Published in final edited form as:

Acad Pediatr. 2021 March ; 21(2): 312–320. doi:10.1016/j.acap.2020.11.026.

Body Mass Index and Blood Pressure Improvements With a Pediatric Weight Management Intervention at Federally Qualified Health Centers

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The authors have no conflicts of interest to report.

Supplementary Data
Supplementary data related to this article can be found online at https://doi.org/10.1016/j.acap.2020.11.026.

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Abstract

Objective: The Mind, Exercise, Nutrition, Do It! 7–13 (MEND 7–13) program was adapted in 2016 by 5 Denver Health federally qualified health centers (DH FQHC) into MEND+, integrating clinician medical visits into the curriculum and tracking health measures within an electronic health record (EHR). We examined trajectories of body mass index (BMI, kg/m^2) percentile, and systolic and diastolic blood pressures (SBP and DBP) among MEND+ attendees in an expanded age range of 4 to 17 years, and comparable nonattendees.

Methods: Data from April 2015 to May 2018 were extracted from DH FQHC EHR for children eligible for MEND+ referral (BMI ≥85th percentile). The sample included 347 MEND+ attendees and 21,061 nonattendees. Mixed-effects models examined average rate of change for BMI percent of the 95th percentile (%BMIp95), SBP and DBP (mm Hg), after completion of the study period.

Results: Most children were ages 7 to 13 years, half were male, and most were Hispanic. An average of 4.2 MEND+ clinical sessions were attended. Before MEND+, %BMIp95 increased by 0.247 units/month among MEND+ attendees. After attending, %BMIp95 decreased by 0.087 units/month ($P < .001$). Eligible nonattendees had an increase of 0.084/month in %BMIp95. Before MEND+ attendance, SBP and DBP increased by 0.041 and 0.022/month, respectively. After MEND+ attendance, SBP and DBP decreased by 0.254/month ($P < .001$) and 0.114/month

($P < .01$), respectively. SBP and DBP increased by 0.033 and 0.032/month in eligible nonattendees, respectively.

Conclusions: %BMIp95, SBP, and DBP significantly decreased among MEND+ attendees when implemented in community-based clinical practice settings at DH FQHC.

Keywords

blood pressure; electronic health record; federally qualified health center; pediatric obesity; pediatric weight management intervention

In 2015–2016, approximately 30% of school-age children in Denver, Colorado, were affected by obesity (body mass index (BMI, weight [kg]/height [m]^2) ≥95th percentile for age and sex) or overweight (85th≤ BMI <95th percentile for age and sex), as defined by the Centers for Disease Control and Prevention (CDC) growth charts.[1,2] In 2019, the prevalence of obesity or overweight among children aged 2 to 18 years enrolled in Denver Health (DH) – a large, public nonprofit healthcare system associated with Denver Public Health – was 36.5% (internal communication). To address childhood obesity in their patients, in 2015 DH piloted implementation of the Mind, Exercise, Nutrition, Do It! 7–13 (MEND 7–13) program in 5 federally qualified health centers (FQHC) in the Denver metro area. MEND 7–13 is a pediatric weight management intervention (PWMI) targeting children aged 7 to 13 years that adheres to the United States Preventive Services Task Force recommendation for child obesity.[3,4] Developed in the United Kingdom (UK), this evidence-based program is packaged, publicly available for purchase, readily implementable, and thus selected by DH.[5,6] MEND 7–13 provided benefits to its participants: it decreased BMI z-scores and waist circumference in a UK randomized controlled trial,[3] demonstrated long-term positive outcomes in community settings when delivered by nonspecialists,[7] and improved BMI, cardiovascular fitness, and psychometric indices in low-income ethnically diverse United States children with overweight and obesity.[8] However, another study raised the question of MEND 7–13 effects beyond decreased adiposity.[9]

The DH MEND pilot increased access, reach, recruitment, and retention for the patient population compared to other interventions in the community; it also demonstrated significant improvement in health behaviors, BMI, body image, and self-esteem (internal communication). However, retrospective chart review of MEND participants found high rates of weight-related comorbidities, such as prediabetes, affecting approximately 50% of pilot participants (internal communication). Therefore, in April 2016, DH integrated brief medical visits with children, their parents, and designated DH FQHC clinicians, which occurred during MEND 7–13 curriculum delivery, at 1 of 2 MEND visits per week of the 10-week program. These medical visits provided individualized treatment, counseling and goal-setting related to obesity comorbidities and addressed any specific barriers or issues that were not managed in the group setting (Fig. 1). This created a new program called MEND+, in which participant ages were also expanded to 4 to 17 years. The MEND+ curriculum included 20 visits, of which a maximum of 10 were documented medical visits in the electronic health record (EHR) (hereafter termed visit; the other nonmedical encounters were not formally documented). Children obtained referrals from their primary care providers (PCP) via EHR within the DH FQHC network, typically during well child visits when discussing children's weight and growth chart. During these integrated visits, height, weight, and blood pressure (BP) measurements were entered into the participant's EHR. The clinicians' medical services were reimbursable health services and promoted program sustainability.

Though MEND 7–13 has been studied in settings of normal service delivery in the United States,[8] there are no known studies of MEND 7–13 in FQHC settings, or use of the MEND+ model in which medical visits were integrated into the curriculum. FQHCs aim to provide quality primary care for low-income, underserved, and marginalized populations.[10-12] Examining EHR data from MEND+ integrated visits created an unprecedented opportunity to examine the effects of MEND+ on childhood obesity and associated comorbidities under real-world conditions at FQHCs. This study's objective was to examine among MEND+ attendees changes in BMI percentile as a measure of weight status, as well as BP since hypertension is a comorbidity related to pediatric obesity; additional metabolic indicators of insulin resistance, hypercholesterolemia, and nonalcoholic fatty liver diseases (NAFLD) were also examined.

Methods

Study Design and Population

We examined observational data from the DH FQHC EHR on a retrospective cohort of children. Demographic and biometric outpatient data from April 2015 to May 2018 were extracted for children aged 4 to 17 years eligible for MEND+ referral (BMI ≥85th percentile) after the introduction of MEND+. Though MEND+ began in April 2016, data were included from one year prior to MEND+ implementation to capture biometric values prior to program participation. The end date was the last day of completed MEND+ programming prior to data extraction. Data were analyzed in 2018–2019.

This family-oriented PWMI welcomes "all-comers" among children aged 4 to 17 years with obesity or overweight, and siblings may join. Therefore, siblings of referred children can participate without referral themselves, even if siblings have a healthy weight. All MEND+ attendees were combined into one group after sensitivity analyses showed no differences in outcome measures with regard to referral status—whether MEND+ participants had received a formal program referral from a PCP or attended with a referred sibling — or whether the few children with healthy weight were included in the analysis. Final analytic groups were: "Attendees," any child who attended MEND+ (primary group of interest); "Referred," children who received at least one MEND+ referral but never attended; and "Eligible," children in the DH FQHC system with a BMI ≥85th percentile but did not attend nor receive a referral to MEND+.

This project was reviewed by the Quality Improvement Committee of Denver Health, authorized by the Colorado Multiple Institutional Review Board at University of Colorado, Denver, and was determined not to be human subjects' research, thus deemed exempt from Institutional Review Board review. The CDC, in collaboration with DH, implemented a retrospective program effectiveness evaluation. All EHR data were provided in a securely transferred limited dataset.

Outcome Measures

Body mass index: The use of BMI z-scores to measure changes in weight among children with severe obesity can result in erroneous conclusions due to previously described statistical limitations of z-scores.[13,14] Relative measures such as BMI % of the 95th percentile for age and sex more accurately track changes in adiposity.[14] Therefore, BMI percentile was expressed as % of the 95th BMI percentile for age and sex (%BMIp95).

***Blood pressure* (Systolic [SBP] and Diastolic [DBP], millimeters of mercury, mm Hg):** In children, hypertension is defined as SBP or DBP ≥95th percentile for age, sex, and height.[15] For BP measurements without a same day height measurement, we calculated percentiles using the closest measured height (within 3 months of the date of the measurement).[16] Designation of hypertension was based on 2017 pediatric BP guidelines.[15] BP measurements documented during primary care and MEND+ visits were included; however, those from urgent care and emergency room visits were excluded.

***Hemoglobin A1c* (HbA1c, Diabetes Control and Complications Trial units, %):** The use of HbA1c among children and adolescents with obesity has become increasingly common to screen for prediabetes and type 2 diabetes.[17,18]

***Alanine transaminase* (ALT, units/liter):** There are no definitive biomarkers of NAFLD; definitive diagnosis is made by liver biopsy and ruling out other potential causes of liver steatosis.[19] However, elevated ALT in children with obesity can be suggestive of NAFLD and is endorsed by the American Academy of Pediatrics as a screening and tracking measure for NAFLD.

***Lipids* (milligrams/deciliter):** There is an association between obesity and dyslipidemia in children, including high levels of triglycerides (TG) and low-density lipoprotein cholesterol (LDL).[20]

Covariates

Covariates included sex, race/ethnicity, age, participation in another PWMI at DH FQHC (a multidisciplinary Healthy Lifestyles Clinic [HLC], which PCPs could also refer children to), and for Attendees, FQHC site, referral status and number of MEND+ visits attended. Demographic covariates were selected at specified time points: for Attendees – first MEND+ visit (or closest antecedent time point); for Referred children – time of last referral (or closest antecedent time point), for Eligible children – the last available data point during their eligibility period for MEND+ referral.

Data Cleaning and Statistical Analyses

Data cleaning was performed in Stata 16.0 and analyses performed in SAS Version 9.4 and R Version 3.2.2. Weight and height data from the EHR were cleaned using an algorithm based on an exponentially weighted moving average method that uses the CDC growth charts and accounts for multiple errors that can occur with measurements from EHRs[21] (Supplementary Table). Thereafter, Lowess (locally weighted scatterplot smoothing) or Friedman's Super Smoother package[22,23] was applied to identify additional erroneous body weight observations not flagged by the automated algorithm (Supplementary Table). Children's %BMIp95 values were calculated using the CDC SAS Macro.[24] Clinicians reviewed BP for biological plausibility; no exclusions were made. Clinicians also reviewed laboratory values. Chi-square tests were performed to determine any significant demographic differences between groups.

We compared the average rate of change for the outcome measures before and after the initial MEND+ visit among Attendees; trajectories of BMI, SBP, DBP, HbA1c, ALT, TG, and LDL were examined pre- and postintervention. We used nested mixed-effects models[25] with random intercepts and slopes for time (coded as months before and after initial MEND + visit) and an interaction between time and an indicator variable designating measurements before and after the start of MEND+ (eMethods). These models account for all longitudinal data points for each child. The model also included sex, age, referral status, HLC participation, and FQHC site (as a nesting variable). Models for BMI change had %BMIp95 as the outcome.[26,27] Models for SBP and DBP changes included height, which is required to normalize BP levels among children. Given that mixed-effects models accounted for starting BMI and BP, it was not necessary to incorporate their baseline status into the model. We tested for nonlinear functions of BMI and BP data in the Eligible group; the relationship was linear throughout the duration of eligibility. We assessed whether other characteristics, such as number of MEND+ visits, influenced results by comparing the Akaike information criterion of nested models. The same analytic technique was used for before and after the last date of referral for Referred children and was also applied to the Eligible group; these groups were analyzed separately. Within-group changes were analyzed for each group and considered in parallel. Statistically significant values had $P < .05$.

Results

The sample included 21,408 children: 347 were MEND+ Attendees, 831 Referred, and 20,230 Eligible for MEND+ (Table 1). Among Attendees, there was an even distribution by sex; most children were 7 to 13 years old, and the majority (87.3%) was Hispanic. A similar distribution was seen in the Referred and Eligible groups, with some significant differences (Table 1). The prevalence of severe obesity (BMI percentile ≥120% of 95th percentile for sex and age) was higher among Attendees and Referred (40.6% and 44.0%, respectively), than among Eligible (15.2%) children. Among Attendees, 30.0% had BP categorized as hypertensive, as did 16.2% of Referred and 10.2% of Eligible children. The number of MEND+ visits completed by Attendees is detailed in Table 2. The mean number of MEND+ visits for Attendees was 4.2 and 17.3% attended HLC at least once; among Referred children, the mean number of referrals was 1.1 (standard deviation 0.29) and 7.5% attended HLC at least once (data not shown). We used 101,201 same-day height and weight measurements to determine BMI (eMethods) and 96,781 records with same-day SBP and DBP (Table 3).

Prior to MEND+, %BMIp95 increased by an average of 0.247/month among MEND+ Attendees (Table 4). After attending, %BMIp95 decreased by 0.087/month ($P < .001$). Attendees with referrals to MEND+ had a mean %BMIp95 of 122.5, which is 14 units higher than the mean %BMIp95 of 108.4 among those who attended without referral (data not shown). Among Referred children, before referral %BMIp95 increased by 0.233/month. After referral, %BMIp95 decreased by 0.056/month ($P < .001$). In contrast, Eligible children had a linear increase of 0.084/month in %BMIp95. Among each of the three groups, a robustness check to examine possible regression to the mean controlled for initial %BMIp95 and yielded similar and statistically significant results. Among Eligible children, a sensitivity analysis showed that if restricted to children with severe obesity at the initial measurement there is still a significant increase, although attenuated (data not shown). Overall, 67% of children showed a stabilization or decline in %BMIp95 trajectory after MEND+ attendance (data not shown). Before MEND+ attendance among Attendees, SBP and DBP increased by 0.041 and 0.022/month, respectively. After MEND+, SBP decreased by 0.254/month ($P < .001$) and DBP decreased by 0.114/month ($P = .008$). Among Referred children, before referral, SBP and DBP decreased by 0.028 and 0.008/month, respectively. After the last referral, neither SBP nor DBP significantly changed, with a decrease of 0.040 ($P = .771$) and 0.015 ($P = .484$)/month, respectively. Among Eligible children, there was a linear increase in SBP and DBP (0.033 and 0.032/month, respectively), during the study period (Table 4); among those with hypertension at their initial measurement the increase is attenuated. None of the examined characteristics substantially influenced the change in slope following the initial MEND visit (Table 5). For laboratory outcomes, there were no significant changes in HbA1c, ALT, LDL, or TG (Fig. 2).

Discussion

We found significantly decreased %BMIp95, SBP and DBP among MEND+ Attendees, with BMI percentile decreased or stabilized among two-thirds of Attendees. To our knowledge, this is the first evaluation that demonstrates not only BMI decrease, but also a statistically significant decrease of BP, in an implementation of the MEND+ model in a FQHC setting. Though a relatively small change in the slope of BP was seen, over time and with sustained lifestyle changes, this rate of decline could lead to decreases in hypertension prevalence among MEND+ attendees. At baseline, Attendees had 3 times the prevalence of hypertension (30%) compared to the Eligible population (10.2%), which could be explained by: 1) the higher percentage of Hispanic children, among whom hypertension is more prevalent,[15] 2) higher likelihood of enrollment if hypertension had previously been diagnosed. The higher percentage of Hispanic children could potentially reflect a referral bias, as 63.7% of children ages 4 to 17 across all DH FQHC in 2017 were reported to be Hispanic (internal communication). Nevertheless, this study provides evidence that MEND 7–13 based programs can improve both obesity and its comorbidities, such as higher BP, thus contributing to the existing body of literature.[7,8] Attendees, on average, attended four medical visits; few completed the full ten medical visits offered during MEND+. However, Attendees and their parents may have incorporated lessons from the intensive curriculum into their daily lifestyle and experienced improvements in both %BMIp95 and BP, even without receiving the maximum dose of the intervention though this cannot be ascertained.

A recent publication focused on MEND 7–13 in low-income, ethnically diverse populations,[8] found improvement in %BMIp95, waist circumference, cardiovascular fitness, body-esteem, self-esteem, and other physical and psychosocial measures. However, this study excluded children outside the 7- to 13-year age range, and those with serious clinical conditions, comorbidities, physical disabilities, or learning difficulties. In contrast, MEND+ has no formal exclusion criteria that prevent participation of eligible children. Our analysis shows improved BMI even when implemented with medical visits among “all-comers” in a broader age group within an ethnically diverse population. There were not enough children in the 4 to 6 years and ≥14 years groups to determine whether the intervention was more or less effective in these individual categories. Another study examined implementation of MEND 7–13 in UK community settings and followed up long-term outcomes at 2.4 years.[7] There were significant improvements in all physical and psychological outcomes except BMI z-score; however, there were differences by sex, and longer sustained outcomes among boys compared to girls. In our investigation, there was no significant difference in outcomes by sex. The present evaluation also had a shorter follow-up time—a mean of approximately 6 months after the first MEND+ visit for BMI and BP outcome data to be collected—than the 2.4 years postintervention follow-up in the aforementioned study. Whether changes in BMI and BP after MEND+ will be sustained over periods of time beyond the duration of this analysis remains to be seen.

Among Attendees, there were no significant changes in assessed laboratory outcomes. Fewer than 20% of attendees had labs both before and after MEND+ participation; therefore, the analysis was underpowered to detect a significant difference. This may be due to the relatively short duration between program initiation and the opportunity to repeat a laboratory test after MEND+. For instance, HbA1c is typically drawn as determined by appropriate clinical care, usually only every 3 months,[28] and a difference may not be detectable in a shorter time period. Laboratories such as ALT, LDL, and TG are typically ordered for Attendees at program initiation but are not often drawn immediately, since laboratories are closed during the time that MEND+ is offered in the evening. By the time these labs are drawn at a time convenient for the participants, it was often a few weeks after MEND+ initiation, and then would not be reordered by providers at graduation if there was insufficient time for a laboratory measure to show significant change. Overall, our result showing a significant change in blood pressure among PWMI Attendees, but not lipids or measures of insulin resistance, is consistent with prior reports.[29]

Referred patients also experienced a decline in %BMIp95, though less than Attendees; they did not have significant changes in BP. While there was no predefined, statistical control group for Attendees (as this study used EHR data collected at variable intervals), the Referred group was similar to Attendees by sex, age, percentage of Hispanic children, and an offer to participate in MEND+. The decline in BMI in the Referred group could have several explanations: 1) participation in HLC, the other DH PWMI (although 92.5% of Referred children never attended HLC); 2) “readiness factor[30-32] – familial or environmental supports, and in turn higher likelihood to attend and engage – perceived by clinician and also driving the child’s ability to achieve BMI reduction even without formal program participation; 3) counseling from PCPs about strategies to improve behaviors related to healthy weight, as recommended by American Academy of Pediatrics.[33,34] These possibilities should be considered, particularly given the relatively low dose of MEND+ achieved, with Attendees completing four medical visits on average. However, changes in BP among Attendees and not those Referred may suggest the education, skill building, or rigor associated with MEND+ curriculum. The BMI and BP changes within Attendees, and

BMI changes among those Referred, are notable. As a comparison, Eligible children experienced substantial and significant increases in both BMI and BP over time in a linear manner. In the absence of MEND+, this increase may have otherwise been seen among the Attendees and Referred children as part of the DH FQHC population.

This study is subject to limitations. First, this was not a randomized controlled trial, but a retrospective analysis of clinical EHR data for children attending a PWMI in FQHCs. Therefore, unmeasured factors could contribute to observed outcomes. For example, we could not account for sibling status, other shared environmental factors, or selection bias among children who attended MEND+ as opposed to those who did not. Another factor could be error in clinical measurements, although these measurements were obtained by experienced Medical Assistants who received additional training on measurements as part of MEND. Additionally, participation was not uniform among the children, the majority of whom did not attend half of MEND+ medical visits, and the EMR did not include tracking for participation in the nonmedical portions of the program. All these factors should be taken into consideration when interpreting outcomes of the study. Second, there were a limited number of laboratory values in the analyses; the analytic period postintervention was on average shorter than the analytic period pre-intervention, yielding a smaller sample of children with pre- and postintervention laboratory data, and follow-up periods also differed between groups. For future evaluations, it is important that health measures continue to be collected in MEND+ Attendees as clinically appropriate well beyond the time of program participation, to better understand long-term program outcomes. Use of EHRs will likely facilitate ongoing follow-up longitudinally and doing so could lead to better understanding the effects of MEND+. Third, unlike the DH MEND pilot, this analysis of MEND+ did not include psychometric measures such as body image, self-esteem, or health behaviors; although previous studies have demonstrated significant improved overall quality-of-life scores after obesity treatment.[29] Fourth, only a small percentage of eligible children were referred to MEND+, and a referral bias could exist that might not be accounted for in the analysis. MEND+ has addressed some barriers to program participation by allowing families to attend at no cost and encouraging PCP endorsement of the program (by presenting about MEND+ at FQHC system wide clinician meetings, providing informational and promotional material, and providing feedback about their patients who attend). Nevertheless, some barriers to participation still exist, such as transportation, parent work schedules, conflicting activities, and limited MEND+ spots to maintain adequate provider to participant ratio and program integrity. However, at the time of publication, MEND+ participation has grown to over 800 attendees (internal communication). Finally, this analysis included data from one FQHC system serving a predominantly Hispanic population in one city. Results may not be generalizable to other MEND implementations, other areas of the country, or in populations where the demographic composition significantly differs.

Conclusions

Our evaluation demonstrated significant declines in BMI and BP among MEND+ participants at FQHCs that served low-income children and families. PWMIs such as MEND +, delivered in FQHCs, might play a key role in helping children with overweight or obesity who are at higher risk for developing cardiometabolic consequences. The unique implementation of MEND+ at DH FQHCs enables the use of EHRs to track both obesity and related comorbidities longitudinally and allows for sustainable integration of medical visits into an evidence-based PWMI implemented in health care settings. The integrated medical visits create more opportunities for reimbursement for health services that offset programmatic costs and facilitate additional clinician engagement with important MEND and health-related data entry into the EHR. Further studies of MEND+ could examine the cost-effectiveness and sustainability of the model. Other health systems could consider adoption of the MEND+ model to provide an evidence-based option to assist children and families in achieving healthy weight and related outcomes.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.

Funding statement:

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

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WHAT'S NEW

This is the first study that demonstrates not only BMI improvement, but also a statistically significant decrease of blood pressure in an implementation of the MEND 7–13 program model in real world, federally qualified health center settings.

	First Hour		Second Hour
Participants	MEND Educational Curriculum	Brief Individualized Provider Visits*	Activity Time
Parents	Mind and Nutrition	Treatment, counseling and goal-setting for obesity related comorbidities	Parenting discussion
Children			Exercise

Figure 1.
Structure of MEND+ visits. MEND, Mind, Exercise, Nutrition, Do It!; *Visits integrated throughout the duration of the first hour.

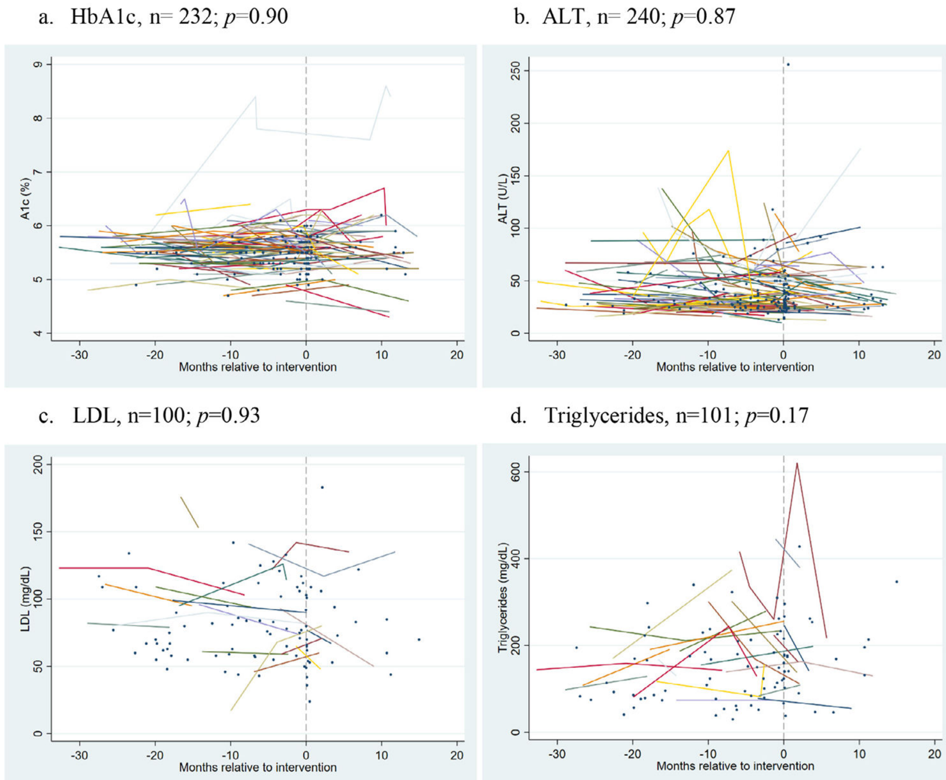

Figure 2.

Laboratory outcome measures among MEND+ Attendees, before and after MEND+ participation Denver Health, 2015–2018. The vertical dashed line represents the initiation of MEND+ intervention. Dots represent children with a single laboratory measurement, and lines represent children with multiple laboratory measurements. HbA1c, Hemoglobin A1c; ALT, Alanine Aminotransferase; LDL, Low Density Lipid Cholesterol.

Table 1.

Demographic Characteristics of Children Eligible for or Who Attended MEND+, Denver Health, 2016–2018

Demographics	Attended MEND+ n (%)	Referred to MEND+ But Did Not Attend n (%)	Eligible for MEND+ (No Referral, No Attendance) n (%)
All	347 (100) *	831 (100) *	20,230(100) *
Sex			
Male	182 (52.4)	449 (54.0)	10,407 (51.4)
Female	165 (47.6)	382 (46.0)	9823 (48.6)
Race/Ethnicity			
Hispanic	303 (87.3)	**662 (79.7)**	**14,261 (70.5)**
Black, non-Hispanic	9 (2.6)	**80 (9.6)**	**2145 (10.6)**
White, non-Hispanic	19 (5.5)	**21 (2.5)**	**1588 (7.8)**
Other, non-Hispanic	16 (4.6)	**68 (8.2)**	**2236 (11.1)**
Age (y)			
<7	32 (9.2)	74 (8.9)	**3730 (18.6)**
7–8	81 (23.3)	198 (23.9)	**2368 (11.8)**
9–10	104 (30.0)	221 (26.7)	**2656 (13.2)**
11–13	114 (32.9)	281 (33.9)	**5269 (26.3)**
≥14	16 (4.6)	55 (6.6)	**6039 (30.1)**
FQHC site			
Site 1	73	**150**	**2054**
Site 2	33	**68**	**622**
Site 3	104	**244**	**1104**
Site 4	25	**20**	**483**
Site 5	112	**342**	**5311**
Other	-	**7**	**10,371**
Weight status †			
All ‡§	347 (100) *	**829 (100)** *	**20,062 (100)** *
Normal weight	12 (3.5)	**4 (0.5)**	-
Overweight	50 (14.4)	**83 (10.0)**	**10,191 (50.8)**
Obesity	285 (82.1)	**742 (89.5)**	**9871 (49.2)**

Demographics	Attended MEND+ n (%)	Referred to MEND+ But Did Not Attend n (%)	Eligible for MEND+ (No Referral, No Attendance) n (%)
Severe obesity	141 (40.6)	365 (44.0)	**3049 (15.2)**
Blood pressure			
All	347 (100)[*]	**823 (100)**[*]	**20,005 (100)**[*]
Normotensive (BP <95th percentile)	243 (70.0)	**690 (83.8)**	**17,957 (89.8)**
Hypertensive (BP ≥95th percentile)[¶]	104 (30.0)	**133 (16.2)**	**2048 (10.2)**

BP indicates blood pressure; FQHC, Federally Qualified Health Center; MEND, Mind, Exercise, Nutrition, Do It!

Bold font indicates Chi-square test *P*-value < .05 vs Attended MEND+ group.

[*] Percentages may not sum to 100% due to rounding.

[†] Weight status defined as: overweight (85 ≤body mass index (BMI) percentile <95), obesity (BMI percentile ≥95), and severe obesity (BMI percentile ≥120% of 95th percentile).

[‡] Excludes children with implausible values for modified z-scores for weight, height, or BMI.

[§] Children with BMI percentile <85 at analytic time point not shown.

[¶] Hypertension defined as SBP or DBP ≥95th percentile. MEND+ Attendees: demographics, weight status, and blood pressure were measured at the time of their first MEND+ visit. For weight, n = 318 children had a valid height and weight on the day of the first MEND+ visit; however, for n = 29 children their weight status was missing on the first day of the MEND+ visit and was calculated as the closest BMI preceding the day of the first MEND+ visit. Referred children: data were assessed at the time of last referral, as some children received multiple referrals (n = 668). For n = 161, interpolation was necessary to identify the closest value prior to the last referral date (for 2 children values could not be interpolated because they did not have any valid measures before or on the date of the last referral). Eligible children: data were examined at the last available data point during their period of eligibility for referral to MEND+.

Table 2.

Number of Completed MEND+ Clinical Visits Among Attendees, Denver Health, 2015–2018

Number of MEND+ Clinical Visits	Number of MEND+ Attendees Who Completed Number of Visits
Total	347
1	85 (24.5%)
2	39 (11.2%)
3	39 (11.2%)
4	37 (10.7%)
5	27 (7.8%)
6	35 (10.1%)
7	35 (10.1%)
8	19 (5.5%)
9	17 (4.9%)
10	8 (2.3%)
>10	6 (1.7%)

MEND indicates Mind, Exercise, Nutrition, Do It!

Table 3.

Number of MEND+ Attendees With Outcome Measures Documented Before and After Participation, Denver Health, 2015–2018

	MEND+ Attendees						MEND+ Referred	
Outcome of Interest	**All Children Total Number of Observations**	**Before MEND+ # Children (# Observations)**	**After MEND+ # Children (# Observations)**	**Children with Values Both Before and After MEND+ (n)#**	**Mean (SD) # of Months Prior to First MEND+ Visit That Outcome Data Were Collected**	**Mean (SD) # of Months Following First MEND+ Visit That Outcome Data Were Collected**	**Mean (SD) # Months Prior to Last MEND+ Referral that Outcome Data Were Collected**	**Mean (SD) # of Months Following Last MEND+ Referral that Outcome Data Were Collected**
Body mass index	101,201	347 (2,235)	290 (1,285)	290	20.1 (9.0)	6.0 (4.7)	16.7 (10.4)	9.8 (6.4)
Systolic blood pressure	96,781	347 (2115)	289 (1232)	289	19.6 (9.0)	6.0 (4.7)	16.4 (10.4)	9.8 (6.3)
Diastolic blood pressure	96,781	347 (2115)	289 (1232)	289	19.6 (9.0)	6.0 (4.7)	16.4 (10.4)	9.8 (6.3)
Hemoglobin A1c	10,195	170 (243)	121 (146)	59	11.0 (8.5)	4.4 (4.8)	8.0 (9.3)	10.0 (6.1)
Alanine transaminase	9112	172 (235)	122 (138)	54	11.2 (8.5)	4.2 (4.6)	7.3 (8.9)	10.2 (6.4)
Low density lipoprotein	2457	77 (91)	31 (33)	8	11.0 (8.7)	3.8 (4.3)	6.1 (8.7)	7.9 (5.9)
Triglycerides	2540	78 (95)	33 (36)	10	10.9 (8.7)	3.7 (4.2)	6.2 (8.8)	7.5 (6.0)

MEND indicates Mind, Exercise, Nutrition, Do It!; SD, standard deviation.

Table 4.

Mixed-Effects Modeled Change in %BMIp95, SBP, and DBP Among MEND+ Attendees Before and After Participation, 2015–2018

	Attendees				Referred				Eligible	
Variable	**Slope Before MEND+ (mos β)**	**Change in Slope (mos*intv β)**	**Slope After MEND+**	***P*[*] Value**	**Slope Before Referral (mos β)**	**Change in Slope (mos*lastref β)**	**Slope After Referral**	***P* Value**	**Slope Over Time**	***P* Value**
% BMI of the 95th percentile	0.247	−0.334	−0.087	<.001	0.233	−0.289	−0.056	<.001	0.084	<.001
SBP (mm Hg)	0.041	−0.295	−0.254	<.001	−0.028	−0.012	−0.040	.771	0.033	<.001
DBP (mm Hg)	0.022	−0.136	−0.114	.008	−0.008	0.023	0.015	.484	0.032	<.001

BMI indicates body mass index; DBP, diastolic blood pressure; MEND, Mind, Exercise, Nutrition, Do It!; SBP, systolic blood pressure; Mos β, amount of change per month prior to point of analysis; Mos* [variable] β, amount of change in unit between prior to analysis point and after analysis point; and After, amount of change per month after point of analysis.

Model sample sizes: Attendees (BMI: n = 3520 %BMIp95 measurements from n = 347 children; SBP: n = 3347 SBP measurements from n = 347 children; DBP: n = 3,347 DBP measurements from n = 347 children).

Referred (BMI: n = 4,549 %BMIp95 measurements from n = 831 children; SBP: n = 4,389 SBP measurements from n = 831 children; DBP: n = 4389 DBP measurements from n = 831 children).

Eligible (BMI: n = 93,132 %BMIp95 measurements from n = 20,224 children; SBP: n = 89,045 SBP measurements from n = 20,067 children; DBP: n = 89,045 DBP measurements from n = 20,067 children).

[*] *P* value indicates the significance of the change in slope before and after first MEND+ visit for Attendees, and before and after last referral for Referred. For Eligible, *P* value shows the significance of the positive linear relationship between age in months and the outcome. For all, significant when $P < .05$.

Table 5.

Mixed Effects Modeled Change in %BMIp95, SBP, and DBP Over Time Among MEND+ Attendees Before and After Participation, Stratified by Characteristics, Denver Health, 2015–2018

	Change in Variable Units Per Month								
	BMI			SBP			DBP		
Population Characteristics	Slope Before MEND+ (mos β)	Change in Slope (mos*intv β)	Slope After MEND+	Slope Before MEND+ (mos β)	Change in Slope (mos*intv β)	Slope After MEND+	Slope Before MEND+ (mos β)	Change in Slope (mos*intv β)	Slope After MEND+
Sex									
Male	0.251	−0.325	−0.074	0.059	−0.412	−0.353	0.007	−0.204	−0.197
Female	0.223	−0.343	−0.120	0.027	−0.157	−0.130	0.038	−0.074	−0.036
Attendance									
With referral	0.292	−0.365	−0.073	0.019	−0.222	−0.203	0.000	−0.123	−0.123
Without referral	0.135	−0.233	−0.098	0.097	−0.522	−0.425	0.068	−0.186	−0.118
MEND+ visits									
<5	0.173	−0.126	0.047	0.023	−0.186	−0.163	0.032	−0.129	−0.097
≥5	0.352	−0.476	−0.124	0.055	−0.381	−0.326	0.007	−0.143	−0.136
HLC attendance									
No	0.221	−0.275	−0.054	0.028	−0.253	−0.225	0.002	−0.091	−0.089
Yes	0.488	−0.525	−0.037	0.106	−0.427	−0.321	0.098	−0.305	−0.207
Weight status									
<Overall median	0.132	−0.324	−0.192	0.091	−0.292	−0.201	0.065	−0.250	−0.185
≥Overall median	0.207	−0.298	−0.091	0.009	−0.237	−0.228	0.000	−0.099	−0.099

BMI indicates body mass index; SBP, systolic blood pressure; DBP, diastolic blood pressure; HLC, Healthy Living Clinic (another pediatric weight management program); Mos β, amount of change per month prior to intervention (MEND+); Mos*intv β, amount of change in unit between prior to intervention and after intervention; and After, amount of change per month after MEND+ intervention.