 wk postnatally until 2 yr of age and covers a wide variety of issues including standard growth and development assessments, interventions where indicated (e.g., family violence, smoking cessation, and postnatal depression), and support and guidance on a range of health issues including physical activity (e.g., breast feeding, nutrition, parenting, safe sleep environments, safety, immunization, illness, oral health, and child development) (24). The three intervention groups also received Well Child care plus additional support and education, depending on their group allocation.
2. The FAB intervention focused on breastfeeding and timely introduction of solids, healthy family foods, and physical activity. Only those components relevant to activity will be discussed here. All participants (and where possible, their partners) attended a group education session at around 37 wk gestation. This session concentrated on breastfeeding but included a brief presentation (3–4 min) on the importance of activity for infants, including "tummy time." Three additional group sessions were held when the infants were 3, 9, and 18 months of age and were delivered by Sport Otago staff (www.sportotago.co.nz). This government agency facilitates physical activity in the community through a variety of initiatives, including "Active Movement" (for the 0–5 yr age-group). Active Movement is based on international physical activity guidelines (2,9,34) and aims to engage children in quality movement experiences in a fun, positive environment. These sessions focused on i) the importance of active play from birth and in particular encouraged fathers to be involved with this; ii) ideas for encouraging activity at different ages (such as moving the child's arms and legs in the opposite direction at 3 months, playing games on the floor to encourage crawling at 15 months, hitting a balloon around the room for the toddler to chase at 21 months) including the provision of extensive resources; iii) avoiding excessive use of car seats, "strollers," and equipment such as walkers or "jolly jumpers"; and iv) encouraging families to be active together. Each session was approximately 1 h long, consisting of 30 min for discussion and illustration of suggested activities followed by an opportunity for parents to try each activity with their infant or toddler. Parents were also provided with an extensive take-home written resource to complement the sessions. Research staff regularly attended activity sessions to determine that interventions were delivered as intended and remained consistent during the study.
3. The sleep intervention focused on antenatal and early postnatal education about preventing sleep problems with optional behavioral strategy interventions from 6 months of age for those parents who considered their infant to have a sleep problem.
4. The combination group received the FAB and the sleep interventions as described previously.

Questionnaires were used at baseline (typically 37 wk gestation) and at ages 4, 6, 12, and 24 months, as outlined in this paragraph. Demographic variables were collected at baseline and included maternal self-reported prepregnancy weight (which was used with height measured at 6 months postpartum to calculate body mass index [BMI]), parity, level of education (three categories: year 12 or less, year 13 or postsecondary, and university degree or higher), age at child's birth, and ethnicity of each parent using New Zealand census questions. Infant ethnicity was then determined from parental ethnicity using a prioritized system (Maori, Non-New Zealand European Other, New Zealand European). Household deprivation was calculated from the home address. "Tummy time" was assessed by questionnaire at 4 and 6 months of age: mothers were asked to indicate the number of times each day and for how long they placed their baby lying on his or her front for play. Similar questions were used at 6 and 12 months to measure the typical amount of time each week that children were "restrained" in "jolly jumpers," car seats, "strollers," playpens, or bouncinettes (fabric harness on a sprung metal frame that allows a gentle rocking motion). Where answers indicated more than 600 min were spent on any of these activities per day, these responses were regarded as invalid and removed from the data (n = 2 and 10 participants for tummy time at 4 and 6 months, respectively; n = 4 participants for car seat at 6 months; and n = 1 participant for playpen at 6 months). Maternal and partner physical activities were measured at 6, 12, and 24 months using the short form of the International Physical Activity Questionnaire (5). Data are expressed as MET-minutes per week from a compilation of time spent walking (3.3 METs) and in moderate (4.0 METs) and vigorous (8.0 METs) activities.

Physical activity at 2 yr of age was assessed using waist-worn Actical accelerometers (Mini-Mitter; Respironics, Bend, OR) during a 5-d period (24 $h \cdot d^{-1}$). Parents were provided with extra belts so that accelerometers could be worn during bathing and swimming wherever possible. The Acticals were initialized using 15-s epochs, in the uniaxial mode. As our accelerometer data were collected for 24 h, data were scored using a count-scaled algorithm, which uses an automated script developed in MATLAB (MathWorks, Natick, MA) to "remove" all sleep from each file at the individual level (i.e., different times for each day for each participant as appropriate). The algorithm then uses the same procedures as Meterplus (http://www.meterplussoftware.com) for scoring physical activity during awake time only (21). A valid day was defined as at least 8 h of awake wear time during the 24-h period, and participants were excluded from the analysis if fewer than three valid days of wear were obtained. Data were expressed as counts per minute and the number of minutes in sedentary time (0–49 counts per minute) and light-to-vigorous activity (LMV, 50-maximum counts per minute). As intensity cutoffs for the Actical have not yet been agreed for children of this age, we used a value of 50 counts per minute as a conservative choice between estimates of 25 counts per minute used in Actical validation studies in older preschool-age children (1) and that of 50 obtained for toddlers using ActiGraph accelerometers (35). These data should thus be interpreted with caution.

Statistics. Data were analyzed according to modified intention-to-treat principles (using all available data) and the results presented following CONSORT guidelines (25). The POI study was sufficiently powered to detect clinically important differences in BMI and weight velocity (main outcomes) rather than physical activity (secondary outcome) (31). Outcomes are described appropriately given their distribution (count and percentage, mean and SD, geometric mean and geometric SD, or median and interquartile range). Children with and without accelerometry at 2 yr were compared using *t*-tests for continuous characteristics, with natural logarithmic transformations where values were skewed within groups, and chi-square tests for categorical characteristics. For counts per minute, minutes in sedentary time, and minutes in LMV activity, descriptives are based on the mean values for the participant over all available days' data. These variables were analyzed using all available data at the participant-day level using linear mixed models with a day of week effect and a random effect for participant to account for the repeated measures. Counts per minute were log-transformed because of skewed model residuals. All other outcome variables displayed very strong positive skew, and logarithmic transformations were not sufficient to correct for this (after adding one for variables including zero values), and so these were compared between groups at each age using quantile regression to model median values for each outcome. Some quantile regression models could not be implemented due to all four groups having median values of zero. All regression models adjusted for the stratification variables (parity and socioeconomic status). Overall (Wald) tests of significance for group were performed, and where these were statistically significant, pairwise comparisons were performed without adjustment for multiple comparisons. All statistical analyses were conducted using Stata 13.1, and two-sided $P < 0.05$ was considered statistically significant in all cases.

RESULTS

Table 1 displays the characteristics of the study sample. Mothers were highly educated with 60% having a university education, and more than half were multiparous. Although a wide range of household deprivation was observed, a smaller proportion of families in our study had high levels of household deprivation (21%) than the national average (30%). The majority of children were New Zealand European (78%), which is higher than national figure (71%), but lower than the local population (86%) (www.stats.govt.nz). Retention at 2 yr of age was 86%, and attendance at the information and activity sessions was high, particularly at younger ages. Those in the FAB group attended 97%, 86%, 80%, and 68% of the antenatal, 3, 9, and 18 month sessions, respectively, and similar figures were observed for the combination group participants (93%, 83%, 72%, and 63%). However, only 303 children (38%) provided usable accelerometry data at 2 yr of age (Fig. 1). These children did not differ in terms of sex, infant ethnicity, maternal prepregnancy BMI, or household deprivation from those who did

TABLE 1. Baseline characteristics of the study population.

		Control (n = 209)	Sleep (n = 192)	FAB (n = 205)	Combination (n = 196)
Child sex, n (%)	Female	111 (53)	82 (43)	98 (48)	100 (51)
	Male	98 (47)	110 (57)	107 (52)	96 (49)
Child ethnicity, n (%)	New Zealand European	162 (78)	147 (77)	160 (78)	156 (80)
	Maori	24 (12)	14 (7)	19 (9)	18 (9)
	Other	23 (10)	31 (16)	26 (13)	22 (11)
Maternal ethnicity, n (%)	New Zealand European	177 (85)	161 (84)	176 (86)	168 (86)
	Maori	15 (7)	8 (4)	9 (4)	14 (7)
	Other	17 (8)	23 (12)	20 (10)	14 (7)
Maternal education,[a] n (%)	Year 12 or less	27 (13)	31 (16)	26 (13)	32 (17)
	Year 13 or postsecondary	57 (28)	46 (24)	41 (20)	49 (25)
	University degree or higher	122 (59)	115 (60)	136 (67)	112 (58)
	Missing	3	0	2	3
Parity (including study child), n (%)	1	99 (47)	90 (47)	96 (47)	97 (49)
	2	66 (32)	63 (33)	70 (34)	62 (32)
	3 or more	44 (21)	39 (20)	39 (19)	37 (19)
Household deprivation,[b] n (%)	Low (1–3)	74 (36)	65 (34)	70 (34)	67 (35)
	Medium (4–7)	93 (45)	84 (44)	86 (42)	87 (45)
	High (8–10)	39 (19)	43 (22)	47 (23)	39 (20)
	Missing	3	0	2	3
Maternal age at birth, mean (SD), yr		31.5 (5.0)	31.6 (5.2)	32.1 (5.3)	31.0 (5.4)
Maternal prepregnancy BMI, geometric mean (SD), kg·m^{-2}		24.7 (1.21)	24.4 (1.19)	24.8 (1.22)	24.5 (1.19)

[a]Secondary education in New Zealand is from years 9 to 13 inclusive.
[b]Determined using the New Zealand Index of Deprivation.

APPLIED SCIENCES

TABLE 2. The effect of the intervention on "tummy time," child restraint, and parental activity.

	Age of Child (Months)	Control (n = 202)	Sleep (n = 182)	FAB (n = 193)	Combination (n = 174)	P
"Tummy time" (min·d^{-1})	4	20 (31.0)	16 (20.0)	20 (30.0)	20 (40.0)	0.445
	6	30 (90.0)	30 (65.0)	45 (105.0)	30 (75.5)	0.350
Car seat (min·d^{-1})	6	60 (60.0)	50 (54.0)	40 (60.0)	45 (50.0)	0.076
	12	40 (37.5)	40 (36.6)	35 (40.0)	30 (40.0)	0.064
"Jolly jumper" (min·d^{-1})	6	4.3 (11.4)[a,b]	5.7 (19.3)[b]	1.4 (6.1)[a]	2.4 (8.6)[a]	**<0.001**
	12	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	—
Play pen (min·d^{-1})	6	0.0 (25.0)	0.0 (30.0)	0.0 (15.0)	0.0 (20.0)	—
	12	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	—
Maternal physical activity (MET·wk^{-1})	6	986 (1236)	785 (1037)	1011 (1261)	1063 (1276)	0.147
	12	874 (1242)[a]	546 (776)[b]	980 (1487)[a]	975 (1158)[a]	**0.011**
	24	953 (1352)	733 (1269)	815 (1268)	960 (1254)	0.687
Paternal physical activity (MET·wk^{-1})	6	1440 (2355)	2121 (2640)	2034 (3845)	1628 (3568)	0.205
	12	1709 (2809)	1756 (3234)	1780 (2625)	1256 (4440)	0.513

Data are presented as median (interquartile ranges). n refers to those with useable data for at least one outcome at any time point. Different superscripts within the same line indicate a significant difference between the median values (P < 0.05). –, the regression model could not be estimated as the medians were all zero.

not provide usable data (all $P \geq 0.100$) but had significantly younger mothers ($P < 0.001$) who were less educated ($P = 0.004$) and less likely to identify as Maori ($P = 0.012$).

Table 2 demonstrates the effect of the intervention on measures of infant activity and restraint at various ages. Almost all parents placed their infant lying on his or her front at least once a day (95% at 4 months and 90% at 6 months), with infants spending a median of 25 min·d^{-1} in this prone position (median of 20 min at 4 months, 35 min at 6 months). However, there was no evidence of a difference between intervention groups at 4 or 6 months ($P = 0.445$ and $P = 0.348$, respectively). The amount of time spent restrained in car seats did not vary significantly between groups at either 6 or 12 months, but at 6 months, the physical activity intervention groups (FAB and Combination) spent fewer minutes in a "jolly jumper" each day than the sleep group (Table 2). However, this represented a difference of just 4.3 min for the FAB group relative to the sleep group (95% confidence interval [CI] = 2.1–6.5, $P < 0.001$), with similar figures for the combination group (4.3 min lower than sleep, 95% CI = 2.0–6.5, $P < 0.001$).

Parental participation in physical activity is also presented in Table 2 at different time points. In general, mothers were expending 800–1000 MET·wk^{-1}, which is equivalent to approximately 5 h of walking. No real change was observed from 6 to 24 months of age for mothers, and few intervention differences were apparent. The only significant difference for maternal activity (overall $P = 0.011$) was observed when the infants were 12 months of age with mothers in the sleep group reporting less activity than mothers in all other groups (adjusted median 289 METs lower than control; 95% CI = 21–556, $P = 0.035$), FAB (384 METs lower; 95% CI = 119–649, $P = 0.005$), and Combo (426 METs lower; 95% CI = 150–702, $P = 0.003$). No significant group differences were observed for partners at any time point (Table 2).

Table 3 displays the awake-time accelerometry data for those infants with valid data (n = 303). Additional 149 participants (20%) agreed to wear an accelerometer but did not provide 3 d of data (n = 137), or the accelerometer malfunctioned (n = 12). On average, 2-yr-old children were spending approximately 8 h·d^{-1} in sedentary time while awake (naps and sleeps not included) and 3.6 h in activity that was at least light in nature. However, no differences were apparent between the intervention groups for any measure, including counts per minute ($P = 0.759$), which reflects total physical activity during the day (awake time only).

DISCUSSION

An intervention designed to promote family physical activity from birth, and limit the amount of time children spent restrained in car seats and "strollers," did not increase physical activity of children, or their parents, whether estimated by questionnaire or measured objectively by accelerometry. Although small differences were observed between the groups in the amount of time children spent in "jolly jumpers," these are unlikely to be clinically important.

Relatively few physical activity interventions have been undertaken in children younger than 2 yr. We observed no group differences in the amount of "tummy time" in our infants at 4 or 6 months of age, whereas an intervention in Sydney reported that intervention mothers introduced "tummy time" at a younger age ($P = 0.03$) and that a greater proportion of intervention infants engaged in daily "tummy time" at 6 months of age (76% to 83%, $P = 0.05$) (38). This discrepancy in findings may reflect differences in demographics between the two studies, given the Sydney sample was considerably more disadvantaged than the current study. It is certainly apparent that "tummy time" is widespread in New Zealand, with 95% of our control sample

TABLE 3. Effect of the intervention on physical activity (awake hours only) at 24 months of age measured using accelerometry.

	Control (n = 76)	Sleep (n = 76)	FAB (n = 92)	Combination (n = 59)	P
Counts per minute	274 (1.43)	276 (1.37)	285 (1.51)	287 (1.40)	0.759
Time in sedentary activity (min·d^{-1})	472 (57)	470 (72)	470 (66)	480 (54)	0.853
Time in LMV activity (min·d^{-1})	221 (60)	216 (59)	218 (53)	221 (49)	0.960

n refers to those with usable data. Data are expressed as mean (SD) except for counts per minute, which is geometric mean (geometric SD). Data are analyzed using linear mixed models (count-per-minute data were log-transformed before analysis).

engaging in daily "tummy time"; such high rates allow little room for improvement in terms of prevalence but may still allow for improvements in the quantity of tummy time. Since the 1990s, New Zealand has had a very strong "back to sleep" campaign, which recommends that parents place babies supine (on their back) to sleep rather than prone (on their front) to reduce the risk of sudden unexpected death in infancy (23). Initially, this led to concerns that emphasis on supine sleeping might limit the amount of time parents place infants prone for play, which might have implications for their motor development (16). However, studies have since shown that the effect of positioning while awake or asleep on the acquisition of motor milestones does result in some differences, but they seem to be transient in nature (28). We included education on "tummy time" in our intervention because estimates of adherence to this guideline did not exist at the time our POI study commenced, and because encouraging "tummy time" is part of internationally accepted guidelines for promoting physical activity in infants (2,34).

Our accelerometry data indicated that children who received the physical activity intervention (FAB and combination) were no more active than children who did not receive the intervention (control and sleep) at 2 yr of age. A similar lack of effect was reported by the existing interventions that have measured physical activity objectively in this young age-group (8,12,15,37). Other large early life obesity prevention studies either have not targeted physical activity (6) or have assessed it by questionnaire, also demonstrating no significant effect on activity (39). Although it is possible that the relatively small dose used in the current study contributed to our lack of effect, all intervention studies to date have been reasonably low dose, either in terms of contact (8,37) or for those with a greater degree of contact, because a large number of topics in addition to physical activity were included (12,15).

In combination, these results would suggest that it may be very difficult to increase physical activity levels in young children. Why this is so is not clear, but it is feasible that other health priorities such as infant crying (11) and sleep problems (29) are more important to parents at this age. However, the difficulty of producing sustained increases in physical activity in older children is also apparent from recent reviews. Although individual studies do demonstrate success for some interventions, meta-analyses demonstrate that, overall, physical activity interventions have only a very small effect on activity levels in children (3,18), perhaps as little as 4 $\text{min}\cdot\text{d}^{-1}$ of moderate to vigorous activity (22). This may be even more relevant for very young children than for older age-groups given the high proportion who already meet the physical activity guidelines for their age. Our New Zealand POI study findings agree with data from U.S. (36) and Australian (15) studies in indicating that, on average, children are meeting guidelines to engage in at least 3 h of LMV activity each day. Although high compliance with guidelines has not been seen universally in young children (14,40), this may be explained, at least in part, by variation in the accelerometry cut points used to define different intensities of activity and differences in data reduction methods, both of which make it difficult to compare studies (26).

Targeting reductions in sedentary behavior as opposed to increases in physical activity might prove a more successful initiative in infants and toddlers. Sedentary behavior has distinct effects on health, even in 0- to 4-yr-old children (19), and may track more strongly during childhood than physical activity (17). It is clear that television viewing is common in children less than 2 yr of age, although much less is known regarding other forms of sedentary behavior, including whether they are restrained for more than one h at a time (10). However, several large interventions have now demonstrated that reductions in television viewing time are possible in infants and toddlers (4,39), and restricting time spent restrained is associated with more favorable growth patterns early in life (30). Although such reductions in sedentary time are unlikely to produce a corresponding increase in physical activity, given the very weak relationship between these two behaviors (27), decreasing sedentary time remains a major public health target for all age-groups (20).

The strengths of our large randomized controlled study include the high adherence to intervention sessions (particularly at 3 and 9 months of age), the strong retention overall, with 86% of families remaining in the study at 2 yr of age, and the initial high response rate (58% of those eligible). This is considerably higher than has been reported in some other studies of new parents (7) and comparable with others (4,39). Given the difficulties inherent in measuring physical activity by questionnaire in very young children, particularly when parents perceive their child is naturally active (13), our use of objective monitoring by accelerometry is also a major strength. However, contrary to our experience with slightly older age-groups where compliance was considerably higher (32), we found that uptake of the devices was poor, with parents reporting that they were too busy or that their child did not like wearing the belt. Rather than develop our own physical activity intervention, we used trained staff from the regional Sports Trust, whose role is to promote physical activity within the community. This meant that we did not contribute to the training of these staff, nor did we collect formal measures of fidelity to the intervention. However, our own research staff regularly attended activity sessions to determine whether interventions were delivered as intended. Finally, some of the information that was provided to the participants by Sport Otago was already available to parents as part of their free Well Child care (24), although our intervention was certainly more extensive, providing both educational materials and the opportunity to interact with physical activity specialists in a fun group setting.

In conclusion, a broad intervention targeting improvements in child and parent physical activity as part of a wider obesity prevention initiative had little effect on physical activity. Minor differences in maternal activity, and less use of one type of restrained activity, were considered of little practical importance. Although there is only limited research in infants and toddlers, the existing literature would suggest that it may be very difficult to increase physical activity levels in this age-group. Whether this differs at older ages when the child is able to be more independently active will be the topic of future research when these POI children are 3–5 yr of age.

The POI study was funded by the Health Research Council of New Zealand (grant nos. 08/374, 12/281, and 12/310). RWT is supported by the KPS Fellowship in Early Childhood Obesity. The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

The results of the present study do not constitute endorsement by the American College of Sports Medicine.

The authors declare that they have no competing interests.

Authors' contributions: R. W. T. and B. J. T. are the principal investigators of the POI study; C. M. was involved in data collection and analysis and wrote the paper with R. W. T.; K. M.-J. undertook the accelerometer analyses; A. G. designed and undertook statistical analyses; and B. G.[a], A.-L. M. H.[b], J. L.[d], R. S.[a], and K. D.[c] were active in the conception and execution of the study, especially sleep[a], nutrition[b], physical activity[c], and project management[d]. All authors read and approved the final manuscript.

REFERENCES

1. Adolph AL, Puyau MR, Vohra FA, et al. Validation of uniaxial and triaxial accelerometers for the assessment of physical activity in children. *J Phys Act Health*. 2012;9(7):944–53.
2. Australian Government. *Move and Play Every Day. National Physical Activity Recommendations for Children 0–5 Years*: Department of Health and Ageing, Commonwealth of Australia; 2010, 4 p. Available from: http://www.health.gov.au/internet/main/publishing.nsf/content/9D831D9E6713F92ACA257BF0001F5218/$File/0-5yrACTIVE_Brochure_FA%20SCREEN.pdf.
3. Brown HE, Atkin AJ, Panter J, et al. Family-based interventions to increase physical activity in children: a systematic review, meta-analysis and realist synthesis. *Obes Rev*. 2016;17:345–60.
4. Campbell K, Lioret S, McNaughton S, et al. A parent-focused intervention to reduce infant obesity risk behaviors: a randomized trial. *Pediatrics*. 2013;131(4):652–60.
5. Craig CL, Marshall AL, Sjöström M, et al. International physical activity questionnaire: 12-country reliability and validity. *Med Sci Sports Exer*. 2003;35(8):1381–95.
6. Daniels LA, Mallan KM, Battistutta D, et al. Evaluation of an intervention to promote protective infant feeding practices to prevent childhood obesity: outcomes of the NOURISH RCT at 14 months of age and 6 months post the first of two intervention modules. *Int J Obes (Lond)*. 2012;36(10):1292–8.
7. Daniels LA, Wilson JL, Mallan KM, et al. Recruiting and engaging new mothers in nutrition research studies: lessons from the Australian NOURISH randomised controlled trial. *Int J Behav Nutr Phys Act*. 2012;9(1):129.
8. de Vries AGM, Huiting HG, van den Heuvel ER, et al. An activity stimulation programme during a child's first year reduces some indicators of adiposity at the age of two-and-a-half. *Acta Paediatr*. 2015;104:414–21.
9. Department of Health, Physical Activity, Health Improvement and Protection. *Start Active, Stay Active: A Report on Physical Activity for Health From the Four Home Countries Chief Medical Officer's*. UK: Department of Health; July 2011, 59 p. Available from: https://www.gov.uk/government/publications/start-active-stay-active-a-report-on-physical-activity-from-the-four-home-countries-chief-medical-officers.
10. Downing KL, Hnatiuk J, Hesketh KD. Prevalence of sedentary behavior in children under 2 years: a systematic review. *Prev Med*. 2015;78:105–14.
11. Forsyth BW, Leventhal JM, McCarthy PL. Mothers' perceptions of problems of feeding and crying behaviour. *Am J Dis Child*. 1985;139:269–72.
12. Harvey-Berino J, Rourke J. Obesity prevention in preschool Native-American children: a pilot study using home visiting. *Obes Res*. 2003;11(5):606–11.
13. Hesketh K, Hinkley T, Campbell KJ. Children's physical activity and screen time: qualitative comparison of views of parents of infants and preschool children. *Int J Behav Nutr Phys Act*. 2012; 9(1):152.
14. Hinkley T, Salmon J, Okely AD, Crawford D, Hesketh K. Preschoolers' physical activity, screen time, and compliance with recommendations. *Med Sci Sports Exerc*. 2012;44(3):458–65.
15. Hnatiuk J, Ridgers ND, Salmon J, Campbell K, McCallum Z, Hesketh K. Physical activity levels and patterns of 19-month-old children. *Med Sci Sports Exerc*. 2012;44(9):1715–20.
16. Jantz JW, Blosser CD, Fruechting LA. A motor milestone change noted with a change in sleep position. *Arch Pediatr Adolesc Med*. 1997;151:565–8.
17. Jones RA, Hinkley T, Okely AD, Salmon J. Tracking physical activity and sedentary behavior in childhood: a systematic review. *Am J Prev Med*. 2013;44(6):651–8.
18. Kamath CC, Vickers KS, Ehrlich A, et al. Clinical review: behavioral interventions to prevent childhood obesity: a systematic review and metaanalyses of randomized trials. *J Clin Endocrinol Metab*. 2008;93:4606–15.
19. LeBlanc A, Spence J, Carson V, et al. Systematic review of sedentary behaviour and health indicators in the early years (aged 0–4 years). *Appl Physiol Nutr Metab*. 2012;37(4):753–72.
20. Manini TM, Carr LJ, King AC, Marshall S, Robinson TN, Rejeski WJ. Interventions to reduce sedentary behavior. *Med Sci Sports Exerc*. 2015;47(6):1306–10.
21. Meredith-Jones K, Williams SM, Galland BC, Kennedy G, Taylor R. 24 h accelerometry: impact of sleep-screening methods on estimates of sedentary behaviour and physical activity while awake. *J Sports Sci*. 2016;34(7):679–85.
22. Metcalf B, Henley W, Wilkin T. Effectiveness of intervention on physical activity of children: systematic review and meta-analysis of controlled trials with objectively measured outcomes (EarlyBird 54). *BMJ*. 2012;345:e5888.
23. Miller LC, Johnson A, Duggan L, Behm M. Consequence of the "Back to Sleep" program in infants. *J Pediatr Nurs*. 2011;26(4):364–8.
24. Ministry of Health. *Well Child/Tamariki Ora National Schedule*. Wellington (New Zealand): Ministry of Health; 2013, 11 p. Available from: http://www.health.govt.nz/publication/well-child-tamariki-ora-national-schedule-2013.
25. Moher D, Schulz KF, Altman DG. The CONSORT statement: revised recommendations for improving the quality of reports of parallel-group randomised trials. *Lancet*. 2001;357(9263):1191–4.
26. Pate R, O'Neill J, Brown W, Pfeiffer KA, Dowda M, Addy CL. Prevalence of compliance with a new physical activity guideline for preschool-aged children. *Child Obes*. 2015;11(4):415–20.
27. Pearson N, Braithwaite RE, Biddle SJ, van Sluijs EM, Atkin AJ. Associations between sedentary behaviour and physical activity in children and adolescents: a meta-analysis. *Obes Rev*. 2014;15:666–75.
28. Pin T, Eldridge B, Galea MP. A review of the effects of sleep position, play position, and equipment use on motor development in infants. *Dev Med Child Neurol*. 2007;49:858–67.
29. Sepa A, Frodi A, Ludvigsson J. Psychosocial correlates of parenting stress, lack of support and lack of confidence/security. *Scand J Psychol*. 2004;45(2):169–79.

30. Sijtsma A, Sauer PJJ, Stolk RP, Corpeleijn E. Infant movement opportunities are related to early growth—GECKO Drenthe cohort. *Early Hum Dev*. 2013;89:457–61.
31. Taylor BJ, Heath A-LM, Galland BC, et al. Prevention of Overweight in Infancy (POI.nz) study: a randomised controlled trial of sleep, food and activity interventions for preventing overweight from birth. *BMC Public Health*. 2011;11:942.
32. Taylor RW, Williams SM, Farmer VL, Taylor BJ. Changes in physical activity over time in young children: a longitudinal study using accelerometers. *PLoS One*. 2013;8(11):e81567.
33. Telama R. Tracking of physical activity from childhood to adulthood: a review. *Obes Facts*. 2009;2(3):187–95.
34. Tremblay M, LeBlanc A, Carson V, et al. Canadian physical activity guidelines for the early years (aged 0–4 years). *Appl Physiol Nutr Metab*. 2012;37(2):345–56.
35. Trost SG, Fees BS, Haar SJ, Murray AD, Crowe LK. Identification and validity of accelerometer cut-points for toddlers. *Obesity (Silver Spring)*. 2011;20(11):2317–9.
36. Vale S, Trost S, Ruiz J, Moreira P, Mota J. Physical activity guidelines and preschooler's obesity status. *Int J Obes (Lond)*. 2013;37(10):1352–5.
37. Verbestel V, De Coen V, Van Winckel M, Huybrechts I, Maes L, De Bourdeaudhuij I. Prevention of overweight in children younger than 2 years old: a pilot cluster-randomized controlled trial. *Pub Health Nutr*. 2014;17(6):1384–92.
38. Wen LM, Baur LA, Simpson JM, Rissel C, Flood VM. Effectiveness of an early intervention on infant feeding practices and "tummy time": a randomised controlled trial. *Arch Pediatr Adolesc Med*. 2011;165(8):701–7.
39. Wen LM, Baur LA, Simpson JM, Rissel C, Wardle K, Flood VM. Effectiveness of home based early intervention on children's BMI at age 2: randomised controlled trial. *BMJ*. 2012;344:e3732.
40. Witjzes AI, Kooijman MN, Kiefte-de Jong JC, et al. Correlates of physical activity in 2-year-old toddlers: the Generation R study. *J Pediatr*. 2013;163(3):791–9.