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Social dynamics of supported walking in 11-month-old infants

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ABSTRACT

Before infants walk independently, they move upright with support by holding caregivers' hands, pushing a wheeled walker, and "cruising" along walls or furniture. To what extent do caregivers and infants engage in these activities and do these experiences with supported walking relate to independent walking status? To address these questions, we assessed supported walking in 50 11-month-olds and their mothers in the context of everyday routines. For each bout of supported walking, coders scored the type of support, frequency of supported bouts, and the number of steps infants took per bout. Mothers tracked onset ages for independent walking prospectively, and researchers verified infants' walking skill using a standardized task. Infants who produced more child-controlled supported walking achieved independent walking earlier than infants who produced less child-controlled supported walking. But, supported walking experience did not predict proficiency of independent walking, suggesting that the two types of locomotion are distinct. These data highlight the role of experience of locomotor behaviors and indicate that not all experience is equally effective.

1. Introduction

Before infants walk independently, they can pull themselves up to a stand and keep balance for brief moments. This behavior signals to parents that their babies are ready to walk. Anecdotally, parents are often seen hunched over their wobbly upright babies, clutching their hands, supporting their balance, and waddling from side to side as they "walk" their infants to practice the imminent skill. There are even commercial products available, such as baby harnesses, specifically designed to facilitate supported walking activities. This childrearing practice is often a delight for infants, allowing them to cover more ground and view their surroundings unobstructed, looking outward rather than being limited to what's at hand when crawling on hands and knees (Kretch et al., 2014). For parents, this practice is likely an uncomfortable workout that they endure, perhaps hoping to enhance their infants' walking skills. To what extent does this childrearing practice occur during everyday routines? Does this practice relate to independent walking in infants? In this study, we explored experiences with supported walking in 11-month-old crawling infants and whether these experiences are associated with the onset and proficiency of independent walking.

Research has illustrated the diversity of childrearing practices and its effects on development. Across Africa and the West Caribbean, caregivers report handling infants in ways that differ from typical Western routines, by tossing infants into the air, suspending them by the neck or from the ankles, and jiggle them by the limbs (for review, see Adolph et al., 2010; Karasik, 2018). Caregivers note that they prop infants into sitting positions in holes dug into the ground, designed to support their posture (Super, 1976). In Kenya, the

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Kipsigis engage in a routine called "kitwalse," meaning "to make jump," where they hold infants upright in their laps and bounce them vigorously (Super, 1976). Jamaican mothers encourage infants to balance, bounce, and make stepping movements (Bril, 1988; Hopkins & Westra, 1988). In Bali, caregivers set up bamboo rails for children to hold as they practice taking upright walking steps (Mead & Macgregor, 1951). These childrearing practices happen as part of daily routines, months before infants display these skills, and are explained as part of good parenting to accelerate motor development (Keller et al., 2002). Indeed, infants experiencing these tactics tend to demonstrate earlier sitting and walking onsets than infants who do not (Hopkins & Westra, 1988).

Experimental studies support these correlational reports (for review, see Adolph & Hoch, 2019; Adolph et al., 2010). Infants who receive vestibular stimulation and daily leg pumping demonstrated more advanced performance on developmental assessments in contrast to those who do not (Clark et al., 1977; Porter, 1972). Compared to controls, infants who experienced daily, active training rather than passive training with object skills, crawling, and stepping displayed increased frequency and retention of manual skills, stepping patterns, and earlier onset ages (Lagerspetz et al., 1971; Libertus & Needham, 2010; Needham et al., 2002). For instance, when mothers allowed their 2-month-olds to practice stepping by supporting infants in an upright stance against a flat surface, infants retained the stepping behavior compared to mothers who simply moved the infants' legs for them while lying supine. Importantly, active practice led to longer-term benefits; infants who self-produced stepping attained independent walking at earlier ages as compared to infants who experienced passive practice of their mothers moving their legs for them (Zelazo et al., 1993). This suggests that self-generated movement leads to subsequent benefits rather than mother-produced practice.

In these studies, the effects of experimentally induced experience were observed much earlier than the skill in question. For example, mothers exercised their 2-month-olds several months before walking onset (Zelazo, et al., 1972a). Similarly, 3-month-olds were given "sticky" mittens several months before the development of reaching, grasping, and manipulating (Needham et al., 2002). These studies demonstrate the powerful effects of experience. The question remains about the nature of infants' spontaneous experiences. Do mothers recognize when infants are on the cusp of acquiring a skill—walking—and encourage it either directly or indirectly? During everyday routines, do mothers "walk" their infants by holding their arms once they recognize they are on the brink of independent walking?

Although for infants, supported walking or cruising involves different perception-action systems compared to walking—particularly in terms of balance maintenance and relevant perceptual information for navigating the ground—parents may interpret cruising as a sign that their infants are ready to take independent steps and, as a result, engage in support-walking activities with them. However, walking with assistance from caregivers or using external supports to take upright steps are behaviors that are rarely distinguished or described in the developmental literature and often used interchangeably (Wijnhoven et al., 2004; Schneider & Iverson, 2023). According to the World Health Organization, typically developing infants begin walking with support between 7 and 12 months of age, with most starting around 9 months. By 13 months, the majority of infants (97 %) are able to walk independently (WHO 2006). On the WHO standards and developmental milestone charts, cruising is wedged between hands-knees crawling and independent walking, suggesting it is a precursor to walking. Studies show that experience with cruising is accompanied by improvements in postural control in standing (Sveistrup & Woollacott, 1996). Researchers have long agreed that leg strength and balance control are prerequisites to the acquisition of walking (e.g., Bril & Breniere, 1992; Thelen & Ulrich, 1991; McGraw, 1935). In the weeks prior to independent walking, infants take forward steps while holding caregivers' hands, "cruise" stationary furniture or push detached furniture (Haehl et al., 2000; Vereijken & Adolph, 1999). Caregiver or furniture provide manual support to compensate for the wobbly balance and weakened leg strength.

Although studies claim that experience with cruising is associated with the development of walking, the understanding of this relation remains limited. Prior studies typically define experience in terms of the number of days since the onset of the skill and have found moderate correlations among crawling, cruising, and walking (Adolph, et al., 2011). Essentially, infants who began crawling at younger ages tended to start cruising and walking at younger ages as well.

Laboratory experiments with cruising infants have sparked debate about the connection between cruising and walking. When faced with gaps in the floor, cruisers made their decisions to cross on whether a handrail was available for manual support (Adolph et al., 2011). This behavior indicates that infants prioritize support for their hands and torso over the stability of their legs. Given that walking requires infants to assess whether the ground can support their upright balance, these findings suggest that the skills learned during cruising may not directly translate to walking or may be less relevant (Adolph, 2000). Moreover, in lab experiments, infants are placed in a cruising position rather than being given the option to walk with support, making it difficult to inquire about its connection to walking. Observations in natural family settings could provide valuable insights into the frequency of caregivers and infants engaging in supported walking activities and whether these behaviors portend independent walking.

Only one such study described infants' experience with movement, including cruising and supported walking at home (Schneider & Iverson, 2023). In their longitudinal study of 30 12-month-olds, researchers scored how much time infants spent in motion and all forms of locomotor activity. In the weeks leading up to independent walking, infants spent similar amount of time crawling, cruising, and supported walking, generally preferring upright mobility over prone. Their findings revealed significant variability in infants' locomotor behavior prior to achieving independent walking, with no discernible patterns associated with the onset of independent walking. The authors prioritized describing the incredible individual differences in infants' movement experiences prior to walking, rather than focusing on distinguishing between the various types of supported walking experiences.

Beyond its timing, scant knowledge is available regarding the development of cruising and its relation to walking. Previous research indicates that practicing specific skills can enhance their development. However, there remains a gap in understanding infants' experiences and how they relate to motor skills. Studies often demonstrate the diversity in childrearing practices, typically relying on maternal reports and binary measures: whether a practice is performed or not. In naturalistic settings, it is unclear how frequently mothers engage in activities such as practicing upright stepping with their infants and whether these interactions predict walking.

Alternatively, it may be sufficient for mothers to allow infants to explore freely, providing ample opportunities for movement. The question remains whether these self-initiated experiences can predict the onset of walking.

In this study, we asked about the frequency and variety of infants' experiences with supported walking and their potential association with the onset and proficiency of independent walking. To do so, we observed 11-month-old infants and their mothers in their natural home environments during typical daily routines. We assessed the spontaneous instances of supported walking among infants to gain insight into the nature and frequency of their engagement in this activity. To investigate whether variety of supported walking experiences relates to walking proficiency, we revisited the families when infants reached 13 months of age. For infants who had begun walking independently, we assessed their walking proficiency by measuring walking speed and step length in a standard walking task (Karasik et al., 2023; Adolph et al., 2003). Additionally, we gathered onset dates of independent walking from mothers.

We hypothesized that infants with more supported walking experience, regardless of type (i.e., mother-controlled or child-controlled), would have an earlier onset of independent walking because of the enhanced practice moving upright. Another possibility is that the type of supported walking may matter—infants with more mother-controlled walking may have an earlier onset of independent walking, as suggested in prior studies showing that mothers' direct training affects motor skills (Zelazo et al., 1993; Zelazo, 1984; Zelazo, et al., 1972b). Yet another possibility, is that the type of supported walking may not significantly relate to the onset of independent walking, and instead factors such as overall level of activity or environmental supports might have notable influence (e.g., Schneider & Iverson, 2023).

Moreover, we hypothesized that supported walking experience would relate to walking proficiency, with infants who have more supported walking experience demonstrating faster speeds and longer step lengths, indicating more advanced walking abilities compared to those with less supported walking experience. If supported walking serves as practice for independent walking, it should relate to walking proficiency. During supported walking, infants might practice alternating their legs, building up leg muscle groups, and incorporate perceptual information from an upright posture and bipedal movements. Alternatively, it is plausible that supported walking may not correlate with improved independent walking since the balance control required for locomotion in the cruising posture is different from that required for independent walking (Adolph, 2000).

2. Method

2.1. Participants and Procedure

We observed 50 11-month-old ($SD = 0.28$) healthy, term infants in their homes. Families were recruited from maternity wards of local hospitals and parenting websites and received photo albums of their infant as souvenirs. Infants were White (74 %), Asian (8 %), Black (4 %), Latino (6 %), and 8 % identified as having mixed ethnicity. During a structured interview (Adolph et al., 2003) the researcher probed mothers about the first day they witnessed their infants crawling on hands-and-knees (for 3 m, typically the length of a room) and cruising along furniture (for 1.5 m, the length of a couch or coffee table). Mothers used baby books and calendars to aid their memory. Locomotor experience was calculated as the number of days between skill onset date and test date. Infants were experienced crawlers and 37 infants (74 %) were able to "cruise," move upright with support (Table 1). None could walk independently. Boys and girls began crawling and cruising at similar ages and had equivalent amounts of crawling and cruising experience, $ps > .05$.

Infants were video recorded for 1 h in their homes at a convenient time when they were not napping or being fed a meal. During this time, mothers were asked to go about their usual day. No specific instructions were given about whether or how to interact with infants; mothers were free to play with infants or to leave them on the floor or confine them in a highchair or playpen.

When infants were 13 months old, families were visited again. At that visit, mothers reported whether infants began to walk independently and the date of walk onset. At 13 months, 24 infants (12 girls and 12 boys) were walking, and 26 infants (12 girls and 14 boys) were still crawling. The researcher verified infants' walking status and assessed walking proficiency by observing infants on a 5-meter-long runner, marked every 25 cm. The researcher placed infants at one end of the mat (1-meter starting place) while caregivers were positioned at the opposite end (1-meter landing place), encouraging infants to locomote toward them with the help of toys and snacks. To confirm locomotor status, infants needed to walk continuously for 3 m without stopping or falling. Infants who were unable to walk, crawled as their primary mode of locomotion. Infants were observed on the runner for a minimum of two trials, with a maximum four trials. Standard gait measures (i.e., walking speed and step length) were calculated by averaging two fastest trials (e.g., Adolph et al., 2003). For infants who were still crawling at 13 months, researchers followed up with mothers via phone or email to determine the date of walk onset. Crawling, cruising, and walking ages were moderately correlated (Table 2); infants who began crawling and cruising at younger ages, tended to walk at younger ages.

Table 1
Number of participants, skill onset ages (months), and experience (months).

	11-Month-Olds			13-Month-Olds	
Skill	*N*	*Mage* (*SD*)	*Mexper* (*SD*)	*N*	*Mage* (*SD*)
Crawling	50	8.52 (1.67)	2.23 (1.16)	26	14.16 (0.89)
Cruising	37	9.00 (1.12)	2.00 (1.15)	—	—
Walking	0	—		24	12.00 (0.55)

Table 2
Correlations among motor skill onsets.

Variable	1	2	3
1. Crawling Onset Age (months)	—	.38*	.33*
2. Cruising Onset Age (months)		—	.36*
3. Walk Onset Age (months)			—

* * $p < .01$
* $p < .05$

2.2. Data Coding

Behavioral data were scored from video using a computerized video coding system, Datavyu (datavyu.org), which records frequencies and durations of specific behaviors. A primary coder scored 100 % of the data; a second coder scored between 25 % and 33 % of each infant's data for reliability. Inter-observer reliability ranged from 94.4 % to 99.6 % (κs =.75 –.96, *p*s < .05); correlation on duration variables were $r = .95$. Disagreements between coders were resolved through discussion. With permission, videos of sessions are openly shared with authorized investigators in the Databrary digital library (http://doi.org/10.17910/b7.271).

In one pass, a researcher scored the frequency and type of supported walking during the hour-long video. Episodes of supported walking began with the first frame an infants' foot lifted off the ground, or slid, and ended on the first frame when both feet remained in place for 0.5 second (Adolph, et al., 2012). Researchers credited supported walking if infants' hands were in contact with a surface for support. Child-controlled walking included instances when infants took steps while gripping movable furniture or while grazing stationary surfaces for support. Mother-controlled walking included when infants' hands were in contact with their caregivers' hands while taking steps. Caregivers were often positioned behind infants during supported walking but would also occasionally be positioned on the side or in front of infants.

In a second pass, a researcher counted the number of steps accumulated during each supported-walking bout. Only forward or sideways steps when walking along furniture were considered. Steps infants took to pull into a standing position before cruising and stationary steps were not included.

Walking proficiency was assessed for the 24 infants who began walking by 13 months. Walkers were observed on the gridded runner. Trials began with the first frame an infants' foot lifted off the ground and ended with the first frame when both feet stopped moving for 0.5 ss, when the infant fell, or when moved off the mat. Within each walking trial, coders counted the number of continuous steps and the number of 25-cm segments infants crossed. Trials in which infants did not move continuously, stopped, or fell were repeated. Walking proficiency in the form of speed and step length was calculated by measuring the distance (i.e., number of grid lines multiplied by 25 cm) between the first and last step divided by time measured in seconds. Step length for walking was computed by dividing the distance traversed by the number of steps (Adolph et al., 2003). For analyses, the fastest two trials were averaged. Walking speed correlated with step length (Table 3). Walking proficiency and mother-reported walk onset age were correlated corroborating maternal reports.

3. Results

This study documented 11-month-old infants' experiences with supported walking during everyday activities at home. We examined whether and how infants engaged in supported walking, how much they traveled, and whether supported walking experiences predicted the onset and proficiency of independent walking.

Preliminary analyses revealed no differences by infant sex (all *p*s > .05), so data were collapsed across these categories for analyses. We used G*power software version 3.1.9 (Faul et al., 2009) to conduct an *a priori* power analysis for a logistic regression with two predictors and two control variables (α = 0.5). A sample of 50 participants is needed to detect a moderate effect (effect size of 0.63). This sample size is also based on prior work (e.g., Karasik et al., 2012).

3.1. Episodes of Supported Walking Were Frequent

Our first research question was about the nature of infants' experiences with supported walking during everyday activities. Supported walking took on several forms. Mothers typically held infants' hands raised overhead and were positioned in the back of their

Table 3
Walking proficiency correlations.

Variable	1	2	3
1. Walking Speed (cm/s)	—	—	—
2. Step Length (cm)	0.92 * **	—	—
3. Walk Onset Age (months)	−0.56 * *	−0.66 * **	—

* $p < .05$
* * $p < .01$
* ** $p < .001$

infants (Fig. 1A). These bouts of mother-controlled walking were typically mother-initiated; mothers approached infants, took their hands and walked them around the home. Child-controlled walking typically involved infants initiating supported walking episodes by using specially designed push toys (Fig. 1B), stationary furniture (Fig. 1C), or moveable furniture (Fig. 1D).

Supported walking episodes were frequent and most infants (86 %; $n = 43$) engaged in supported walking activities. Seven infants did not display any type of supported walking but used other forms of prone progression during the session. Fig. 2 illustrates individual differences in the distribution of infants engaging in supported walking and proportion of bouts per infant that were mother- versus child-controlled. Of infants who displayed supported walking, 74 % ($n = 32$) engaged in mother-controlled walking and 93 % ($n = 40$) in child-controlled walking. More than two thirds (67 %, $n = 29$) of infants engaged in both types of supported walking and 26 % ($n = 11$) opted for child-controlled walking or mother-controlled walking (7 % $n = 3$) exclusively. No significant correlation was found between mother-controlled and child-controlled bouts ($p > .05$).

During the parent interview, 13 mothers reported that they had not witnessed their infants' cruising and did not specify an onset age for cruising. However, of these 13 infants, 6 infants did display supported walking activities during their observation; these tended to be more mother-controlled than child-controlled. Mothers of the 7 infants who did not display any supported walking activities during the observation confirmed that their infants were not yet cruising and did not specify a cruise-onset date. Overall, infants whose mothers deemed them to be cruisers did not differ from non-cruisers on mother-controlled bouts (*M*s = 3.14 and 3.70, *SD*s = 7.20 and 10.67, respectively, $p > .05$). But cruisers and non-cruisers differed on total supported walking activity because cruisers displayed more child-controlled bouts (*M*s = 11.62 and 0.84, *SD*s = 13.19 and 1.95, respectively, $t(48) = 2.92$, $p < .05$).

At the level of supported walk bouts, variability was high among infants who engaged in supported walking activities. Mother-controlled walking ranged from 1 to 42 bouts ($M = 5.13$, $SD = 9.72$) and child-controlled walking ranged from 1 to 68 bouts ($M = 11.03$, $SD = 12.87$). Proportionally, infants engaged in more child-controlled walking bouts than mother-controlled walking bouts, $t(42) = -4.34$, $p < .001$.

Moreover, infants displayed high variability in accumulated steps and average steps per bout for both types of supported walking

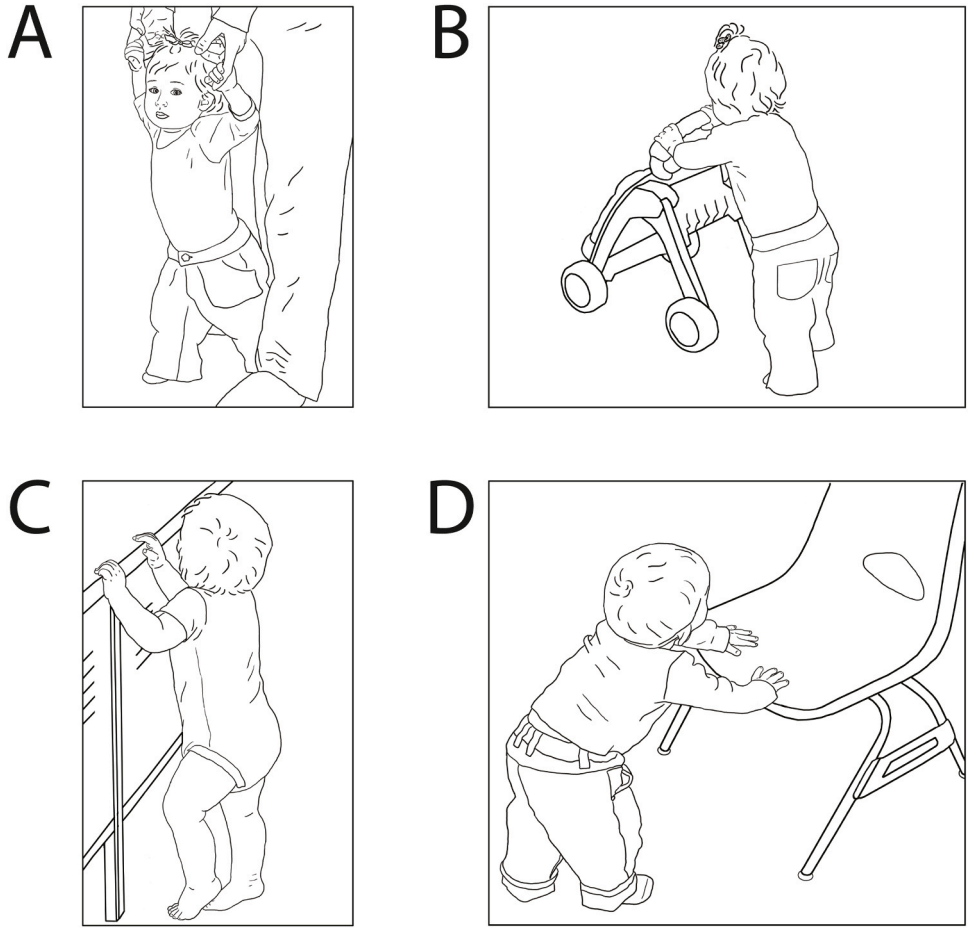

Fig. 1. Line drawings from video files illustrating four types of supported walking: (A) mother-controlled walking with caregivers; (B) child-controlled walking using a push toy; (C) child-controlled walking using stationary furniture; and (D) child-controlled walking using moveable furniture.

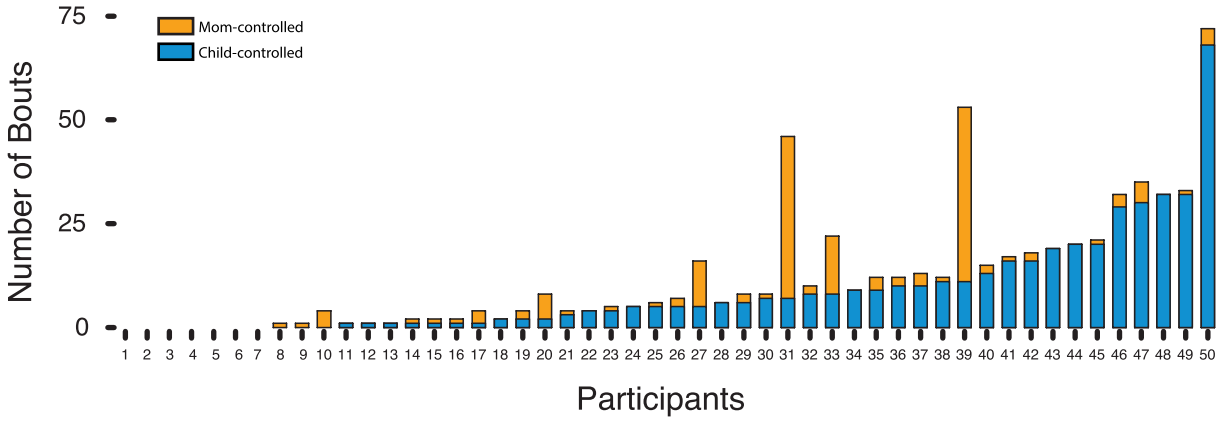

Fig. 2. Distribution of child- and mother-controlled walking bouts. Each bar represents one infant. Data are sorted from infants who demonstrated no supported walking bouts during the session to infants who demonstrated most supported walking bouts.

(Table 4). Mother-controlled walking ranged from 4 to 839 accumulated steps and 4 to 49 average steps per bout. Child-controlled walking ranged from 4 to 808 accumulated steps and 4 to 28 average steps per bout. Given that child-controlled bouts were more frequent than mother-controlled bouts, infants accumulated more child-controlled steps than mother-controlled steps (Table 4). However, infants took more steps per bout when engaged in mother-controlled walking than self-controlled walking. Also, infants took more steps per minute during mother-controlled bouts than child-controlled bouts (Fig. 3, Table 4).

3.2. *Frequency and Type of Supported Walking Predicted Walk Status and Onset Age*

Our second research question was to examine whether the frequency and type of supported-walking experiences related to walking status and onset age. Child-controlled, but not mother-controlled, experience was found to predict whether infants achieved independent walking by 13 months, controlling for crawling and cruising experience, $\chi^2(4, 50) = 31.39$, $p < .001$. A logistic regression analysis was used to predict walking status at 13 moths, with child-controlled and mother-controlled bouts included as predictors and crawling and cruising experience (in days) included as controls. The model accounted for 62.2 % (Nagelkerke R^2) of the variance in locomotor status at 13 months. Only the frequency of child-controlled bouts emerged as a significant predictor of walking status at 13 months in the model (Wald = 6.72, $p < .05$, OR = 1.30). For every one unit increase in child-controlled bouts, there was an expected 1.3 increase in the likelihood of achieving independent walking by 13 months.

Similarly, the frequency of child-controlled bouts, rather than mother-controlled bouts correlated with age of walk onset (Fig. 4, Table 5). The onset age for independent walking was significantly correlated with number of child-controlled bouts, accumulated steps, and average steps per bout, controlling for crawling and cruising experience. Even after removing outliers, the correlations remained significant. Infants who accumulated more child-controlled bouts, steps, and took more steps per bout displayed independent walking at younger ages. Age at walking onset was not related to frequency of mother-controlled bouts, accumulated steps, or average steps per bout, controlling for crawl and cruise experience.

3.3. *Supported Walking Was Not Associated with Walking Proficiency*

Our third research question was to examine whether supported walking related to proficiency once infants can walk independently. Fig. 5 shows that child-controlled walking did not predict walking proficiency (i.e., walking speed and step length). Walking speed was not correlated with number of child-controlled bouts, accumulated steps, and average steps per bout, controlling for crawling and cruising experience (Table 5). Similarly, step length was not correlated with child-controlled bouts, accumulated steps, and average steps per bout (Table 5), controlling for crawling and cruising experience.

Likewise mother-controlled bouts did not relate to walking speed, accumulated mother-controlled steps, or average steps per bout, controlling for crawling and cruising experience. Step length also was not related to mother- controlled bouts, accumulated steps, or average steps per bout, controlling for crawling and cruising experience (Table 5).

Table 4
Differences in the number of steps produced during both types of supported walking.

	Child-controlled Walking		Mother-controlled Walking			
Variable	*M*	*SD*	*M*	*SD*	*t (42)*	*p*
Accumulated Steps	107.00	176.31	91.75	194.88	2.97	<.01
Steps per Bout	7.26	3.98	13.35	10.19	2.04	<.05
Steps per Minute	44.67	19.35	58.15	43.37	2.02	<.05

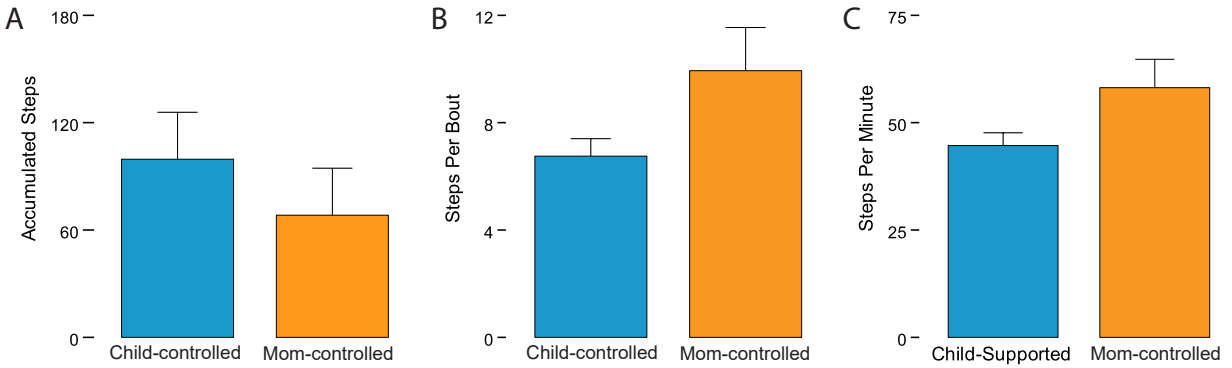

Fig. 3. Bar graphs showing the averages and standard errors for (A) accumulated steps; (B) steps per bout, and (C) steps per minute taken by infants during child-controlled and mother-controlled bouts. Asterisks denote significant differences.

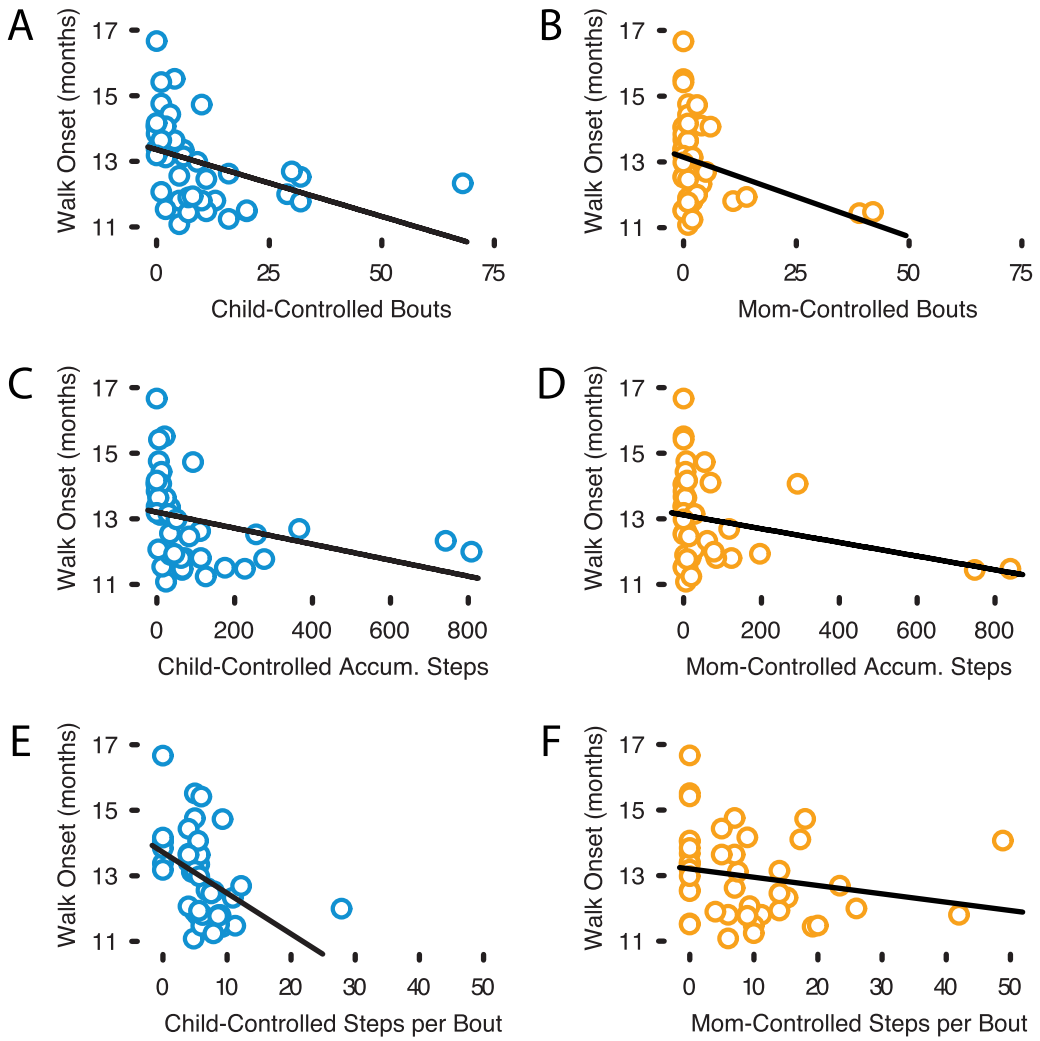

Fig. 4. Scatterplots of child-controlled bouts (A), accumulated steps (C), and steps per bout (E) predicted age at walk onset. But, relations between mother-controlled bouts (B), mother-controlled accumulated steps (D), and mother-controlled steps per bout (F), plotted against walk onset age were not significant. Each symbol represents one infant.

Table 5
Correlations among supported walking experience at 11 months and walk onset age and proficiency.

		Walk Onset (months)	Walking Speed (cm/s)	Step Length (cm)
Variable	*M*(*SD*)	*r*(40)	*r*(19)	*r*(19)
Child-Supported Bout Frequeny	11.03 (12.87)	−.37 *	−.17	−.08
Child-Supported Accumulated Steps	107.00 (176.31)	−.33 *	−.16	−.06
Child-Supported Steps per Bout	7.26 (3.98)	−.39 * *	−.10	−.05
Mother-Supported Bout Frequeny	5.13 (9.72)	−.25	.11	.21
Mother-Supported Accumulated Steps	91.75 (194.88)	−.19	.10	.19
Mother-Supported Steps per Bout	13.35 (10.19)	−.14	−.04	.03

* $p < .05$
** $p < .01$

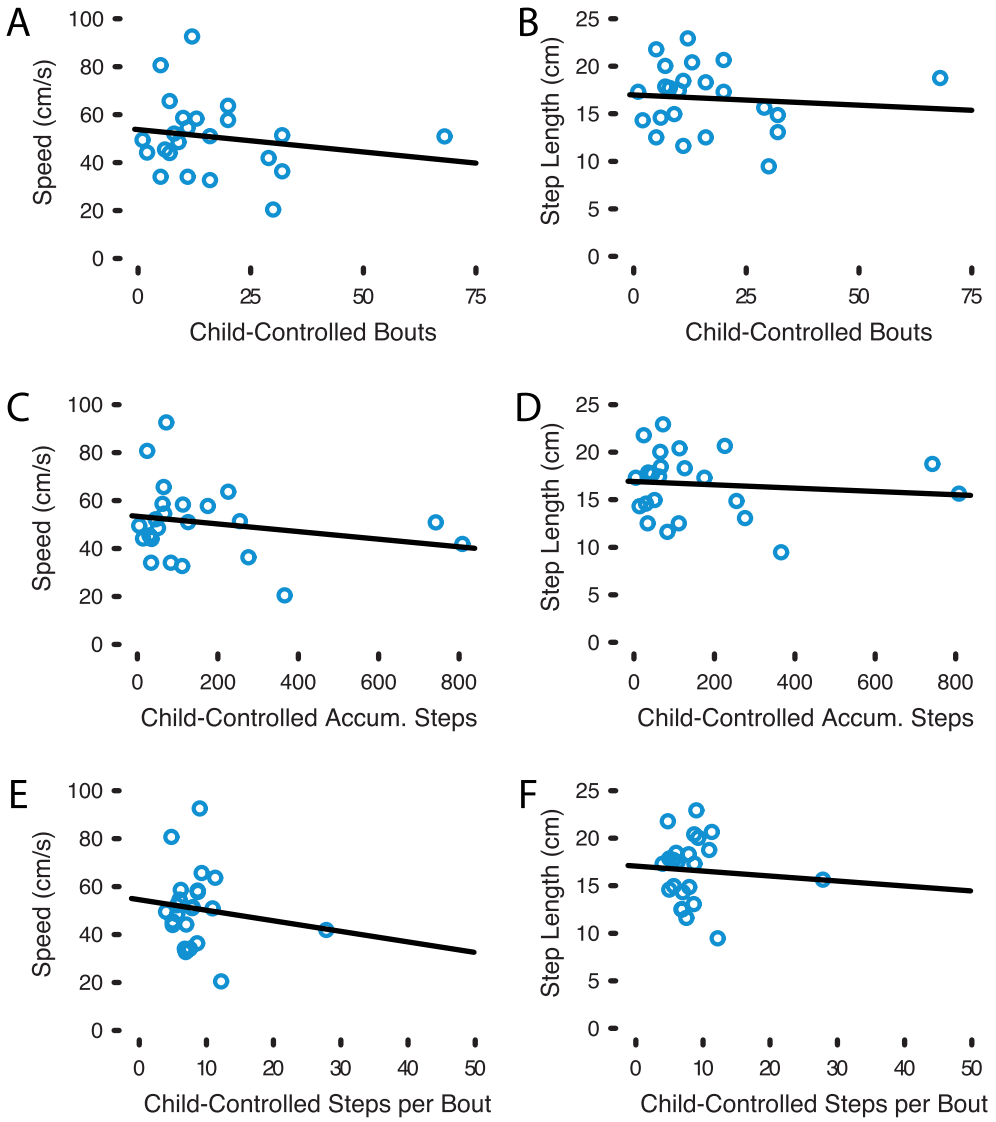

Fig. 5. Scatterplots of walking proficiency (speed and step length) plotted against measures of child-controlled bouts (A-B), accumulated steps (C-D), and steps per bout (E-F). All associations were not significant.

4. Discussion

Researchers have long considered the role of experience in infants' learning and development. In the area of motor development, experience has typically been measured in terms of days since the onset of a particular skill until test date. More recently, researchers have focused on cultural influences and childrearing practices which shape the skills children acquire and the ages at which children acquire them (Adolph & Hoch, 2019; Adolph & Robinson, 2015). In this study, we asked about the nature and frequency of infants' experiences with supported walking in the context of their everyday routines. Previous work points to favorable effects of childrearing practices on infants' motor skills, but little is known about the nature of this experience and its effects.

We observed pre-walking 11-month-olds in their homes with their mothers, focusing on spontaneous instances of supported walking. We examined whether and to what extent supported walking experience predicts independent walking onset and its relation to walking proficiency. We discovered that most infants spontaneously engaged in supported walking and in most cases, it was child controlled. When mothers did support walking, infants' bouts were long and contained faster steps. Notably, supported walking experience uniquely predicted walking status but not proficiency. Infants who engaged in more child-controlled walking acquired independent walking earlier than infants with fewer child-controlled bouts. Despite practice taking upright steps, supported walking experience did not lead to better proficiency of independent walking.

4.1. Role of Mothers in Shaping Infants' Motor Skills

Cross-cultural researchers from Western countries have reported astounding ways that caregivers in non-Western societies support infants' motor development, often using surprising means (for review, see Adolph & Hoch, 2019). But Western childrearing practices also shape infants' skills because childrearing practices provide the context in which infants' skills unfold. Caregivers in the U.S. are particularly mindful of motor skills: looking forward to and documenting these events in baby books, gleefully sharing their infants' accomplishments with family and friends, and often bragging about how early their child attained a given skill. Caregivers have beliefs and expectations that guide how infants are handled, positioned, and where they are situated throughout the day (Karasik & Kuchirko, Dodojonova, et al., 2022). For example, whether families in the U.S. had stairs in their home was related to when infants learned to climb stairs independently and whether parents taught infants to descend stairs (Berger et al., 2007). Infants with stairs in their homes learned to climb stairs earlier than infants without stairs but there was no age difference in when infants learned to descend stairs, suggesting caregivers monitor access and opportunity (Berger et al., 2007). The idea that parents decide whether and when to teach infants about stairs illustrates how childrearing practices shape opportunities for movement and timing of motor skill acquisition.

We found that mothers do support infants' upright locomotion prior to the development of independent walking. However, mother-controlled walking occurred less frequently compared to child-controlled walking. Similar to findings from prior studies in non-Western cultures, mothers directly encouraged walking, likely timing their support to coincide with a developmental window when they believed their infants were ready. Notably, although 25 % of the sample ($n = 13$) had not yet demonstrated cruising, half of this group ($n = 6$) still engaged in mother-controlled supported walking, suggesting that mothers practiced this behavior despite their infants not yet cruising. For the other 75 % of the sample who reported cruising ability, mothers also took part in supported walking by providing access to the floor and allowing infants to use child-designed and adult furnishings for locomotor support.

Whether mothers actively train skills (e.g., Super, 1976; Zelazo et al., 1972a) or indirectly arrange the environment thereby allowing infants to generate their own experiences, caregivers play a contributing role in infants' motor skill acquisition. Our findings do not refute other studies which show positive effects of direct caregiver involvement perhaps because experiences via childrearing practices may depend on the timing of when they are offered. Direct caregiver practice may be relevant outside of the developmental window of the skill. Teaching object skills or stepping behaviors months before skill onset is important and is related to earlier onset of those skills (e.g., Needham et al., 2002). What might infants be gaining from these direct interventions from caregivers? Infants are exposed to the social context of motor skill acquisition. For example, when mothers train infants on objects, infants are hearing mothers label and describe objects in their view; when walked or bounced in their lap, infants hear and see the delight on mothers' faces as they comment on babies' actions. In these interactions, parents inadvertently highlight and support infants' motor behaviors. Indirect supports may be important at the developmental window of when the skill is about to emerge (10–11 months for walking), allowing infants unrestricted time to generate their own practice regiment.

While mother-controlled walking differs biomechanically from independent walking, infants may still benefit from the experience. The act of moving upright on two legs, even with support, mirrors the locomotion of adults and others in the infant's environment. This practice could help infants adapt to an upright posture and the associated perceptual information. The social aspects of learning to walk are significant. When mothers support their infants' balance and posture during walking, they often encourage, praise, and vocalize excitedly. These interactions can be motivational and may reinforce infants' efforts, contributing to the learning process. The supported walking experience may help infants build muscle strength and coordination in their legs, as well as improve their balance control. These skills are crucial for independent walking and could be enhanced through the social and physical support provided by mothers.

4.2. Role of Active Infants

Infants actively contribute to their own learning, gaining from the movement opportunities provided by caregivers. They accumulate extensive practice, as seen in the numerous child-controlled bouts they initiate when given unrestrictive movement opportunities. The episodes of supported walking that infants generate are linked to the timing of their acquisition of independent walking,

indicating the significance of practicing movement and supporting their own balance in the process (e.g., Held & Hein, 1963). As mother-controlled bouts typically stretch over longer durations and encompass mother steps, it is conceivable that mothers haul infants around, steadying their balance as infants cling on, taking mincing steps to keep pace. Perhaps because of the differences in balance control, it is the child-controlled bouts that contributed to independent walking, highlighting the importance of the type of experience rather than simply accumulated experience. This aligns with research showing that self-produced stepping leads to earlier walking onset compared to mother-facilitated experiences (Zelazo et al., 1972). While passive motor practice can advance development, active engagement by the infant is more effective.

Supported walking experience has been liked to walking status but not necessarily to improving walking skill. This finding aligns with previous research suggesting that practice specific to a particular skill is essential for its advancement. It highlights the distinction between progress in supported walking and independent walking. Mastering balance and forward propulsion in one posture does not necessarily lead to proficiency in another posture (Adolph, 2000).

4.3. Limitations and Future Directions

Three important limitations should be noted. First, we should not conclude that mother-controlled experiences are ineffective. It is possible that to observe effects of maternal handing, mothers would needed to support infants' upright movement for longer durations and more frequently. Given the at-home setting of the study, our goal was to examine whether mothers and infants spontaneously engage in supported walking before independent walking begins—and we found that they do. Notably, there was greater variability in child-controlled walking compared to mother-controlled walking. The spontaneous nature of these activities may have led to less variability in mother-controlled walking, which could explain the weaker correlations with walking outcomes. A future study could investigate spontaneous supported walking from an earlier developmental point to determine whether mothers engage in direct training outside the typical developmental window for walking. One study documented patterns of infant locomotion during the two months leading up to walk onset (Schneider & Iverson, 2023). Since infants were tracked relative to their walk onset age, their ages at each session varied. The researchers found that in the two months before walking began, the frequency of mother-supported walking remained low and stable compared to other forms of locomotor activity.

Second, unlike other studies, we did not measure overall movement experience but focused solely on supported walking. It is important to note that the seven infants who did not contribute to supported walking data were all crawlers and demonstrated prone movement during their sessions. While we effectively captured the quality of experiences specific to supported walking, this approach does not allow us to assess the relative contribution of overall self-generated locomotion (crawling combined with supported walking) versus mother-controlled locomotion in predicting independent walking.

Third, our data may be limited since observations were conducted on a single day, albeit for an extended hour. We assume that the behaviors observed during this hour reflect typical patterns across other weeks. Additionally, we did not collect anthropometric data in the families' homes. However, other studies suggest that experience is a better predictor of walking skill than body dimensions (Adolph et al., 2003).

4.4. Conclusions

To understand the relative role of caregivers in infants' acquisition of new motor skills and whether and how infants take advantage of opportunities for learning offered by caregivers, we observed infants and mothers at home, where learning and development typically occurs. Caregivers' expectations—whether to directly practice skills—and childrearing practices—use of containments, access to the floor—in part, explain cultural differences in motor development. Findings confirm experimental reports about enhanced practice. By examining supported walking in the home setting, we highlight the variability and range of experiences in infants' everyday lives and, in turn, the nuanced effects these have on specific motor skill trajectories. Moreover, naturalistic observations extend lab-based findings by revealing the nature of experience supported and organized by caregivers in everyday life.

Ethics Statement

The present study was conducted according to guidelines laid down in the Declaration of Helsinki, with written informed consent obtained from a parent or guardian for each child before any assessment or data collection. All procedures involving human subjects in this study were approved by the University Integrated-IRB at the College of Staten Island (2015–1286-CSI), City University of New York.

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Declaration of Competing Interest

The authors declare no conflicts of interest with regard to the funding source for this study.

Data availability

Data will be made available on request.

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