EXTRINSIC FACTORS THAT INFLUENCE TUMMY TIME BOUT LENGTH AND FREQUENCY IN 6-MONTH-OLD INFANTS; A VIDEO-CODED SNAPSHOT

By

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ABSTRACT

EXTRINSIC FACTORS THAT INFLUENCE TUMMY TIME BOUT LENGTH AND FREQUENCY IN 6-MONTH-OLD INFANTS; A VIDEO-CODED SNAPSHOT

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Introduction and Purpose: Tummy time (TTIME) is position that involves prone placement of an infant to promote motor, social, and cognitive development, as well as provide a feasible physical activity modality. Adequate TTIME is vital for the timely growth and maturity of an infant, but there is limited research into the quantity and quality of TTIME needed for optimal developmental outcomes. The current investigation uses in-home videos to analyze specific environmental characteristics for their influence on TTIME bout length and frequency.

Methods: Two groups of 6-month-old infants (n=11). Instruction (receiving TTIME intervention and advice), and non-instruction groups. Independent samples *t*-tests and/or Mann Whitney U tests were computed for each stream between groups.

Results: Significant group differences in frequencies for Caregiver Actions (CGA) (Physical Touch (PT), t=2.866, p=.034; Reposition (R), t=2.369, p=.042). Significant group differences in durations for CGA (PT, U=.000, p=.004; R, p=.034; CGX, U=3.50, p=.030). Significant group differences in % of total TTIME duration for CGA (CGX, U=3.50, p=.030) and Toys (TM, t=2.464, p=.036).

Conclusions: Further research must be done to investigate quality methods of TTIME support that are feasible for families to implement. This study serves as a useful first step in identifying initial environmental constructs that may impact TTIME bout length and frequency in 6-month-olds.

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KEY TO ABBREVIATIONS

AAP	American Academy of Pediatrics
ANCOVA	Analysis of Covariance
ANOVA	Analysis of Variance
ASD	Autism Spectrum Disorder
BMI	Body Mass Index
CG	Caregiver
CGA	Caregiver Actions
CGP	Caregiver Proximity
CGX	Caregiver No Actions/Off Camera
CNS	Central Nervous System
DP	Deformational Plagiocephaly
DS	Down syndrome
DST	Dynamic Systems Theory
DV	Dependent Variable
FBT	Flat Blanket or Towel
IPD	Infant Positioning Device
IV	Independent Variable
PA	Physical Activity
PI	Ponderal Index
PT	Physical Touch

PU	Pick Up
R	Reposition
SIDS	Sudden Infant Death Syndrome
TM	Toy Manipulation
TNA	Toys Not Available
TOR	Toys Out of Reach
TWR	Toys Within Reach
TTIME	Tummy Time

CHAPTER 1

Introduction & Review of Literature

Tummy time (TTIME) is an exercise that involves placing an infant in the prone position (on his or her stomach) for playtime while awake (Pathways, 2015). TTIME can be done in many ways, with little training. There are documented benefits to participating in tummy time, as well as evidence-based consequences to non-participation. There are also known links between developmental systems in infancy that have implications for later life, and adoption of healthy habits in infancy is of vital concern. However, 26% of families in the United States reported never putting their infants in tummy time, (Mildred et al., 1995; Koren et al., 2005). Though this is a simple, inexpensive activity for families to incorporate into their daily lives, it seems that barriers to successful implementation remain.

Benefits and Consequences

Anatomical. Position choice in infancy can affect anatomical development. Infants who sleep in the supine position (on their backs) are less likely to be put in the prone position while awake (Monson et al., 2003; Mildred et al., 1995), which may increase their risk for Deformational Plagiocephaly (DP). DP is a condition in which flat spots develop on an infant's skull. These flat spots occur due to prolonged pressure in one location, usually on the back or side of the head (Lueng et al., 2017). Increased supine-lying has been shown to result in greater incidence and severity of DP at 9 weeks (Leung et al., 2017). Additionally, a review of the literature suggests that DP may be linked to negative physical and psychosocial effects later in life, including peer teasing, and poor self-perception (Rekate, 1998; Bialocerkowski et al., 2005; Collett et al., 2005).

Fortunately, DP is preventable. The best way to combat DP is to increase TTIME throughout the day (Kennedy et al., 2009). One study showed that infants with severe DP who received TTIME therapy beginning at 7 weeks showed a 46% reduction in severity at 6 months (van Vlimmeren et al., 2008); indicating that TTIME is helpful both as a preventative and as a treatment for DP.

Motor. TTIME is a great avenue by which to provide opportunities to strengthen neck, back, arm and trunk muscles in early infancy. These muscles are vital for achievement of early motor skills that require extension against gravity; such as an infant holding their head up to 45 degrees while in prone. Infants with greater exposure to TTIME achieve certain motor milestones (ie: rolling from front to back, sitting supported, prop sitting, belly crawling, unilateral reaching, pincer grasp, sitting for 60 seconds and holding an object, four-point crawling, pulling to stand, standing up from the floor, and walking independently) at earlier ages than peers with less TTIME exposure (Wentz, 2016; Salls et al., 2002; Davis et al., 1998). Foundational fine and gross motor skills such as these are instrumental for overall development; and timely attainment of initial skills is essential to facilitate later skill development. One study showed that children with delayed (or less developed) fundamental motor skills (FMS) engage in less physical activity than their age-matched peers with greater FMS competency (Williams et al., 2008), reinforcing the need for skill proficiency beginning in infancy.

Physiological. Physiological differences exist between infants who participate in TTIME and those who do not. Infants who participated in a tummy time intervention consisting of daily TTIME exercise had lower Ponderal Index (PI) measures in the first year of life when compared to an untrained group of age-matched peers (Wentz, 2016). PI provides a measure of leanness, and is computed by dividing weight in kilograms by height in meters cubed. According to Ekelund (2006), PI is the preferred pediatric body composition index because it is not as highly correlated with length as BMI, which can cause distortions in long, lean infants (Ekelund et al., 2006; Wentz, 2016). Because infants with greater PI have been shown to display higher BMI as young adults (Rasmussen & Johansson, 1998), it is of vital importance to investigate promising methods of PI reduction in infancy, such as TTIME.

Physical Activity (PA). Though various outreach programs have initiatives to promote infant PA, there are still no evidence-based PA amount or type recommendations available (Ketcheson et al., 2017). The organizations that do have PA recommendations state that infants should spend time on their tummy to ensure timely development of early movement milestones (Wojcicki et al., 2010; Tremblay et al., 2012, SHAPE America, 2009; AAP, 2011). TTIME is a position that leaves the limbs free to explore, while also providing opportunities for neck and trunk strengthening (Wentz, 2016; Pathways, 2015). It is an exercise that engages many muscles of the body, and does not require extensive space or expensive equipment; and is a simple way to incorporate PA into a daily routine for infants regardless of socioeconomic status, gender, age, disability, or other typically-limiting factors.

Social. There may also be advances to social development from participation in tummy time (Wentz, 2016; Fogel et al., 1999). Because TTIME is a position that requires adult supervision to be safe, this exercise is rife with opportunities for social interactions between the infant and caregiver, infant and siblings, pets, and the environment (AAP, 2017). The Center for the Developing Child at Harvard states that when caregivers are sensitive and respond appropriately to social bids from infants, it strengthens neural connections in the child's brain that support the development of communication and social skills. TTIME is a prime example of an interaction in which the caregiver has many opportunities to respond to their infant's gestures and signals, thus bolstering those networks.

Intersections

PA, Motor, BMI, TV time. Physical activity and BMI are frequently related, but relationships between motor abilities, TV-watching time, BMI, and PA also exist. A recent study found that infants who have reduced PA during infancy are three times more likely to spend fewer minutes in moderate-to-vigorous, and vigorous activity as toddlers (Prioreschi et al., 2017). Further, children who had more opportunities to be active (ie: increased floor time, greater time spent unrestrained) demonstrated higher levels of activity than their peers with fewer opportunities (Prioreschi et al., 2017). Sanchez and colleagues (2017) showed that fine and gross motor delays in infancy resulted in a lowered chance of attending a sports club (participating on sports teams) at age 7. They also showed that children with delayed gross motor milestones in infancy spent less time in moderate-to-vigorous PA and more time in sedentary activity in childhood (Sanchez et al., 2017).

Furthermore, the authors found that children with lower fine motor scores as infants spent more time watching TV as 7-year-olds (Sanchez et al., 2017). Prioreschi and colleagues

(2017) also reported links to TV watching in 3- to 24-month-old infants. There was a positive association between sedentary time and BMI z-scores; for every 10 min spent in front of the TV, an approximately a +0.05 increase in BMI z-score was calculated (Prioreschi et al., 2017). These studies suggest that establishment of certain behaviors during infancy may have adverse health outcomes later in life.

Motor and Cognition. There have been suggested links between motor ability and cognition for decades (Piaget, 1953). Recent research investigating the link between motor and cognitive abilities suggests that early gross motor ability is a strong predictor for cognition at school-age for working memory and processing speed (Piek et al., 2008). Another study showed that infants who scored better on a number-sense task at 6-months scored better on math assessments at 3.5 years (Starr et al., 2013). Serdarevic and colleagues (2016) reported that infants with lower neurodevelopment scores from 9-20 weeks displayed decreased abilities in mental rotation, immediate memory, shifting, and planning at 6 years. Interestingly, these relationships are more pronounced in the overweight and obese population. One study showed that obese infants with moderate-to-severe motor and cognitive delays at 9-months were three times more likely to have delays that persisted into toddlerhood than their normal-weight peers with similar delays at 9-months (McManus et al., 2016). Cataldo and colleagues (2016) found similar results; obese infants were more likely to demonstrate motor and cognitive deficits both at baseline (~9 months) and at age 2 than their normal-weight peers.

Obesity (during infancy) with Obesity (later in life). Obesity rates have increased to disproportionate amounts in the past decades (Cunningham et al., 2014). Children in the highest quartiles of weight-for-length (WFL) z-scores at birth and 6-months have a predicted obesity prevalence rate of 40% compared to 1% for those in the lowest quartiles (Taveras et al., 2009). Evidence suggests that the higher the rate of weight gain is for children in the first few years of life, the greater the risk is for becoming obese as they age (Baird, 2005; Monteiro & Victora, 2005). Furthermore, infants with a BMI greater than the 85th percentile have a 2.5 times greater risk of being severely obese by age 6 (Smego et al., 2017). Adolescent obesity links to birth weight were found in a study by Cunningham and colleagues; overweight 5-year-olds with a birth weight of 4000g or more were 5.1 times more likely to be obese at age 14 than normal-weight 5-year-olds with the same birth weight (Cunningham et al., 2014). These shocking numbers elucidate the obesity epidemic our society is currently facing; steps at remediation must be taken in order to prevent global consequences.

TTIME and Restraint. One proposed avenue to prevent obesity is to promote healthy lifestyle choices and habits early in life; a great way to do this is via TTIME, however it seems that a large barrier to TTIME participation is the reliance on infant positioning devices (IPDs). IPDs are those designed to position the infant in a specific manner while also limiting movement in one or more joints. Often IPDs support the infant's trunk, head and neck. Examples include infant swings, bouncy chairs, or sitting devices like a Bumbo™. These devices are more commonly used in early infancy (ie: 0-3 months) when the infant's head and trunk control are less developed (Hauck, 2012). However, one study reported that 6-month-old infants spent an average of only 10 minutes in TTIME, but an average of 150 minutes being restrained in some way throughout the day (Prioreschi et al., 2017). Curiously, evidence suggests that there has been an increase of IPD use in recent years, with average households in the U.S. claiming ownership of three or more IPDs (CanDoKiddo, 2014). A daycare study by

Myers and colleagues (2006) showed that infants 2-6 months of age spent an average of more than 56% of their day in IPDs, with infants 2-3 months spending almost 73% of their time in IPDs. Conversely, this study reported that floor time for infants 2-6 months was only about 11.5% of their day on average, again even more striking was that 2-3-month-olds only spent 4% of the day on the floor (Myers et al., 2006). These shocking IPD-use levels in the daycare study indicate that there is also a need for research in that setting, in addition to recommendations for in the home.

Research has shown that links between PA and floor time exist; infants that have greater exposure to floor time exhibit higher levels of PA as toddlers (Prioreschi et al., 2017). Another study found significant, negative correlations between time in devices (ie: exersaucer, highchairs, infant seat) and scores on motor assessments at 8-months of age (Abbott & Bartlett, 2000). This study also found that total time in devices was inversely correlated to motor scores. These multi-domain relationships highlight the need for evidence-based activity guidelines for infants to prevent unwanted consequences from too much time spent in IPDs, and too little floor time, both in the home and child care settings.

Impact of the Environment

The space available for exploration may dictate both the quality and quantity of learning that occurs. For example, an infant given very little space and ability to move their limbs (such as in a playpen or positioning device) may be at a disadvantage when compared to an infant who is given much more space to roam (such as a living room floor with no safety hazards). As discussed above, infants with greater floor time demonstrate higher levels of PA and those with more minutes of IPD use have lower motor scores (Prioreschi et al., 2017; Abbott & Bartlett, 2000). However, these results warrant further exploration to glean an understanding of the possible underlying mechanisms.

Dynamic Systems Theory (DST). First proposed by Thelen in the early 1990’s, DST is a theory that transcends earlier singular-cause developmental theories. Prior to its inception, information processing and maturational theories were the most commonly accepted viewpoints in terms of developmental sequences. Information processing theory posits that developmental milestones occur as the central nervous system (CNS) matures; instructions for the abilities were encoded during gestation, and the milestones will occur at pre-determined times concurrent with the functional level of the CNS (Simon, 1962). Maturational theory indicates that the maturation of the brain, specifically the myelination that occurs in the motor cortex, is solely responsible for the production of new motor abilities; which occur in a specific, unyielding sequence (Gesell, 1933). This theory suggests that as myelination progresses throughout the motor cortex, a stimulus is able to reach the muscular system to effect a motor command, whereas before this myelination, the stimulus was still occurring, but it was unable to reach the end-stage to produce an action (Gesell, 1933). Both of these theories attribute individual differences in the timing and tempo of milestone achievement to innate, fixed causes, either the genetic code, or the rate at which maturation of the brain naturally occurs within that individual.

In addition to these intrinsic factors, DST proposes that individual differences in rate and order of milestone attainment may also be attributed to modifiable elements of the child’s experiences; such as muscle strength, exposure to the activity, environmental characteristics, and motivation (Thelen, 1989). The dynamic nature of DST allows for greater flexibility of how and why certain behaviors may or may not occur; for example, why some infants never crawl, but instead progress directly to walking. Perhaps those children were mainly exposed to toys on raised surfaces, so they were motivated to be upright rather than down on the floor; or maybe their home had scratchy carpet or hardwood floors that made time on their knees undesirable. DST states that external features such as these may be responsible for the non-traditional motor trajectory that some children experience.

Through numerous experiments, Thelen and colleagues consistently paid tribute to the impact that different environmental factors play on development and task completion. Early infant stepping research showed that when infants were exposed to altered environments (supported in waist-deep water), previously-absent stepping reflexes reemerged, indicating that exposure to varied environmental circumstances can adjust motor behavior. In another instance of task constraint manipulation, ankle weights were added to infants with intact newborn stepping reflexes causing the behavior to halt due to the lack of muscle development needed to counteract the added load (Thelen, 1989). These examples provide evidence of how task context can be modified to elicit different outcomes using extrinsic mediums.

In addition to environmental influences, DST also proposes that the interaction of multiple body subsystems (ie: motor, cognitive, social) are what facilitate development (Thelen, 1989). Thelen states that all contributions are worthy and no single subsystem is more important than another, but rather that they self-organize based upon individual differences (Thelen, 1989). For example, as discussed previously, an infant who is exposed to intensive TTIME therapy may experience advances to motor abilities (Wentz, 2016). These motor advancements may in turn stimulate cognitive and social development (Thelen, 1989; Wentz, 2016). The reverse is also feasible, for children with delays in one domain, subsequent systems may also be impaired (Thelen, 1989; Wentz, 2016; Piek et al., 2008; Starr et al., 2013; McManus et al., 2016). These relationships have implications for early intervention and should be considered in study design.

Application to TTIME. DST can be applied to the activity of tummy time in both forms described above: interaction of subsystems and influence of the environment. Because TTIME primarily promotes the motor domain, it is traditionally viewed as a resource to support motor-related impairments. However, using DST as a framework, TTIME may be a useful first step in treating or preventing multi-domain difficulties in populations with other considerations (ie: cognitive, physical activity, social delays), such as individuals with Down syndrome (DS) or Autism Spectrum Disorder (ASD). For example, use of a motor-stimulating exercise such as TTIME could provide individuals with increased motor abilities, and thus improvement of sister systems such as physical activity involvement, cognitive processing, and social interactions could be conceivable.

Because TTIME can be done in multiple locations with varying characteristics, it allows for investigation into environmental factors that influence task completion. For example, different rooms may result in different TTIME experiences – the soft living room carpet versus a cold tiled kitchen floor, or lying on dad's chest in bed versus on a blanket in the grass outside. Each scenario listed provides different tactile and experiential benefits, but individuals may prefer certain settings over others. These individual differences evident in location choice can also be seen in surface and toy use during TTIME. Using a fluffy blanket on top of hardwood floors adds a level of comfort that infants may prefer over a hard, unwelcoming surface. Conversely, depending on the infant's personal resources (such as muscle strength, locomotion, and motivation), a hardwood floor may actually allow further environmental exploration; by pushing up on arms and scooching backward, an infant may be able to access a greater amount of toys or interesting surfaces than if they were "stuck" on a soft, non-slippery surface such as a fluffy blanket. Investigating individual preferences and the motor and exploration outcomes that result from specific choices is of the utmost importance in the search for useful TTIME positioning recommendations.

Available Tummy Time Research

To date, most TTIME research has investigated the appropriate *quantity* of the exercise needed for timely motor development, necessary physical activity, proper socialization, and to prevent DP (Dudek-Shriber & Zelazny, 2007; Wentz, 2016). As described in the Benefits and Consequences sections, these are all valid and important areas to focus on. However, there is an obvious gap between current recommendations and how many TTIME minutes families actually achieve. Caregiver knowledge of TTIME recommendations, positions, and criteria for safe use are severely lacking (Zachry & Kitzmann, 2011; Koren et al., 2011). Furthermore, limited education further complicates caregivers' jobs of ensuring their infant receives optimal TTIME exposure.

Recommendations. The American Academy of Pediatrics (AAP) has released several recommendations in the last two decades that do not fully provide beneficial standards for TTIME implementation. In 1992, the AAP initiated the Back to Sleep Campaign (BTSC) aimed at reducing the incidence of Sudden Infant Death Syndrome (SIDS) by instructing caregivers to only place their infants to sleep on their back or side. The campaign was successful, with a 50% reduction in SIDS cases by 2010; however, a reciprocal relationship between SIDS cases and incidence of DP and delayed motor skills was instigated (Trachtenberg et al., 2011). In 1996, the AAP released a statement that infants should only be placed to sleep on their backs on a firm sleep surface without any suffocation hazards, and that side-sleeping was no longer recommended; four years later they added that side-sleeping had been shown to increase the risk of SIDS. In 2008, the AAP recommended that infants get 3-5 minutes of TTIME, working up to three times each day; just three years later, the organization changed this recommendation to "spend some time on their tummies each day for developmental reasons", the reduction perhaps due to the large gap in available evidence-based quantitative recommendations at that and the current time (AAP, 2011; Wentz, 2016). Since 2017, the AAP website has linked to the Pathways.org website, which recommends that TTIME should begin immediately once home from the hospital, and for infants to work up to 60 minutes of TTIME each day by 3-months of age.

The AAP recommendations over the last twenty years unfortunately do not provide a very useful pathway for caregivers or clinicians to base their TTIME dosage on, thus highlighting the need for further research in this area.

Position Advice. Pathways.org, a non-profit in Chicago, Illinois, provided the first set of AAP-endorsed recommendations for TTIME position and support advice in 2017. The website provides helpful tips for caregivers of infants 0-6 months; including videos of different TTIME positions, soothing strategies, and engaging activities. The organization also identifies age-specific motor, cognitive, and social milestones for typically-developing infants (Pathways, 2018).

Safety. Both the AAP and Pathways necessitate that TTIME must be wakeful. If infants fall asleep in TTIME, both organizations recommend for caregivers to roll them onto their back and move them to a firm sleep surface. Both also state to avoid loose, or padded surfaces on which an infant can suffocate while doing TTIME. They say not to do TTIME on raised surfaces to prevent a risk of falling, and to supervise the entirety of the exercise.

Beginning to Investigate Quality Factors. DST suggests that the role of the environment is a large factor in the success of motor functioning and goal-directed behaviors, however little research is available. One study (Guidetti, 2011) investigated the use of positional support during TTIME on bout length. The author found that time in prone was greatest with the use of a mini Boppy™ support pillow, and that the first of three trials garnered the best participation for 3-month old infants. This study in conjunction with DST hints that changing the environment to fit the child's personal resources may increase successful outcomes. However, studies of this nature have not been duplicated, nor has the AAP released any positional aid advice for TTIME use.

"Missing the Mark"

Though recent recommendations are clearly explained, and strategies for implementation are now available, it seems that families are still struggling to be successful with TTIME. One factor that is often cited is infant dislike of the position (Graham, 2006; Salls et al., 2002; Dudek-Shriber & Zelazny, 2007). The author states that infants often exhibit crying, fussing, or other forms of distress while in TTIME, which ultimately causes the caregivers to pick them up (Graham, 2006). Another problem caregivers cite is finding time to accrue many minutes in their already-busy lives (Wentz, 2016; Koren et al., 2010). And although the exercise is safe (when following all instructions mentioned in the Safety section above), some parents still report feelings of uneasiness when placing their infants in TTIME (Davis et al., 1998; McQueen et al., 2013; Koren et al., 2010).

Lastly, a global lack of parental education on infancy practices may contribute to the lack of TTIME participation. One study reported that mothers did not know what types of exercise their infants needed, and counted activities like bath time, feeding, and changing as the main forms of exercise for an infant (McQueen et al., 2013). Prioreschi and colleagues (2017) asked mothers about activities their infant participated in throughout the day; mothers reported specific positions within active and restrained time (ie: floor time, outside time, PA with mom, playing with older babies, playing alone, time in various IPDs, TV, etc...). Overwhelmingly, time restrained made up an average of 150 minutes, while tummy time consisted of only 10 minutes (Prioreschi et al, 2017).

Because TTIME is a primary PA modality for infants, ensuring adequate knowledge of the exercise is vital to successful use. In a postpartum interview, only 15% of mothers reported having been instructed to place their infant on his/her tummy while awake (Koren et al., 2010). 45% of mothers received zero information about positioning for wakeful play (Koren et al., 2010). Furthermore, 25% of parents had no knowledge of the AAP’s 2005 TTIME recommendations, and a quarter of those did not know there were consequences to not doing

TTIME (Zachry & Kitzmann, 2011). This points to a large gap in the dissemination of TTIME guidelines and support that should be more readily available to families.

Next Steps

The usefulness of TTIME as a preventative or treatment for a multitude of conditions (delays in motor, cognitive, social domains; DP; physical activity promotion; DS and ASD) is unparalleled. The current quantitative TTIME and physical activity recommendations available need support from evidence-based studies; and there needs to be greater investigation into quality factors that facilitate TTIME success. The current proposal aims to incorporate the framework of DST into an observational, home-video analysis of environmental factors that occur during TTIME practice. The purpose of this research is to investigate the impact of caregiver proximity, infant-caregiver interactions, use of toys, surfaces, and locations on the bout duration and frequency of TTIME in two groups of 6-month-old infants; a group that received TTIME instruction, and a group that did not. The translational goal of this study is to provide initial evidence-based findings that may inform parents, caregivers, childcare settings, and pediatric practitioners (pediatricians, physical therapists, occupational therapists) of helpful strategies for TTIME implementation in order to increase successful use of the activity.

Specific Aims.

Aim 1: Examine group differences in duration and frequency of tummy time bouts.

Aim 2: Examine group differences in ***caregiver proximity*** during TTIME.

Aim 3: Examine group differences in ***infant-caregiver interactions*** during TTIME.

Aim 4: Examine group differences in ***toys, locations, and surfaces*** during TTIME.

CHAPTER 2

Manuscript

INTRODUCTION & REVIEW OF LITERATURE

Tummy time (TTIME) is an activity that involves placing an infant in the prone position (on his or her stomach) for playtime while awake (Pathways, 2015). There are evidence-based benefits to participating in tummy time, as well as documented consequences to non-participation. There are also accepted interactions between developmental systems in infancy that have repercussions for later life. Despite these concerns, 1 in 4 families in the United States reported never putting their infants in tummy time, (Mildred et al., 1995; Koren et al., 2005). Though this is a simple, inexpensive activity for families to include in their daily lives, it seems that obstacles to successful participation remain.

Benefits and Consequences

Anatomical. Infants who sleep on their backs (in the supine position) are less likely to be put in prone while awake (Monson et al., 2003; Mildred et al., 1995), which may heighten their risk for Deformational Plagiocephaly (DP). DP is a condition in which flat spots develop on an infant's skull. These flat spots occur due to prolonged pressure in one location, usually on the back or side of the head (Lueng et al., 2017). Fortunately, the best way to prevent or fight DP is to increase TTIME throughout the day, and activity that also promotes motor skill practice (Kennedy et al., 2009).

Motor. TTIME provides a great opportunity for infants with and without DP to strengthen neck, back, arm and trunk muscles in early infancy. These muscles are necessary for attainment of early motor skills that require extension against gravity; such as an infant holding their head up to 45 degrees while in prone. Infants with more experience in TTIME achieve certain motor milestones (ie: rolling from front to back, sitting supported, prop sitting, belly crawling, unilateral reaching, pincer grasp, sitting for 60 seconds and holding an object, four-point crawling, pulling to stand, standing up from the floor, and walking independently) at earlier ages than peers with less TTIME practice (Wentz, 2016; Salls et al., 2002; Davis et al., 1998). Introductory fine and gross motor skills such as these are influential for global development; and timely attainment of early skills is vital to enable later skill development and allow involvement in peer experiences.

Physiological. Infants involved in a tummy time intervention consisting of daily TTIME therapy had lower Ponderal Index (PI) measures in the first year of life when compared to an untrained group of age-matched peers (Wentz, 2016). Because infants with greater PI have been shown to display higher BMI as young adults (Rasmussen & Johansson, 1998), it is of the utmost importance to study promising methods of PI reduction in infancy, such as TTIME.

Impact of the Environment

The space available for exploration may dictate both the quality and quantity of learning that occurs. TTIME can be done in a variety of settings, but does require an environment conducive to movement. For example, TTIME cannot be done while using an Infant Positioning Device (IPD) because these apparatuses (ie: infant swing, carseat, or stroller) restrict movement in order to ensure the infant is secure. TTIME is best done in a manner that allows the infant to explore their environment with no safety hazards; for example, lying on a colorful blanket on the living room floor with caregiver supervision and toys available. Research has shown that infants with greater floor time demonstrate higher levels of PA and those with higher levels of IPD use have diminished motor scores (Prioreschi et al., 2017; Abbott & Bartlett, 2000). These results highlight the benefits of infant-directed exploration of the environment and the repercussions to use of restrictive gear; constructs that are rooted in developmental theory.

Dynamic Systems Theory (DST). First proposed by Dr. Esther Thelen in the early 1990's, DST is a theory that surpasses earlier singular-cause developmental theories. Prior to its inception, information processing and maturational theories were the most commonly accepted positions in terms of developmental trajectories. Both of these theories accredit individual differences in the timing and tempo of milestone achievement to inborn, biologically-determined triggers, either the genetic code, or the rate at which maturation of the brain (CNS) naturally occurs within that individual (Gesell, 1933; Simon, 1962).

In conjunction with these intrinsic factors, DST proposes that individual differences in rate and sequence of milestone achievement may also be attributed to flexible components of the child's experiences; such as personal resources (ie: muscle strength), experience with the activity, environmental features, and motivation (Thelen, 1989). The dynamic nature of DST allows for greater adjustability of how and why specific behaviors may or may not occur; for example, why some infants never crawl, but instead progress directly to walking.

Application to TTIME. DST can be applied to the activity of tummy time specifically in terms of the influence of the environment. Because TTIME can be done in various locales with changeable characteristics, it allows for examination into environmental factors that may impact task achievement. For example, different rooms may result in different TTIME experiences – the soft living room carpet versus a cold tiled kitchen floor, or lying on dad's chest in bed versus on a blanket in the grass outside. Each situation depicted affords different tactile and experiential benefits, but individuals may prefer certain settings over others. These individual differences apparent in location choice can also be seen in surface and toy use during TTIME. Using a fluffy blanket on top of hardwood floors adds a level of comfort that some infants could prefer over a hard surface. Conversely, depending on the infant's personal resources (such as muscle strength, locomotion, and motivation), a hardwood floor may actually allow further environmental exploration; by pushing up on arms and scooching backward, an infant may be able to access a greater amount of toys or interesting surfaces than if they were "stuck" on a soft, non-slippery surface such as a fluffy blanket. Exploring individual preferences and the motor and exploration outcomes that result from particular choices is of vital importance in the search for valuable TTIME positioning recommendations.

Available Tummy Time Research

Recommendations. As of 2011, the American Academy of Pediatrics (AAP) recommends that infants "spend some time on their tummies each day for developmental reasons" (AAP, 2011; Wentz, 2016). In 2017 the AAP website added a link to the Pathways.org website, which recommends that TTIME should begin immediately once home from the hospital, that infants should work up to 60 minutes of TTIME each day by 3-months of age.

Position Advice. Prior to the 2017 linking to Pathways.org, the AAP offered no position advice for TTIME use. Pathways, however, provides many helpful tips for infants 0-6 months; including videos of different TTIME positions, soothing strategies, and engaging activities.

Safety. Both the AAP and Pathways necessitate that TTIME must be wakeful. If infants fall asleep in TTIME, both organizations recommend for caregivers to roll them onto their back and move them to a firm sleep surface. Both also state to avoid loose, or padded surfaces on which an infant can suffocate while doing TTIME. They say not to do TTIME on raised surfaces to prevent a risk of falling, and to supervise the entirety of the exercise.

Beginning to Investigate Quality Factors. DST suggests that the function of the environment is a large aspect in the success of motor abilities and goal-directed movements, however few research studies have been conducted. One study (Guidetti, 2011) investigated the use of positional support during TTIME on bout length. The author found that time in prone was greatest with the use of a mini Boppy™ support pillow, and that the first of three trials showed the best participation for 3-month old infants. This study in conjunction with DST posits that changing the environment to fit the child's personal resources may increase successful outcomes. However, studies of this nature have not been duplicated, nor has the AAP released any positional aid advice for TTIME use.

Questions for Use Still Remain

While there are some quantitative TTIME recommendations available for use, and Pathways.org provides useful tips to aid in TTIME success, there still remain many questions that parents and caregivers (CGs) need evidence-based answers to. For example, a CG may aim for 15 minutes of TTIME each day, but there are no concrete recommendations for how long each bout should be, nor ways to incorporate TTIME into an existing routine. There are also no evidence-based strategies on how to promote positive TTIME experiences, to ensure that the activity is an enjoyable one for both CG and infant. A CG may be concerned that their infant is not enjoying the activity, or that they may be distressed. Manipulating the positioning of the infant is a simple strategy to help with distress, but guidance for varying use is not available. CGs may also wonder where TTIME can be done, does it require specialize equipment, space, or toys? Is it best done at a certain time of the day? Before feeding or after feeding? These questions have no evidence-based answers, and the suggestions currently available vary widely in their content.

Current Study

Purpose. To circumvent the lack of information on TTIME ***quality*** recommendations, as well as provide a better account of what successful TTIME looks like, the current proposal will examine environmental factors during video-taped bouts of TTIME; such as caregiver proximity, infant-caregiver interactions, toys, locations, and surfaces, with the intent to provide clear and measureable advice that parents can use to simplify and increase the enjoyment of tummy time with their infants.

The purpose of this prospective behavioral investigation is to compare differences in average bout duration, average bout frequency and strategies used during tummy time between two groups of 6-month-old infants; one whose caregivers received tummy time instruction, and one whose caregivers did not.

Specific Aims.

Aim 1: Examine group differences in duration and frequency of tummy time bouts.

Aim 2: Examine group differences in ***caregiver proximity*** during TTIME.

Aim 3: Examine group differences in ***infant-caregiver interactions*** during TTIME.

Aim 4: Examine group differences in ***toys, locations, and surfaces*** during TTIME.

METHODOLOGY

Design

This secondary analysis of observational video data investigated tummy time behaviors in 6-month old infants. It employed a 2-group design, 1) instructional group, and 2) non-instructional group. Participants were recruited as part of a larger intervention study, and were grouped based on whether or not they received prone positioning educational instruction, therefore group randomization was not possible.

Participants

Participants include 11 infants with typical development aged 6-months and their primary caregiver. All infants were born full-term and were not diagnosed or suspected of having any conditions which could interrupt or delay typical development. These participants were recruited from an ongoing motor intervention study and then placed into either an instruction group or a non-instruction group. Participant demographic information can be found in Table 1.

Recruitment from Ongoing Study. All participants were currently enrolled in an ongoing motor intervention study before consenting to participate in this study. That ongoing study was investigating the effect of motor therapy on motor skill development and body composition outcomes during infancy. Infants receiving motor therapy in the form of prone positioning or tummy time (TTIME) were provided instruction and began intervening at 1-month of age. Infants receiving motor therapy in the form of supported stepping on a pediatric treadmill began intervening at 6-months of age.

For this study, infants were conveniently placed into either a TTIME instruction group or a non-instruction group (the existing treadmill group) which was based on whether they had received formal tummy time instruction as part of the ongoing study. Specific details regarding group placement are detailed below.

Instruction Group. 6 infants were enrolled in the instruction group. They were specifically recruited from the TTIME group (from the ongoing motor intervention) because they had received tummy time instruction. As part of their participation in the motor intervention, these participants were instructed to accumulate 60 minutes of tummy time each day, starting at one month old. These families were seen in the lab at 1, 3, and 6 months and were given ongoing tummy time support both at these sessions as well as via email communication. The support consisted of tummy time advice, including to provide interesting toys, surfaces, and different positions to their infant, and to increase caregiver interaction during these bouts. New, age-appropriate positions were demonstrated at each lab visit and/or via email. In-lab, the caregiver demonstrated each new position after being taught proper technique, and was given an opportunity to ask questions to the researcher. The researcher completed a fidelity checklist to standardize instruction and ensure the caregiver was well-versed in the handling and positioning necessary for TTIME.

Non-instruction Group. 5 infants were enrolled in the non-instruction group. They were specifically recruited from the treadmill group (from the ongoing motor intervention) because they had not received any formal TTIME instruction. All tummy time education and participation is assumed to be 'standard of care' prescribed by a pediatrician, usually less than 30 minutes each day (Dudek-Shriber & Zelazny, 2007; Wentz, 2016; AAP, 2011). Participants in this group were first seen in the lab at 6-months; prior email contact consisted only of recruiting and demographic information. These infants began motor therapy directly following participation in the current study through 12 months of age. That motor therapy involved treadmill training only.

Table 1. *Participant Demographics*

		Instruction (n=6)	Non-Instruction (n=5)	% of the total sample
Sex	Female	3	1	36.4%
	Male	3	4	63.6%
Race	White	6	5	100%
Average Ponderal Index		3.04	3.51	--
Maternal Age	24-29	3	2	45.5%
	30-35	0	2	18.2%
	>35	3	1	36.4%
Maternal Education Level	Some College	1	0	9.1%
	Associate's	1	0	9.1%
	Bachelor's	2	2	36.4%
	Master's	1	2	27.3%
	Doctoral	1	1	18.2%
Marital Status	Married	5	5	90.9%
	Single	1	0	9.1%
# Siblings	0	5*	1*	54.5%
	1	1*	3*	36.4%
	2	0*	1*	9.1%

*Level of Significance *p<.05*

Procedures

All infants visited the lab at 6 months of age. Families were informed of the study protocols and caregivers provided voluntary consent for themselves and their infant. Caregivers were told that this study was interested in early motor abilities and how their infant plays while at home. It was explained that this study required the caregivers to place a camera for one day, in the room of their home in which "they spend the most amount of time throughout the day" in order to capture instances of infant play and usual household dynamics. Caregivers were instructed that they were allowed to move the camera from room to room if necessary to remain with the infant, but zero families ended up doing so.

Families were then provided a camera and a detailed instruction sheet on how to use the device. They were given verbal instruction on where to place the camera in their home and when to use it. The families in both groups were instructed to video a normal day at home, consisting of their usual behavior. They were asked to video on a day when they would be home for the majority of it, allowing for more opportunities to capture tummy time bouts. All bouts of tummy time recorded in these videos were conducted at the family's own discretion.

A wide-angle, high definition camera was used to observe intrinsic, social and environmental details that co-occurred during each bout of tummy time. These videos were then coded by a trained observer.

Equipment

Videos were collected using a Mobius dash camera (C&D Tech, China; version 2.41). These cameras film at a 120-degree vantage in 1080p high definition. The cameras recorded continuously and videos were saved as 15-min clips from the SD card. Each participant placed one camera inconspicuously in the room of their choice; usually in the living room. Families were instructed to plug the camera in in the morning once their infant woke up, and to unplug it the next day around the same time. Families were instructed to act normally and forget that the camera was there. Once completed, participants were provided a stamped/addressed envelope to return the camera via the mail.

Measures

In addition to video recording in the home, infants participated in several laboratory measures during their visit to the lab. This included completing a demographic survey, anthropometric measurement and assessing motor skill development. These measures are used descriptively.

Demographics. Demographic information was collected for both the infant and the caregiver using a survey. All caregivers completed the survey without the assistance of the research staff. Information included birth details, feeding modality, sex, race/ethnicity, sibling information, marital status, maternal education and age, and birth complications. Details and differences between groups are described in Table 1.

Anthropometics. Weight and length measures were taken for all infants enrolled in this study. Percentiles and z-scores were then calculated for each. In addition, all infants completed a PeaPod scan at the 6-month laboratory visit. The PeaPod Infant Body Composition System (Concord, CA) is a device that measures whole body fat percentage using air displacement plethysmography. It is a device specifically designed and validated for use in infant populations (Ellis et al., 2007).

Processing Video Data

Video Coding. Videos were coded using Datavyu software (v1.3.7). All videos were coded by two research assistants who had not interacted with any of the children in this study. Due to the possibly-sensitive nature of mother-child feeding and changing that is common in the home during this time, both coders chosen were female. Prior to independent coding, coders were trained on practice videos to at least 90% agreement. Each coder was responsible for processing video for half of the participants.

To begin, coders were responsible for identifying periods or 'bouts' of TTIME behavior using a standard operational definition (defined below). Once TTIME bouts were identified, coders analyzed each video clip for four different streams of activity: location, caregiver proximity, caregiver action, and toys. These streams were identified because they related to the TTIME instruction we provided to caregivers, as well as current TTIME positioning resources widely available to families (Pathways, 2018). The four streams (location, caregiver proximity, caregiver actions, toys), accompanying codes, and examples of each are outlined below in more detail.

Coders watched each video once per stream, using pause, rewind, fast forward, and slow motion tools as necessary to ensure timestamps were as accurate to the onset and offset of the behavior as possible. In all, coders viewed each 15-minute video with TTIME data 5 total times.

Tummy Time (TTIME) Operationally Defined

TTIME is defined as placement of the infant in prone (on their tummy) on a horizontal or semi-inclined surface while awake.

Bouts*.* Each occurrence of TTIME is considered one distinct bout. A bout begins when the infant is positioned on their tummy and ends when their tummy is no longer in contact with the surface they were placed on. Examples of the end of a bout of TTIME include; infant raised themselves into a crawl position, infant rolled completely over or rolled to one side, infant was picked up by a caregiver.

Coding Streams

Location Stream. Tummy time is done in many different places in the home, on many different surfaces and using many different positions. The point of this stream was to give voice to these differences. The specific codes were room, surface, and object.

The broadest code, room, was coded for four different options, or subcodes; living room, kitchen, bedroom, and other. Coders selected which room the infant was in for each bout of TTIME, ignoring the subcode options that were not applicable for that occurrence. For example, if the infant was on the living room floor, the coders would select living room and ignore kitchen, bedroom, and other.

The surface code was coded for four different subcodes; bed/crib, couch/ottoman, floor, and other. This code was also analyzed using the “as applicable” format, meaning that if the infant was on the floor with no support devices, the coder would select floor, and ignore bed/crib, couch/ottoman, and other.

The third code, object, was the most specific. It consisted of six options; CG’s lap/chest/body, flat blanket/towel/rug, boppy, rolled blanket/towel, none, and other. Coders used ‘as applicable’ coding procedures for this code as well. For example, if the infant was propped on a boppy on a rug the floor, they would code onset/offset times for boppy and flat blanket/towel/rug, but ignore CG's lap/chest/body, rolled towel/blanket, none, and other subcodes.

The progression of the location, surface, and object codes paint a clear picture of what the tummy time looks like in that particular occurrence, without having to view the video itself. For example, if one bout of TTIME was coded as living room, floor, and caregiver's lap, we know that the infant was lying on their tummy on the caregiver's lap in the living room on the floor.

Caregiver Proximity Stream. Part of the advice given to families in the TTIME instruction group was to remain close to their infants during tummy time, as this is an exercise that needs to be supervised while the infant is awake to be safe in the position (AAP, 2011; Pathways, 2018). The non-instruction group did not receive this advice from our research staff, although these recommendations are commonly taught by pediatricians, and are available from many online resources (AAP, 2017; Pathways, 2018).

We coded the primary CG's proximity to the infant while in tummy time. If more than one caregiver was in the frame, we coded the CG closest to the infant, and/or the one that remained in the frame the longest. For example; when the clip began, a male CG was sitting on the floor next to the infant and a female CG was sitting on the couch across the room. The male CG gets up 5 seconds into the clip and leaves the room, and does not return before the end of the 15-minute clip. We coded the male CG's proximity for the duration of his stay, then switched to the female CG's proximity for the duration of the clip. This ensures that we are always coding a caregiver's proximity for supervision purposes, while also nodding to the teamwork dynamic integral to caring for a child.

Caregiver proximity was scored in four levels of codes. The first code was 'caregiver <1ft from infant'. The second was '1-5 feet from infant'; the third was '>5 feet', and the final code was 'caregiver off camera'.

Caregiver Action Stream. Similar to the proximity stream, we also advised families in the instruction group to interact with their infants during TTIME. The non-instruction group did not receive this advice. We coded four CG actions; physical touch, reposition, pick-up, and N/A. All codes in this stream were coded for the whole TTIME bout, using event-based coding. This means that the coders coded specific behaviors when they occurred, and ignored the code if it never occurred. They coded onset and offset for each code each time it occurred. Codes could occur simultaneously, so coders were instructed to focus on one code at a time and code the entire bout for each applicable code.

Physical touch consisted of patting, rubbing, or holding of any part of the infant's body, i.e. hand holding. The physical touch could not affect the infant's body position in a way that intervened with their ability to independently perform TTIME. For example, the infant lying on the CG's chest and the CG patting the infant's back while ensuring their safety, but leaving the head, neck, and limbs free to move and activate muscles would be an example of a physical touch.

A reposition was coded if the caregiver lifted or rearranged a part of the infant's body while in TTIME. The infant's belly needed to remain in contact with the surface during the reposition or it would signal the end of the TTIME bout. An example of this would be if the infant's arms were stuck under their body and the CG pulled them forward and propped the infant on their forearms.

A pick up was coded if the CG lifted the infant out of tummy time. This action resulted in the end of the bout of TTIME.

Lastly, N/A was coded to indicate that CG actions “cannot be coded”. This was used if the CG was off-camera.

Toy Stream. The final advice we gave to the instruction group was to use toys to entertain their infants during TTIME. ‘Toys’ is loosely interpreted for the purposes of this stream. We count any non-harmful and appropriately-sized object as a toy for the infant to manipulate. For this code, the objects must be individual things – not a caregiver’s hand, or the infant’s own hand or other body part. For example, if the infant is motivated to reach for the CG’s cell phone lying on the floor in front of them, we would consider this a toy. If the infant pulls their socks off and holds them in their hand during TTIME, we count these as toys – even if a sock is dropped after manipulation, it remains a toy within infant reach and is coded to specify that proximity. If the infant is sucking on a pacifier, it is not considered a toy. But, if they pull the pacifier out of their mouth and manually manipulate it, we would count it as a toy.

We scored the toy usage on four hierarchical levels; toys not available, toys available but out of infant reach, toys within infant reach, and toys being manipulated. Coders were instructed to select the most advanced code. For example, an infant holding a block clearly demonstrates that the toys were within reach, but the correct code would actually be ‘toys being manipulated’ as it classifies the behavior to the fullest extent possible.

We coded ‘toys not available’ if we could not see any toys visible on the video.

We coded ‘toys available but out of infant reach’ if we could see toys on the video but out of reach of the infant. Any toys greater than arms length from the infant are classified as ‘out of reach'. For example, an older sibling playing with blocks five feet away from the infant would be considered out of infant reach.

Likewise, 'toys within infant reach' are those that are within arm's reach of the initial position of the infant during TTIME.

The final code for this stream was 'toys being manipulated'. As discussed previously, toys must be manipulated with the infant's hands. The mouth, chest, surface, caregiver, or any other object may also be included, but the hands' involvement are what dictate manipulation for this code. An example of this would be an infant lying propped on a boppy holding a rattle with the right hand and mouthing it at the same time.

Statistical Analysis

Independent Variable. This study has one independent variable with only one level. It is group placement into either the instruction or non-instruction group.

Dependent Variables. This study has several dependent variables that were summarized as durations, frequencies, and percentage of TTIME in the behavior for each code within the four streams (location, caregiver proximity, caregiver action, and toys). Each variable is described in more detail below. Descriptive statistics for demographic variables are presented in Table 1.

Durations. Durations were calculated using onset and offset for each bout of TTIME as well as for each stream/code listed above. Durations were calculated for each participant and for each group as a whole.

Frequencies. Bout frequency was calculated by counting the number of discrete bouts of TTIME for each infant. Frequencies of behavior occurrences were calculated by counting the number of times each subcode was used per participant for all TTIME. For example, 'toys being manipulated' was coded as 'YES' 12 times total for Participant 1012, and 24 times total for Participant 1010. Whole group differences in code frequencies are presented in the results section under their respective code headings.

Percentage of TTIME in Behavior. Using the per-code durations for each stream, the percentage of time spent in each behavior for all bouts of TTIME (%TTIME_behavior) divided by the total TTIME duration was calculated for each participant. This is calculated as follows: total time spent with the caregiver repositioning the infant divided by the total amount of TTIME that specific baby achieved (%TTIME_CGA_R / %TTIME_Dur_Total).

Analysis

Baseline characteristics were summarized using means and count data. Baseline differences between groups were determined using *t* tests for continuous variables. Only the number of siblings was significantly different between groups (t=-2.453, p=.037) at baseline, but this difference did not persist through the current TTIME investigation.

Aim 1: Total TTIME duration was compared between groups using an ANCOVA because the data was approximately normally-distributed. Total bout frequency was compared between groups using the Mann Whitney U test because the data was not normally distributed.

Aim 2-4: Normality was assessed for all subcodes using histograms and Q-Q Plots; visual comparison to the normal approximation curve was determined. Independent samples *t*-tests were computed between groups for normally-distributed subcodes in Caregiver Proximity, Caregiver Actions, Location, and Toy streams. This test was done for sum totals of behaviors (frequencies and durations) as well as for the % of Total TTIME variable described above (durations only). Mann Whitney U tests were computed for variables in each stream that were not normally distributed; also for sum totals (frequencies and durations) and % of Total TTIME (durations only).

RESULTS

Aim 1

TTIME Totals. No significant differences were found in total TTIME duration or total TTIME bout frequency between groups. There were both high and low levels of TTIME duration and frequency in each group, but the instruction group had lower average and total TTIME frequencies compared to the non-instruction group. Conversely, the instruction group had higher average and total TTIME durations than the non-instruction group.

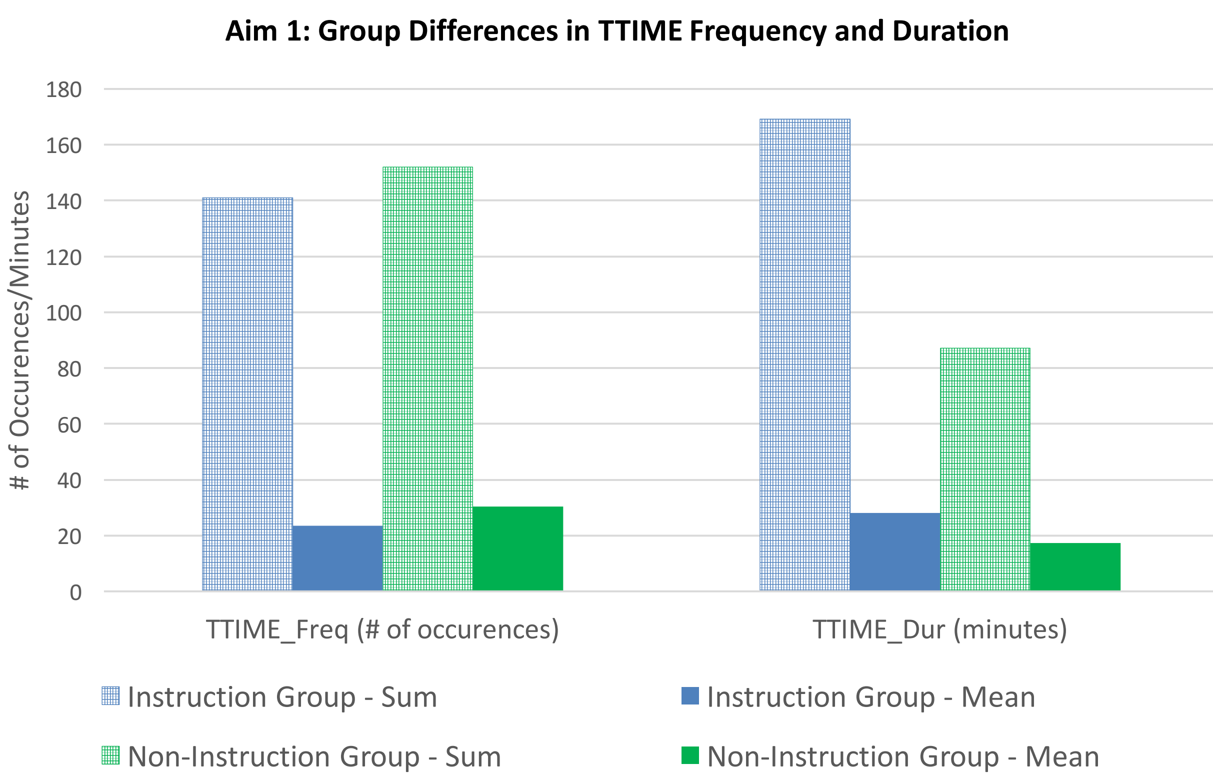

Figure 1. Group differences in TTIME frequency and duration.

Aim 2

Caregiver Proximity. Group differences in proximity of CG during TTIME were non-significant. CGs in both groups spent a percentage of the total TTIME duration in each level of CG Proximity (<1ft, 1-5ft, >5ft, off camera), with the non-instruction group spending greater percentages in the latter three levels than the instruction group.

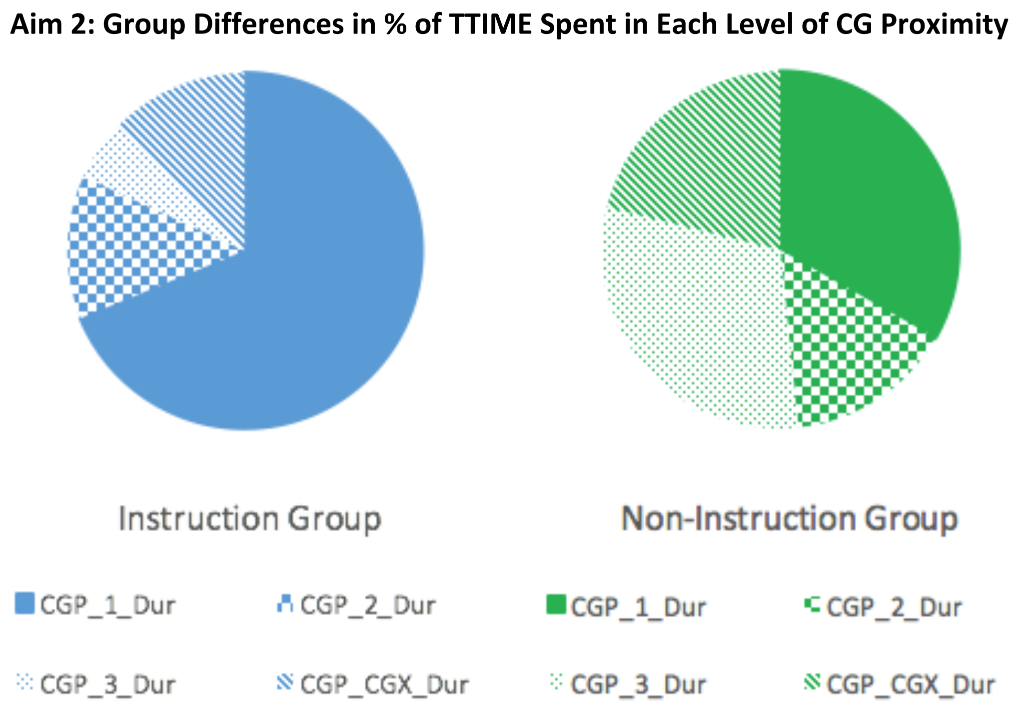

Figure 2. Group differences in percentage of TTIME duration spent in each level of CG Proximity. *In both pie charts, the solid sections represent duration spent in CGP1, which is the first level of Caregiver Proximity – less than 1 foot from the infant. Moving clockwise on each chart, the checkered sections` represent duration in CGP2 – 1-5 feet from the infant. The dotted sections represent duration in greater than 5 feet from the infant. The lined sections represent the final level of CGP – CGX, which is the duration that the Caregiver was not on camera.*

Aim 3

Caregiver Actions. Significant differences were found between groups for 'Physical Touch' frequency (t=2.866, p=.030) and (U=2.50, p=.017), total duration (U=.000, p=.004) and was approaching significance for % of total TTIME (U=4.00, p=.052). 'Reposition' frequency

(t=2.369, p=.042), and duration (t=2.494, p=.034) were also significantly different between groups. Time when the caregiver was not on camera (CGX) was also significant for total duration (U=3.5, p=.030), % of total TTIME duration (U=3.50, p=.030) and was approaching significance for frequency (U=4.00, p=.052). No significant differences between groups were found for 'Pick Up', or 'NONE'.

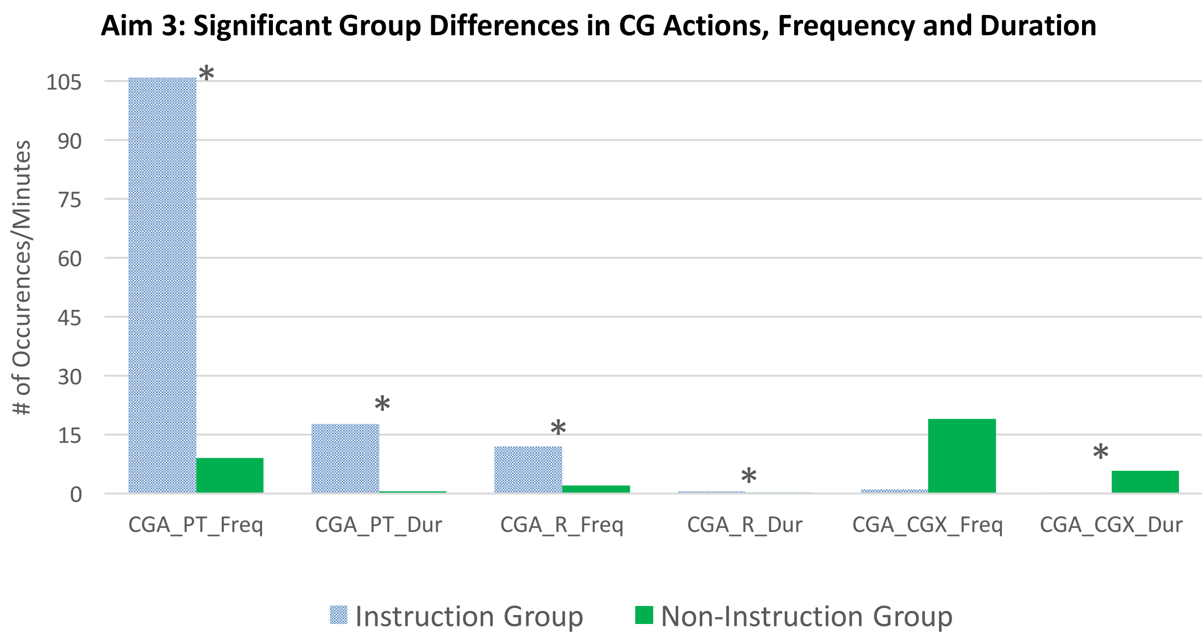

Figure 3. Significant group differences in duration and frequency of CG Actions. *The blue checkered bars represent the instruction group; the solid green bars represent the non-instruction group. Level of significance *p<.05. Variable naming key: PT = Physical Touch, R = Reposition, CGX = caregiver off camera.*

Aim 4

Toys. Significant differences between groups were found for 'Toys being Manipulated (TM)' % of total TTIME duration (t=2.464, p=.036). No significant differences were found for 'Toys Not Available (TNA)', 'Toys Out of Reach (TOR)', or 'Toys Within Reach (TWR)'.

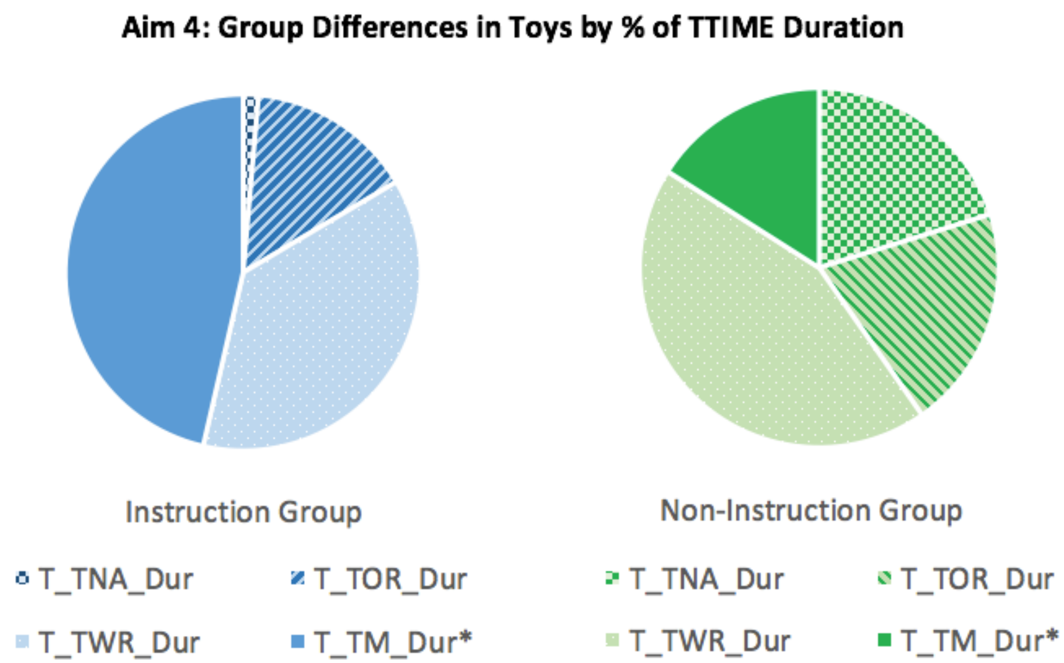

Figure 4. Group differences in % of Total TTIME Duration spent in varying levels of Toy use. *The solid blue and solid green represent TM (significance level *p<.05). The dotted blue and dotted green represent TWR. The blue and green striped sections represent TOR and the blue and green checkered sections represent TNA for each group. Variable naming key: TM = Toy Manipulation, TWR = Toys Within Reach, TOR = Toys Out of Reach, TNA = Toys Not Available.*

Locations. No significant differences were found for any of the location subcodes (Living Room, Bedroom, Kitchen, and Other). Both groups spend the highest frequency and duration of TTIME in the Living Room, with the instruction group being greater for both values.

Surfaces. For the % of Total TTIME Duration, use of no surfaces (NONE) was approaching significance ($U=4.00$, $p=.052$) OR ($t=-2.188$, $p=.056$). No significant differences were found for any of the other surface subcodes (Bed/Crib, Couch, Floor, Other, CG, Flat Blanket/Towel (FBT), Rolled Blanket/Towel and Boppy™). The non-instruction group showed much higher frequency for the Floor code than the instruction group, but the total durations for each group on the Floor were similar. Frequencies and durations were higher in the instruction group for the FBT subcodes, and higher in the non-instruction group for the NONE subcodes.

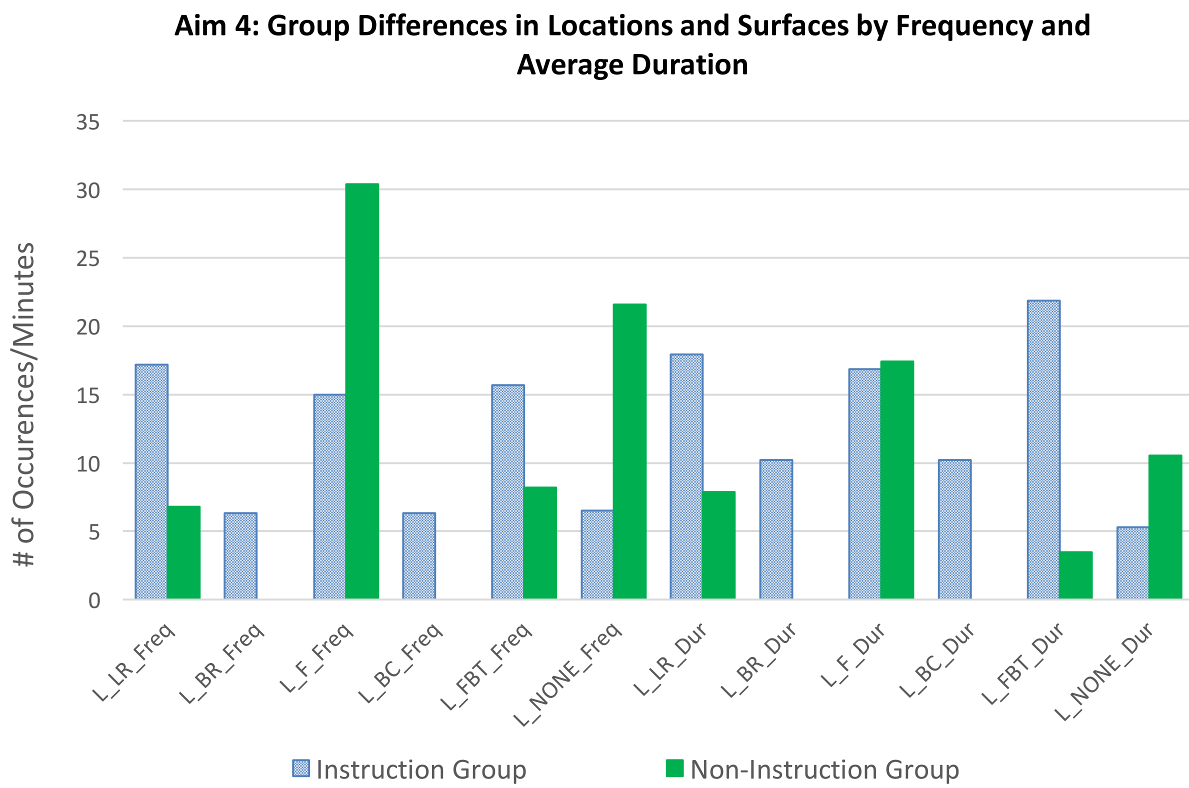

Figure 5. Durations and frequencies of Location and Surface subcodes per group. *Checkered blue bars represent the instruction group; solid green bars represent the non-instruction group. Frequency variables are on the left half of the graph and durations of the same subcodes are on the right. Variable naming key: LR = Living Room, BR = Bedroom, F = Floor, BC = Bed/Crib, FBT = Flat Blanket/Towel, NONE = no surfaces used (i.e.: infant is lying directly on the floor).*

Aim 1-4

Descriptives tables for duration and frequency of all codes can be found below. Codes with a significance level of $p<.05$ are denoted with an asterisk. Means, standard deviations, minimums and maximums are listed for each variable for both the instruction and non-instruction group.

Table 2. *Code Duration Descriptive Statistics by Group*

	Instruction Group				**Non-Instruction Group**				
	Mean	S.D.	Minimum	Maximum	Mean	S.D.	Minimum	Maximum	Effect Size
TTIME_Dur	28.189	22.006	4.956	61.244	17.433	20.637	2.192	47.790	0.502
CGP_<1ft_Dur	18.163	17.356	4.181	51.464	6.617	7.706	0.131	15.816	0.829
CGP_1-5ft_Dur	4.790	5.738	0.028	14.210	3.644	6.650	0.131	15.507	0.186
CGP_>5ft_Dur	0.605	0.431	0.203	1.313	5.517	7.555	0.000	13.875	-0.973
CGP_Off Camera_Dur	4.656	7.687	0.000	19.508	1.642	0.923	0.233	2.578	0.523
CGA_Physical Touch_Dur*	2.938	2.591	0.626	6.570	0.099	0.101	0.000	0.240	1.469
CGA_Pick Up_Dur	0.264	0.437	0.000	1.140	0.063	0.114	0.000	0.267	0.601
CGA_Reposition_Dur*	0.100	0.080	0.000	0.236	0.009	0.015	0.000	0.035	1.510
CGA_NONE _Dur	24.825	21.435	3.700	54.980	15.692	20.120	1.331	44.327	0.438
CGA_Off Camera_Dur*	0.026	0.064	0.000	0.157	1.150	0.961	0.000	2.364	-1.751
Toys_Not Available_Dur	0.770	1.887	0.000	4.622	0.962	1.714	0.000	3.956	-0.106
Toys_Out of Reach_Dur	2.764	3.446	0.022	9.230	7.026	9.554	0.000	17.959	-0.621
Toys_Within Reach_Dur	10.378	8.328	0.729	21.636	6.717	7.686	0.000	17.171	0.455
Toys_Manipulation_Dur*	10.772	8.747	2.512	22.811	4.214	5.937	0.000	13.433	0.860
Locations_Bedroom_Dur	10.207	25.003	0.000	61.244	0.000	0.000	0.000	0.000	0.548
Surfaces_Bed/Crib_Dur	10.207	25.003	0.000	61.244	0.000	0.000	0.000	0.000	0.548
Surfaces_Floor_Dur	0.000	46.108	16.864	18.192	17.421	20.626	2.189	47.777	-0.471
Surfaces_CG_Dur	0.279	0.341	0.000	0.716	0.000	0.000	0.000	0.000	1.096
Surfaces_FBT_Dur	21.857	25.126	0.000	60.764	3.481	6.794	0.000	15.574	0.954
Surfaces_Boppy_Dur	0.719	1.642	0.000	4.065	3.402	7.608	0.000	17.011	-0.514
Surfaces_NONE _Dur	5.288	7.884	0.000	19.299	10.538	12.975	0.567	32.203	-0.502

*Level of Significance *p<.05; a negative Effect Size means that the Non-Instruction Group was significantly larger than the Instruction Group for that subcode. Variable naming key: CGP = Caregiver Proximity; CGA = Caregiver Actions – further details can be found in the methodology section of Chapter 2.*

Table 3. *Code Frequency Descriptive Statistics by Group*

	Instruction Group				Non-Instruction Group				
	Mean	S.D.	Minimum	Maximum	Mean	S.D.	Minimum	Maximum	Effect Size
TTIME_Freq	23.500	15.437	6.000	44.000	30.400	49.470	1.000	118.000	-0.198
CGP_<1ft_Freq	23.833	15.880	5.000	48.000	12.800	11.628	1.000	30.000	0.780
CGP_1-5ft_Freq	16.000	17.470	1.000	48.000	14.200	24.519	2.000	58.000	0.086
CGP_>5ft_Freq	3.000	2.000	1.000	6.000	8.600	17.082	0.000	39.000	-0.488
CGP_Off Camera_Freq	8.167	11.703	0.000	30.000	5.600	8.142	1.000	20.000	0.250
CGA_Physical Touch_Freq*	17.667	13.486	2.000	41.000	1.800	1.304	0.000	3.000	1.573
CGA_Pick Up_Freq	5.500	4.680	0.000	13.000	1.600	1.140	0.000	3.000	1.092
CGA_Reposition_Freq*	2.000	1.414	0.000	4.000	0.400	0.548	0.000	1.000	1.434
CGA_NONE_Freq	30.000	17.286	10.000	61.000	28.400	43.741	2.000	106.000	0.050
CGA_Off Camera_Freq*	0.167	0.408	0.000	1.000	3.800	4.817	0.000	12.000	-1.126
Toys_Not Available_Freq	1.667	4.082	0.000	10.000	0.600	0.894	0.000	2.000	0.344
Toys_Out of Reach_Freq	8.833	8.909	1.000	21.000	12.600	25.413	0.000	58.000	-0.207
Toys_Within Reach_Freq	26.000	21.624	3.000	60.000	18.800	29.575	0.000	71.000	0.283
Toys_Manipulation_Freq	25.500	18.534	4.000	55.000	9.600	12.818	0.000	31.000	0.979
Locations_Bedroom_Freq	6.330	15.513	0.000	38.000	0.000	0.000	0.000	0.000	0.547
Surfaces_Bed/Crib_Freq	6.333	15.513	0.000	38.000	0.000	0.000	0.000	0.000	0.548
Surfaces_Floor_Freq	0.000	35.000	15.000	13.914	30.400	49.470	1.000	118.000	-0.723
Surfaces_CG_Freq	0.667	0.816	0.000	2.000	0.000	0.000	0.000	0.000	1.095
Surfaces_FBT_Freq	15.667	16.219	0.000	37.000	8.200	11.584	0.000	26.000	0.520
Surfaces_Boppy_Freq	0.500	0.837	0.000	2.000	0.600	1.342	0.000	3.000	-0.092
Surfaces_NONE_Freq	6.500	7.556	0.000	17.000	21.600	39.564	1.000	92.000	-0.560

*Level of Significance *p<.05; a negative Effect Size means that the Non-Instruction Group was significantly larger than the Instruction Group for that subcode. Variable naming key: CGP = Caregiver Proximity; CGA = Caregiver Actions – further details can be found in the methodology section of Chapter 2.*

DISCUSSION

TTIME is an activity that generally requires little training to do. However, this study suggests that perhaps there is a need for short, initial instruction in order to provide a richer, more complete TTIME experience for families with infants. The instruction group in this investigation was presented with simple tips for TTIME safety and enjoyment: to stay near their infant during the exercise, to interact as much as possible, to provide toys, and to vary the locations and surfaces in which they do TTIME.

Aim 1

While not statistically significant, the total duration and frequency of TTIME for each group was quite alarming when you consider the Pathways.org (2018) “60-min-per day by 3-months-of-age’ recommendation. The average total TTIME duration for the non-instruction group was only 17 minutes; the instruction group was 28 minutes, almost double the TTIME exposure, but still well under the Pathways suggestion. The non-instruction group participated in a higher frequency of TTIME bouts, with an average of 30.4 bouts. Interestingly, the instruction group participated in fewer TTIME bouts (mean=23.5), suggesting that they are able to do longer, less frequent bouts – perhaps due to the 5 months of daily training they had participated in. These findings contradict the recent Pathways.org recommendations, but the non-instruction group still accumulated more total TTIME minutes than the AAP’s 2008 recommendations of 3-15 minutes. These dissimilar recommendations suggest that further research into the appropriate dosage of TTIME must be conducted.

Aim 2

There were no significant group differences in CG Proximity (CGP) in this sample; however, the results still suggest interesting differences between groups. The instruction group CGs were within one foot of their infants about twice as long as the CGs in the non-instruction group. As depicted in Figure 2, a trend begins to develop in the subsequent proximity levels; the non-instruction group spent a greater percentage of time in the more-distant levels of CGP than the instruction group (1-5 ft, >5ft, off camera). Most striking is the large percentage of TTIME duration that the CGs in the non-instruction group were coded as 'off camera', indicating that their infants were not being supervised while in TTIME. These trends suggest that additional investigation of "safe TTIME practices" must be done, and that perhaps as an infant ages the supervision needs might change from what is currently advised.

Aim 3

There were many significant group differences for CG Actions. Most interesting is the frequency, duration, and % of TTIME for the 'Physical Touch (PT)' subcode between groups. The instruction group CGs spent significantly more time physically interacting with their infants, which directly fits with the instruction we provided to this group. Also noteworthy is that the instruction group spent significantly greater duration and frequency repositioning their infants during TTIME; for example, moving their arms forward so they could attain toys that were within their reach, or making sure their legs were not under their bodies so they could kick freely. The non-instruction group CGs also spent a significantly greater duration 'off camera', thus not interacting with their infants. This discovery is the most concerning, as all CGs should be advised at well-child visits to supervise their infants while in TTIME, not just the instruction group that we provided this advice to. Perhaps the instruction group CGs were more apt to follow our advice as it was repeated multiple times, and that the frequency of reminders at well-child visits alone was not sufficient.

Aim 4

The instruction group used more locations and surfaces than the non-instruction group, and had greater durations in most. The one surface that was more frequently used by infants in the non-instruction group was the Floor subcode: 100% of this group's TTIME took place on the floor. Conversely, the instruction group also used a bed, crib, Boppy™, and CG's lap, chest, or legs.

Both groups used a flat blanket or towel (FBT) on the floor or other surface (ie: bed, Boppy™), but the instruction group used FBT more frequently and for a longer total duration. The instruction group used no extra surfaces/objects (ie: TTIME only on floor) more frequently and for a longer duration (approaching significance, t=-2.188, p=.056) than the instruction group. Part of the advice we provided to the instruction group was to vary the surfaces and objects used during TTIME to hold the infant's interest; the group differences reported here clearly support our advice in this area, instruction group infants had longer TTIME bouts, and used more varied locations and surfaces.

Percent of total TTIME spent in Toy Manipulation (TM) was significantly (t=2.464, p=.036) greater in the instruction group. The non-instruction group spent a greater percentage of total TTIME with 'Toys Out of Reach (TOR)' and 'Toys Not Available (TNA)'. Again, part of the training we gave to CGs in the instruction group was to provide toys during TTIME: so a significant difference between groups for TM was expected and appreciated.

Since there are no published evidence-based guidelines for surface, location, or toy use during TTIME, these findings may serve as a useful first step in identifying particular items, settings, or combinations of both, that may facilitate greater TTIME for 6-month-old infants.

CHAPTER 3

Summary

Measurable recommendations for families and child care providers are needed to facilitate quality TTIME that is feasible to implement. In this study, instruction was provided to caregivers (CGs) of one group of infants, and that group participated in a greater duration of TTIME. They also achieved longer bouts of TTIME than the non-instruction group.

The significant results presented provide helpful suggestions for pediatric practitioners when advising caregivers on TTIME tips. Including suggestions about access to toys, variety of locations and surfaces, as well as positioning for younger infants would be a welcome addition to TTIME conversations. This study also highlights the need for reaffirmation of safety protocols. CGs in both groups spent time ‘off camera’, indicating a lack of supervision during TTIME, which the AAP and Pathways both advise against.

Instruction Effect

Because one group of infants and CGs were provided with instruction and the other was not, we can assume that group differences seen in targeted training topics was due to instruction. This “instruction effect” is especially important to discuss as the training I provided to families was brief, simple, and feasible to implement – providing evidence that creation of similar strategies can be swiftly incorporated to well-child visits with a pediatrician.

I advised CGs to vary the surfaces and locations used during TTIME, to promote exploration and provide a different backdrop so the infant remained entertained during TTIME.

The instruction group partook in TTIME in a greater number of locations and with more surfaces than the non-instruction group. Conversely, the non-instruction group spent the majority of their TTIME on the floor with no additional surfaces – they also had shorter, more frequent bouts (perhaps speaking to their discontent with their selected environment).

I also directed CGs to provide toys to their infant during TTIME, and the instruction group participated in significantly (t=2.464, p=.036) more time with 'Toys being Manipulated (TM)' than the non-instruction group. The non-instruction group spent a greater percentage of total TTIME duration with 'Toys Not Available (TNA)', although this was not statistically significant between groups. Again, the instruction group participated in longer TTIME bouts, and a greater amount of total TTIME than the non-instruction group. Perhaps providing and manipulating toys during TTIME influenced the duration of TTIME these infants were able to achieve. Tips about offering toys are also simple to incorporate into a well-child visit, and can be personalized to each child and their available toys.

Lastly, I advised CGs in the instruction group to supervise and interact with their infants during all TTIME bouts. This was for safety purposes as well as for social enrichment during the exercise. The AAP and Pathways.org both state that TTIME should be wakeful and supervised by an adult CG at all times; I relayed this same recommendation to all instruction group CGs. I also advised CGs to interact with the infant during TTIME (ie: to get on the same level so the CG and infant were face-to-face, to do TTIME on the CG's chest while reclined, to sing songs, to pat or rub the infant, to talk to the infant, etc…) in order to stimulate and entertain the infant during the activity. CGs in the instruction group spent a significantly longer duration (t=2.866, p=.030) and frequency (U=.000, p=.004) in the 'Physical Touch (PT)' and 'Reposition (R)' duration

(t=2.494, p=.034) and frequency (t=2.369, p=.042) subcodes, which coincides with my instruction to interact with their infants during TTIME.

Alarmingly, both groups' CGs spent time off camera while their infants were in TTIME, indicating a definite a need for greater emphasis to be placed on the importance of supervision during TTIME – perhaps further studies can investigate the precise type of supervision needed for 6-month-olds compared to younger infants. It is possible that the instruction group CGs in this sample felt confident in their infants' TTIME abilities after 5 months of practice, and did not deem it as necessary to fully supervise the exercise at all times. Also important to note, there was a significant difference in the number of siblings for the non-instruction group versus the instruction group, so perhaps the great amount of non-supervised TTIME comes from having multiple children and feeling comfortable to step away during TTIME. Additional research into sibling status, caregiver characteristics, and rearing habits is needed to further explore this phenomenon.

Limitations

Both groups of infants should ideally be participating in greater TTIME activity than was reported in this study, but it is important to note that this investigation only video-taped for a single day – meaning that the infant could have been sick, the schedule could have been atypical, or that they had an "off" day and participated in less TTIME than usual. Another limiting factor of this study is the small sample size; with only 11 infants, it was much harder to reach significance for many variables. If this study were expanded, perhaps more relationships would be discovered.

Changes

There are a few vital alterations to the existing methodology and training provided to the instruction group that I think would improve the overall structure of the study, and the meaningfulness of the findings. For example, I was only able to see the instruction group families at 1 and 3 months to provide TTIME feedback and guidance. I think a richer intervention would be to see families each month beginning at 1 month, and have email follow-ups/check-ins as needed between those visits.

I also think that doing home visits rather than lab visits provides a more realistic and translational use of TTIME tips – for example, I could have used the family's locations, surfaces, and toys in their home to describe a TTIME experience that would foster their infant's existing skillset and promote behaviors that would scaffold them into the next skill. This 'routine-spaced' approach places greater emphasis on helping the family find periods in their routine when TTIME is feasible for their lifestyle. Using lab-specific toys, and talking about in-home locations in a general sense has limitations for replication by the CGs.

Camera-wise, I would have preferred to use a camera that had a screen on the back, so CGs could check the placement to make sure their infant was visible on camera; I had multiple issues with objects being placed in front of the camera lens, or the camera being positioned so the infant was not fully visible when on the floor. The instruction group had multiple months to get their placement figured out, but the non-instruction group had their first attempt at month 6, which meant that I had more unusable video from them due to poor camera locations. Future studies should consider cameras with a viewing screen whenever feasible.

Next Steps

This analysis serves as a useful first step into the environmental factors that may influence the quality of TTIME, but further research is needed to explore these and additional variables that may be impactful. Studies of infants at younger ages are especially vital, as 6-months is at the tail end of TTIME-appropriateness. Families of young infants could benefit greatly from positioning and environmental strategies that could help to introduce TTIME in a quality way from day one, rather than trying to correct adverse TTIME feelings or behaviors that may already be established by 6-months. An additional future idea would be to include verbal/audio interactions between the infants and their environment (ie: CG, siblings, pets, screentime) to see if there is a relationship between these factors and TTIME duration and/or frequency; this study was limited in the secondary-data analysis nature as the videos used had sound disabled.

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