RESEARCH ARTICLE

Realistic dosage of tummy time practice during infancy

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Abstract

Background: The pediatricians recommend "tummy time" (placing a baby on their stomach while awake) as a physical activity for non-locomotor infants. However, parents often do not fully understand specific methods for fulfilling tummy time recommendations, then did not implement tummy time in the early stage of life. Aim of the study: The study aimed to determine the realistic dosage of daily tummy time for parents and infants of various ages. Methods: A total of 11 infants (7 girls, 4 boys, start age 61. 5days) participated in the intervention. Accumulate 60 minutes of tummy time was requested throughout the day. Results: Infants completed the intervention (achievement of sitting milestone age) at an average of 182.18 days old. The average duration of intervention days was 120.63 days. The average daily practice was 50.12 minutes. During the intervention, the percentage of completed days infants meet their required dosage was an average of 46.3 %. The percentage of missing days infants did not practice tummy time at all was an average of 18.64%. The percentage of days that infants did practice tummy time, but were under the required dosage was an average of 23.51%. Conclusion: It was evident that the prescribed dosage of daily practice was a too ambitious goal and maybe far from realistic for non-locomotor infants.

Keywords: tummy time, early exercise, physical activity, motor development

Introduction

Obesity can begin in early infancy, and in fact, infant obesity has increased rapidly over the past few decades [1-3]. Approximately 9.2 % of U.S. infants (< 2 years old) have a high weight-for recumbent length (above 97.7th percentile of the World Health Organization growth standards). Ethnicity and socioeconomic challenges may contribute to the risk of obesity: a higher prevalence of Hispanic infants is overweight (11.3 %) compared with African Americans (10.2%) and whites (8.8%) [4]. Early overweight status often persists into adulthood [5-10] and is strongly associated with health issues as adults [11]. Early emergence and long-term persistence of being overweight underscore the need for effective interventions during infancy.

Environmental factors such as restricting infants' position or mobility, limited time for parent-child play, concern for neighborhood safety, screen time, etc. have been strongly associated with sedentary behavior, which is a major factor for becoming overweight in later childhood [12,13]. To counteract sedentary behavior, physical activity is essential and also helps prevent obesity. Current guidelines for physical activity in children were adapted from evidence gathered about children and adolescents over the past decade [14,15]. There is less data about infants (< 2 years old), however, and part of the reason is that physical activity is difficult to quantify in infants [16-18]. As a consequence, few studies have focused on the role of physical activity in infant obesity, and recommendations for promoting infant activity are scarce [19].

National guidelines around the word recommend floor-based play in safe environments for young infants [19-22]. The most readily available, easiest to perform by families, and the most recommended form of floor-based play for infants is *tummy time*. Tummy time is the deliberate placement of an infant on their belly for tolerable periods of time during awake play [23]. The recommendation by World Health (2019) is that infants who are not locomotor should spend at least 30 minutes in tummy time practice while they are awake and supervised [21]. Alternatively, on the basis of an expert panel, the AAP gives the most specific requirements on tummy time that infants on their tummy 2 to 3 times each day for a short period (3-5 minutes), increasing the amount of time as they show enjoyments of the activity [24]. These types of recommendations are relatively common.

In a variety of countries, national tummy time recommendations are publicly available to emphasize the importance of physical activity for non-locomotor infants. However, those national recommendations are largely based on health experts' opinions, not research-driven evidence. Moreover, none of the recommendations clearly delineate how parents or caregivers deliver tummy time practice in accordance to infants' age and motor skills. Due to the vague nature of the guidelines for tummy time, it is possible that parents do not fully understand specific methods for fulfilling tummy time guidelines (dosage, frequency, location, or position of the body), and consequently do not implement tummy time in the early stage of life.

In reality, 53-56% of new-born parents were aware of tummy time recommendations [25-27], and 40% of the sample initiated tummy time with their infants as early as less than 2 weeks [26]. Of parents who reported being aware of tummy time, the majority of infants spent 1-2 times per day for short durations of 3 to 5 minutes [27], receiving far less than 30 minutes of daily tummy time [6,25,26,28]. These results were inconsistent with the 30 minutes recommended in several national guidelines. A number of explanations for low adherence to tummy time have been proposed, including

(1) a lack of awareness on the importance of tummy time [25], (2) infants' discomfort and intolerance (e.g., cry or fussy), and (3) parents' fears on infants' positions [21,28,29].

Without a doubt, growing evidence supports that tummy time should be a form of early physical activity to support gross motor skill achievement (e.g., sitting, crawling), physical activity levels, and healthy weight gain [30]. However, many studies have relied exclusively on retroactive parent-report to understand the effects of tummy time on infants' development. Moreover, we still are not sure whether tummy time could be practically served as a form of physical activity for young infants: many parents are not practicing tummy time with their kids, and those parents who participate in tummy time fail to meet the daily recommendation within the first few months of life. Thus, action to advocate specific recommendations (e.g., infants' positions and duration and frequency increments) of tummy time practice is needed to promote adherence to the national tummy time guideline.

Further, because of a lack of clarity on tummy time guidelines, researchers are not able to investigate how well parents-infant dyads meet daily physical activity guidelines at a young age. This is particularly important as low adherence to tummy time does not necessarily mean that the parents-infant dyads did not care about early physical activity. Since many studies indicated that intolerance of being on the tummy discourages parents from pursuing tummy time practice with their infants, the lack of participation in tummy time may simply imply that the current common national guidelines for tummy time are not realistic to parents and infants. Identifying the realistic dosage of daily tummy time for parents and infants at various age ranges is critical to modify the current national guidance of tummy time prior to advocating specific recommendation and examining its effectiveness in a larger sample. Therefore, the aim of this study was to examine how well infant-parent(s) dyads complete a tummy time practice when they were given a goal of minutes to achieve daily (60 minutes). We anticipate our results would guide health practitioners in determining the feasibility of tummy time duration in early life.

Participants

We initially recruited 11 infants (7 girls, 4 boys) between 1.02 and 5.13 months of age from the Orange County area in C.A. and Lansing area in Michigan. All were born at term and typically developing without neuromuscular disorders. Parents reported children's race as White (82%) and multi-races (18%): 27% were Hispanic. Infants completed the intervention when they were able to get in and out of sitting position independently (M = 5.98 months, range = 4.96 ~ 6.84 months). However, families were free to withdraw from the study at any time. Study procedures in this study were approved by the Institutional Review Board at California State University Fullerton and Michigan State University. Written informed consent was obtained from parents prior to their infant's participation in the study.

Procedure

Tummy Time Practice

Parents received instruction on how to deliver practices and strategies for successfully engaging their infant in tummy time practices. Parents were instructed to supervise their infants at all times during practice. Infants were to engage in practices during times when they were fully awake and could tolerate the practice during weekdays and weekends. Initially, depending on infants' tolerance level to the posture, they were either on their parent's chest when the parent was lying horizontally or on a hard surface (e.g., floor or hard play mat surface).

The couch, bed, or a hard surface with a blanket on top that can slide was discouraged since it can be a hazard for the infant. When the infant gained strength and became accustomed to the positioning, as determined by the researcher during home visits, the hard surface was required practice location.

Based on results from Dudek-Shriber and Zelazny (2007) and Davis et al. (1998), parents were told to accumulate 60 minutes of tummy time throughout the day; the 60 minutes of tummy time did not have to be performed all at once [25,28]. When the infant was able to get in and out of a sitting position on his/her own, the infant could independently decide when to enter and exit the tummy time practice. Thus, the parents were instructed to stop performing and logging deliberate tummy time practice after infants' achievement of independent sitting skill.

Researchers scheduled the home visits when the infants were between naps, meals, and baths and would normally be home with their parents/caregivers. During each visit, parents shared their concerns, and researchers checked the practice logs and provided tips to adhere to the practice (e.g., infants' position, location of the practice).

Tummy Time Log

To verify compliance of practice dosage, parents entered each practice bout either on a notebook or the *Tummy Time* application that could be downloaded onto the parents' smartphone. A notebook was provided to each participant to log the duration of daily practice. The notebook included the date and time duration of tummy time and any notes the parent deemed necessary to note (e.g., an infant was fussy, infant was happy, or infant at daycare that day). Each practice bouts were recorded by stating the start time and end time whenever the infant was placed on their tummy. With the *Tummy Time* application, practice logs were recorded by pressing the app's play or stop button. For both options, tummy time practice was logged as many times as needed to complete the required minutes. Once participation in the study was complete (i.e., infant was able to get in and out of sitting position independently), practice logs were returned to researchers.

Data processing and statistical analysis

Each practice bout from the practice logs was re-entered into the Datavyu software program to evaluate infants' compliance with their given practice.

Due to the small sample size, participants' characteristics and tummy time practice behaviors were summarized descriptively. Based on daily practice duration, missing and completed days were calculated from the total length of tummy time intervention. In completed days, the over and under dosage days were calculated and percentage were calculated based on the total intervention days. Practice pattern was statistically examined by the Kruskal-Wallis H test and practice patterns were compared in 3 time periods - the beginning of the intervention defined as the first month, end of the intervention defined as the last month of the intervention, and the middle of the intervention defined as the remaining months. All variables were summarized descriptively.

All 11 infants (7 girls and 4 boys) completed the intervention. Based on the research related to low practice adherence [25-27], there was concern that the intervention would be challenging for families to complete at the start of the study. However, to the investigators' surprise, no family found the commitment of daily tummy time practice was too much and needed to end the intervention. Infants could only participate in tummy time practice when their

parent(s)/caregiver put them on the tummy following the planned daily routine. Accordingly, we viewed tummy time practice as teamwork between parents and their infants rather than infants' only responsibility. Here in this paper, we referred to the parent(s)-infant dyads as our participants.

Infants were either in a stay at home or daycare introduced midway through the intervention. Tummy time was only documented while the infant was at home with the parents. It is possible that infants who spent time in daycare may have tummy time, but it was not recorded as tummy time practice. 10 parent(s)-infant dyads completed the intervention using the handwritten log option, and 1 family completed the intervention using both the log at the start of the intervention and switching to the application midway through for convince.

Intervention Days

The average start age of infants was 61.5 days (*SD* = 38.34 days), with a range of 31 days to 156 days old. Family completed the intervention when their infant achieved achievement of sitting milestone age (*M* =182.18 days old). The average number of days parent(s)-infant dyads were part of the study (start age – sitting milestone age) was 120.63 days with a range of 32 days to 152 days.

Daily Practice Duration

The average daily practice was 50.12 minutes (*SD* = 42.24) and ranged from 2 to 303.00 minutes [Figure 1]. Most practice average was under the daily requirement, while only 1 parent(s)-infant dyad exceeded the daily requirement. The majority of parent(s)-infant dyads (n= 8) were consistent in the amount of tummy time practice performed daily throughout the intervention. Of the remaining parent(s)-infant dyads, three increased in daily practice for the intervention (1, 4, & 6) [Figure 1].

Differences in daily cumulative duration of practice was observed between the beginning of the intervention, defined as the first 4 weeks, the end of the intervention, defined as the last 4 weeks, and the middle of the intervention, defined as the remaining weeks in between. Levene's test indicated that the variances for the daily mean duration were not equal, $F(2, 1148) = 15.71$, $p = 0.000$. Kruskal-Wallis H test confirmed very strong evidence of a difference in daily practice duration across time frames, $X^2(2) = 15.72$, $p < .000$. Dunn's pairwise tests were carried out for the three pairs of groups. The middle of the intervention significantly differed from the beginning ($p = .000$) and end ($p = .010$). The beginning did not significantly differ from the end ($p = .884$). The beginning of the intervention had the least amount of daily tummy time practice ($M = 39.39$, $SD = 19.38$) and daily practice increased in the middle ($M = 55.36$, $SD = 47.53$) but, decreased at the end ($M = 46.69$, $SD = 44.47$) [Figure 1c].

Figure 1

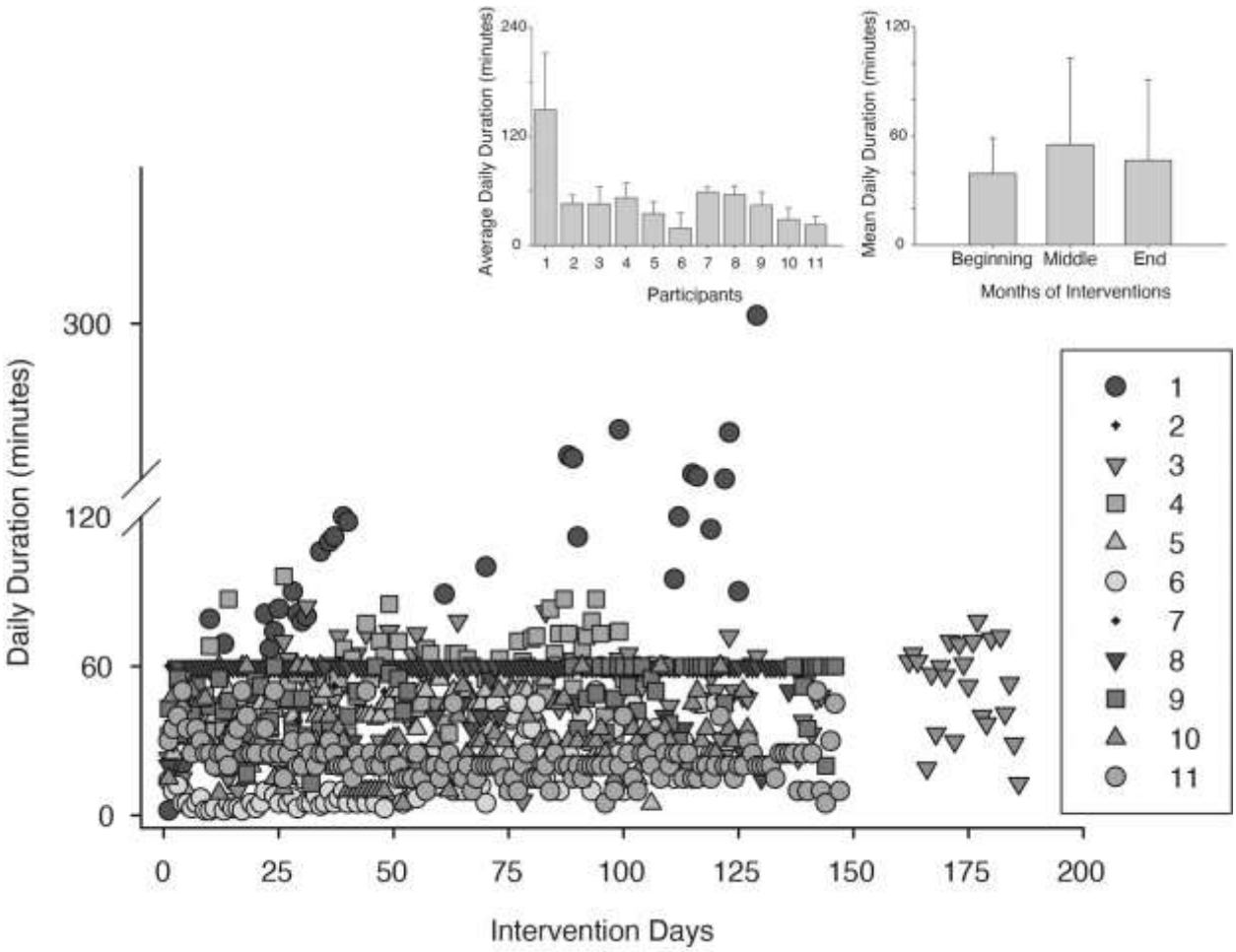

Figure 1. Accumulated duration over intervention for (A) daily practice, (B) average practice, and (C) patterns of practice. Practice patterns were compared in 3 time periods - the beginning of the intervention defined as the first month, the end of the intervention defined as the last month of the intervention, and the middle of the intervention defined as the remaining months.

Compliance of Practice Dosage

During the intervention, daily cumulative practice duration was reviewed to verify whether daily dosage meets requirements or not [Figure 2a]. The parent(s)-infant dyads completed their required dosage if they achieved the required dosage (60 minutes). From total intervention days, the percentage of complete days infants fulfilled their recommended dosage was an average of 46.3 %, with a range of 6.92 % to 96.43%. The percentage of missing days the parent(s)-infant dyads did not practice tummy time at all was an average of 18.64%, ranged from 0 % to 45.75%.

Overdosage was defined as anything over the required dosage. From total intervention days, the percentage of days that participants went over their recommended dosage was an average of 11.55%, ranged from .00% to 77.69%. Under dosage was defined as anything under the required dosage range. From total intervention days, the percentage of days that the parent(s)-

infant dyads did practice tummy time but were under the required dosage was an average of 23.51%, ranged from 0.00% to 81.08%) [Figure 2b].

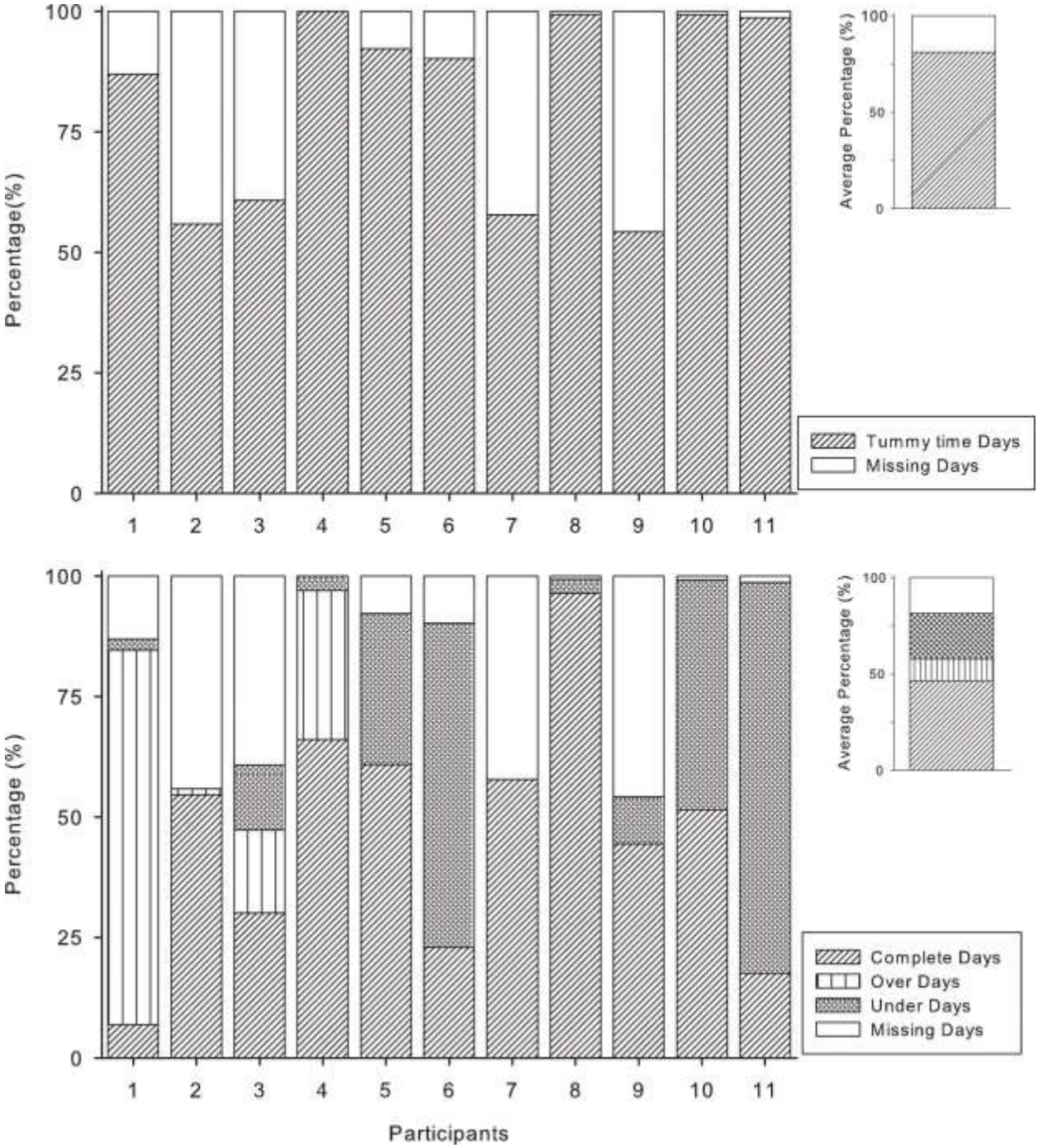

Figure 2. Compliance of practice dosage for (A) percentage of completion and missing practice days and (B) percentage of over-dosage and under-dosage practice days. Complete days were counted when infants fulfilled the accumulated 60 minutes dosage. Missing days were counted when infants did not practice at all. Over Days were counted when the accumulated daily dosage was over the required dosage. Under Days were counted when the accumulated daily dosage was lower than the required dosage. All percentages were calculated based on full intervention days.

This study's goal was to determine the feasibility of tummy time practice to parent(s)-infant dyads. It is hard to draw conclusions from the current research on tummy time practice behaviors, due to the vague tummy time recommendations and/or research methods used. Our study was one of few studies to set specific tummy time practice behavior goals and measure prospectively practice performance rather than a retrospective survey form based on parents' recall. Our results demonstrated how well the parent(s)-infant dyads committed to the prescribed dosage of tummy time practice during the early year of life, starting as early as 1 month old.

Despite the fact that parents verbally mentioned to the researchers that infants were sometimes intolerant to the position and that parents struggled to deal with their infant's crying or fussiness during the practice, parent(s)-infant dyads continued to attempt daily tummy time practice over the intervention. Even if the average duration of daily practice was lower than the imposed dosage, commitments of the parent(s)-infant dyads were high, resulting in that they missed only on average 18.63 % of the total intervention days. Unlike previous studies that used indirect education on the needs for tummy time, we directly provided specific goals to the parent(s)-infant dyads, requested practice logs, and communicated regularly with the parents about practice progress. Because of those strategies, we believe that parents were able to stick to the practice schedule and understand the importance of tummy time practice. Richard and Metz (2014) report a similar outcome, that is, parents persisted in implementing tummy time practice even when their infants cried because they understood the purpose of training [26].

The vagueness of frequency and intensity in daily physical activity in the current national guideline, might make it difficult to convey the role of early physical activity, causing parents to be deterrent to their infants' physical activity [26,27]. Without an imposed dosage of physical activity, infants were spending median 14.3 minutes per day in tummy time (ranged 8.6 – 30 minutes) at 4 months old and 34.3 minutes (ranged 0 – 120 minutes) at 9 months [17]. Compared to studies using retrospective parent questionnaires regarding tummy time practice, our average daily duration was higher than infants who were not involved in the intervention [25-27]. It is important to note that the specific dosage used in this study encouraged the parent to deliver practice environments for their infants.

Regardless of the strategies listed above, the average cumulative duration of daily practice was below the prescribed dosage [60 minutes]. Infants were in the prone position on average daily 50.83 minutes even though they attempted to be in multiple times of the day. Although our required dosage was based on the results of previous survey studies [28,31], it appears that 1-hour daily tummy time is too ambitious of a goal at least for participants at such a young age. Alternatively, a realistic duration of tummy time might be 50 minutes for non-locomotor infants, during approximately the first 6 months of life.

The patterns of practice behaviors should be considered to define realistic tummy time. In this study, the pattern of tummy time practice fluctuated rather than progressively increased over the intervention. In the early days of intervention, infants were not accustomed to the prone position, so their daily practice's cumulative duration was only half of the required dosage, which the current guideline proposed for pre-locomotor infants. As infants improved their tolerance to the position and achieved motor skills (lifting the head or chest while in prone position), average cumulative duration increased from

the beginning month of intervention but failed to meet the prescribed dosage in the middle part of the intervention. Later on, practice duration fell lower, causing a further decrease from the allotted practice duration.

Our practice patterns are inconsistent with the current national guideline for tummy time, suggesting the duration of tummy time practice gradually increase as the tolerance increases [25,27,28,32]. In a retrospective survey study, Davis et al. (1998) also reported that infants increased their daily practice from 0.5 – 1.42 hours to 2.5 - 3.7 hours over the first 6 months of life [31]. While it can only be speculated on why the current study's practice behaviors were less consistent despite the required dosage, requiring the same dosage of tummy time practice over the intervention seems too challenging goals for such a young age (1-2 months old). It seems that a more realistic recommendation for tummy time practice might be half-hour at an earlier age and increase up to 50 minutes before becoming locomotors.

Further research

Because of the small sample size with no control group, findings were presented descriptively and were required to increase sample size with control to get conclusive effects. However, our preliminary descriptive outcomes highlight few points that future researchers should consider promoting early physical activity for parent(s)-infant dyads.

The specified goal, along with a practice log and constant supports, facilitated participation in freely structured prone time starting at an early age, possibly contributing to developing good habits toward physical activity later. With a large sample size, future study should examine how encouragement tools may impact infants' participations. In the current study, parent(s) rolls during practice were not monitored. It is possible that parents' behaviors may attribute to impede practices, particularly when infants showed discomfort. Further investigation into parents' attitudes and behavior toward their infants' practice is warranted.

Additionally, parents verbalized the ease of using the *Tummy Time* application to track their infant's progress, but we did not directly measure how models of practice logs (paper vs. application) influence the actual practice performance. The *Tummy Time* application has a feature that allows parents to record the mood per each session by selecting a predetermined mood. Examining the possible effects on infants' mood during the practice could provide further insight into successful physical activity in early life.

Conclusions

Given the small sample size, the conclusive outcome could not be drawn from our preliminary descriptive findings. However, our study might advocate "tummy time" as a form of daily physical activity for young infants. The majority of participants practiced daily tummy time activity with a high adherence rate, and no one withdraws from our protocols. Tactical strategies such as clear goal setting or practice logs were definitely supportive of pursuing daily practice with young infants.

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