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ORIGINAL ARTICLE

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The effects of lifestyle changes on serum lipid levels in children in a real life setting

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Abstract

Objective: Studies have shown improvement in lipid levels after institution of lifestyle changes in children enrolled in closely monitored programs. There programs are difficult to mimic in real world clinics. We aim to determine if diet and exercise result in improvement in lipid levels in patients seen in a designated lipid clinic in a real life setting.

Design: Retrospective review of patients followed for dyslipidemia at the Texas Children's Hospital Lipid Clinic from May 1, 2012 to May 1, 2015. Patients included were seen more than once, had repeat lipid testing, and abnormal baseline lipid levels. Multivariate analysis using mixed models were performed to compare outcomes in patients who did and did not participate in lifestyle change.

Results: Of the 268 patients seen within the study period, 174 (56% male, 44% female) met inclusion criteria. Median age was 11 years. Compared to patients who did not make lifestyle changes: patients who made only diet changes demonstrated significant improvement in weight only (slope = −1.55, *P*-value = .014), and those who made only exercise changes demonstrated significant improvements in serum cholesterol (slope = −22.8, *P*-value = .017) and non-HDL cholesterol (slope = −28.7, *P*-value = < .01) levels. Patients who participated in both diet and exercise demonstrated significant improvement in weight (slope = −1.13, *P*-value = .011), diastolic blood pressure (slope = −1.82, *P*-value = < .01), and serum lipid levels: LDL (slope = −10.8, *P*-value = 0.017), HDL (slope = 1.52, *P*-value = .24), Triglycerides (slope = −0.11, *P*-value = .033) compared to those who did not make lifestyle changes.

Conclusions: Outpatient management of dyslipidemia is difficult. Only patients who participated in both diet and exercise showed significant improvement in outcomes when compared to those who did not make lifestyle changes.

KEYWORDS
dyslipidemia, lifestyle change, preventive cardiology

1 | INTRODUCTION

The relationship between increased body mass index (BMI), dyslipidemia, and cardiovascular disease has been well established in adult literature.[1–5] Since 2000, the prevalence of overweight/obese status among United States youth has been greater than or equal to 29%.[6,7] This strikingly high prevalence has raised concerns regarding the cardiovascular outcomes associated with the development of dyslipidemia early in life. Studies have demonstrated a relationship between early onset dyslipidemia and development of premature atherosclerotic coronary and peripheral artery disease in young adults as well as increased incidence of cardiovascular disease in adulthood.[8,9]

Although controversy still exists, the American Academy of Pediatrics, National Lipid Association, American Heart Association and National Heart, Lung, and Blood Institute (NHLBI) endorsed universal lipid screening for children and adolescents.[10–12] Currently, the treatment guidelines for children with dyslipidemia follow adult recommendations; which stress initiation of lifestyle changes prior to pharmacologic therapy.

This study aims to determine if lifestyle modifications were associated with improvement in serum lipid levels, blood pressure, and BMI when compared to no lifestyle modification in children seen at a designated lipid clinic in a real life outpatient setting.

2 | METHODS

We performed a cross-sectional retrospective cohort study of patients followed for dyslipidemia from May 1, 2012 to May 1, 2015 at the Texas Children's Hospital Lipid Clinic, Houston, TX, which serves as a pediatric cardiology-based preventative clinic. The clinic is staffed by a senior cardiology attending and cardiology-trained nurse practitioner with specific expertise in pediatric lipid management and cardiac preventive care. All patients seen in this clinic are counseled on appropriate diet and exercise. Dietary recommendations are based on the Cardiovascular Health Integrated Lifestyle Diet (CHILD-1), as endorsed by the American Academy of Pediatrics (AAP).[13] This diet emphasizes fat-free/low fat dairy products and increased intake of fruits and vegetables. In patients with hypercholesterolemia, a low-fat, low cholesterol, high fiber diet is recommended. For patients with hypertriglyceridemia, we recommend a diet low in simple sugars, including avoidance of sweetened drinks and fruit juice. Exercise recommendations emphasize at least 15–30 minutes of *moderate* exercise daily. Patients were excluded from analysis if follow-up lab results were unavailable or if they were loss to follow-up after the initial visit.

2.1 | Study variables

Data was obtained via review of clinical documentation and laboratory data for each patient during their course of follow-up. Baseline variables were obtained at the time of initial clinic visit and included patient's age, sex (male/female), race/ethnicity (categorized as White, African American, Hispanic, Asian, Other), etiology of dyslipidemia (familial vs. environmental), weight, body mass index (BMI), blood pressure (BP), and serum lipid levels (triglycerides, total cholesterol, HDL cholesterol, non-HDL cholesterol, and LDL cholesterol). Patient evaluation by a dietician was also noted. Familial dyslipidemia was diagnosed according to degree of serum lipid elevation. Specifically, an LDL $>$ 200 on presentation, that remained $\geq$180 despite 6 months – 1 year of lifestyle modification met criteria for a probable genetic component. Additionally, if first degree relatives had a similar/worse lipid profile and there was a history of early cardiovascular event in first or second degree relatives, the patient was deemed to have a familial type of hypercholesterolemia. For familial hypertriglyceridemia, the triglyceride level $>$1000 on presentation and remained $>$700 despite reported dietary changes.

2.2 | Outcomes

Participation with recommended lifestyle modification, assessed by the clinician (cardiologist or nurse practitioner) during the patient interview at each visit, was obtained from documentation found in the interim history portion of the clinic visit note. Patients were placed in one of the following groups depending on their endorsed participation in lifestyle modifications by the second follow-up visit: (1) Patients who participated in diet and exercise, (2) Patients who participated in diet, but no exercise, (3) Patients who participated in exercise, but not diet. A fourth group consisted of patients who reported making no lifestyle changes but continued to follow-up in clinic. Patient height (cm), weight (kg), and BMI at subsequent visits were obtained from visit documentation. Results of subsequent serum lipid levels were noted for each patient.

2.3 | Statistics

Multivariate analysis using mixed models, adjusted for age, gender, race, familial trait, and dietician evaluation were performed to compare outcomes in patients who did not participate in lifestyle changes to those who participated in one or more lifestyle changes, categorized as: diet and exercise, diet only, and exercise only. Triglycerides were log-transformed due to the presence of data outliers. All models adjusted for the same covariates based on the backwards selection approach. Parameters for the mixed model included participant ID as a random effect with random intercepts and slopes. The covariance structure used was unstructured. Two-sided *P* values were used to declare significance. The data was analyzed using SAS 9.4 (SAS Institute Cary, NC). A P value $<$ .05 was considered statistically significant. The protocol was approved by the Baylor College of Medicine Institutional Review Board.

3 | RESULTS

A total 268 patients were evaluated within the 3-year period, and nearly 40% of patients were loss to follow-up after the initial visit. One hundred seventy-four patients maintained routine follow-up and were included in the data analysis. The median age was 11 years. The mean duration of follow-up was 21 $\pm$ 11 months with a mean follow-up interval of 6 months. Over half of the patients were male (55%), and the majority of patients were either Hispanic (49%) or Caucasian (32%). Most of the patients had dyslipidemia secondary to environmental factors. Compared to patients who maintained follow-up, those where lost to follow-up were older in age, 13 years versus 11 years in the follow-up group ($P <$ .001) and were mostly male ($P =$ .018). Patient characteristics are shown in Table 1.

The majority of our patients (70%) made diet and exercise changes as instructed. Patients within this group were younger in age, 11 years, compared to patients in the diet only, exercise only, and no lifestyle change groups (Table 2). These patients, compared to those who did not make lifestyle changes, demonstrated improvements in weight (slope $= -1.13$, $P =$ .011), BMI (slope $= -0.63$, $P >$ .01), diastolic blood

TABLE 1 Patient baseline demographics

Parameter	Patients with follow-up (N = 174) n (%)	Patients lost to follow-up (N = 94) n (%)	*P* value
Median age in years (IQR)	11 (9, 14)	13 (10, 15)	<.001
Sex			
Male	97 (56.07)	67 (71.28)	.018
Female	76 (43.93)	27 (28.72)	
Race			
White	55 (31.79)	22 (24.20)	
Hispanic	84 (48.55)	45 (49.5)	
African America	16 (9.25)	16 (17.6)	.257
Asian	17 (9.83)	8 (8.8)	
Other	1 (0.6)	0	
Familial trait			
No	113 (65.32)		
Yes	60 (34.68)		
Lifestyle change			
No change in diet or exercise	19 (10.98)		
Change in diet only	18 (10.40)		
Change in exercise only	14 (8.09)		
Change both in diet and exercise	122 (70.52)		
Median (IQR)			
Weight (kg)	55 (39, 72)		
Systolic blood pressure (mm Hg)	116 (108, 124)		
Diastolic blood pressure (mm Hg)	65 (59, 71)		
Low density lipoprotein (mg/dL)	140 (98, 171)		
High density lipoprotein (mg/dL)	42 (34, 51)		
Cholesterol (mg/dL)	217 (187, 252)		
Triglycerides (mg/dL)	173 (98, 325)		
Non-HDL Cholesterol (mg/dL)	172 (140, 212)		
Body Mass Index (BMI)	24 (19, 29)		

TABLE 2 Baseline characteristics of patients who maintained follow-up by lifestyle change

Parameter	No lifestyle change N = 19 n (%)	Both diet and exercise N = 122 n (%)	Diet only N = 18 n (%)	Exercise only N = 14 n (%)	*P* value
Median age (IQR)	13 (10, 14)	11 (8, 13)	15 (11, 16)	13 (11, 14)	<.01
Sex					
Female	9 (47.4)	51 (41.8)	9 (50.0)	7 (50.0)	.84
Male	10 (52.6)	71 (58.2)	9 (50.0)	7 (50.0)	
Race					
White	5 (26.3)	39 (32.0)	8 (44.4)	3 (21.4)	
Hispanic	6 (31.6)	62 (50.8)	6 (33.3)	10 (71.4)	
African American	6 (31.6)	8 (6.6)	1 (5.6)	1 (7.1)	.04
Asian	2 (10.5)	13 (10.7)	2 (11.1)	0	
Other	0	0	1 (5.6)	0	
Familial trait					
No	18 (94.7)	69 (56.6)	13 (72.2)	13 (92.9)	<.01
Yes	1 (5.3)	53 (43.4)	5 (27.8)	1 (7.1)	
Dietician					
No	8 (42.1)	61 (50.0)	12 (66.7)	7 (50.0)	.49
Yes	11 (57.9)	61 (50.0)	6 (33.3)	7 (50.0)	

TABLE 3 Multivariate analysis of outcomes by lifestyle change compared to no lifestyle change

Outcome[a]	Change in diet and exercise		Change in diet only		Change in exercise only	
	Slope (SE)	*P* value	Slope (SE)	*P* value	Slope (SE)	*P* value
Weight (kg)	−1.13 (0.44)	.011	−1.55 (0.62)	.014	−0.87 (0.69)	.208
SBP (mm Hg)	−0.84 (0.96)	.382	1.92 (1.82)	.293	−0.40 (2.04)	.844
DBP (mm Hg)	−1.82 (0.64)	<.01	1.54 (1.39)	.269	−1.78 (1.56)	.255
LDL (mg/dL)	−10.8 (4.48)	.017	9.60 (10.69)	.370	−20.6 (10.49)	.051
HDL (mg/dL)	1.52 (0.67)	.024	−1.53 (1.36)	.261	0.09 (1.45)	.949
Cholesterol (mg/dL)	−17.0 (4.30)	<.01	−6.55 (9.39)	.486	−22.8 (9.44)	.017
Triglycerides (mg/dL)[b]	−0.11 (0.05)	.033	0.01 (0.09)	.941	−0.17 (0.09)	.078
Non-HDL (mg/dL)	−18.1 (4.34)	<.01	−9.79 (9.25)	.292	−28.7 (9.67)	<.01
BMI	−0.63 (0.16)	<.01	−0.37 (0.23)	.106	−0.44 (0.25)	.079

Note: Predictor = Lifestyle changes (Yes vs. No)
[a]All mixed models were adjusted by age, sex, race, visits, familial trait, change of medicine, and see dietician. Backward method was applied for model selections
[b]Logarithm transformation.

pressure (slope = −1.82, $P < .01$), LDL (slope = −10.8, $P = .017$), total cholesterol (slope = −17, $P < .01$), non-HDL cholesterol (slope = −18.1, $P < .01$), and HDL cholesterol (slope = 1.52, $P = .024$), noted in Table 3.

Figure 1 shows the comparison of serum lipid levels per visit of patients who participated in both diet and exercise and those who did not make lifestyle changes. Patients who made lifestyle changes demonstrated a statistically significant decrease in serum total cholesterol, triglyceride, and non-HDL levels per subsequent visit when compared to those who did not make lifestyle changes. In patients who made diet and exercise changes, HDL increased compared to patients who did not make lifestyle changes in whom HDL remained the same per visit.

Although patients who did not make lifestyle changes initially presented with lower serum LDL (median: 137 mg/dL) than those who made diet and exercise changes (median: 144 mg/dL), those who made lifestyle changes demonstrated a significantly decreasing serum LDL per visit compared to those who did not make lifestyle changes (Figure 1).

Ten percent of patients made recommended diet changes without participating in exercise. Patients within this group were older in age, median 15 years, than patients in the other three groups (Table 2). This group demonstrated a statistically significant improvement in weight (slope = −1.55, $P = .014$) when compared to patients who made no lifestyle modifications. Although there was a trend toward a decrease in BMI in these patients, when compared to those who did not participate in lifestyle changes, this did not reach statistical significance (slope = −0.37, *P*-value = .106). Additionally, significant improvements in blood pressure, and serum lipid levels were not seen despite weight reduction as noted in Table 3.

A slightly lower proportion of patients, 8%, participated in recommended exercise regimens without making dietary changes. These patients showed statistically significant improvements in total cholesterol (slope = −22.8, $P = .017$) and non-HDL cholesterol (slope = −28.7, $P < 0.01$) when compared to those who did not participate in exercise. HDL cholesterol, weight, BMI, and blood pressure did not differ significantly between the two groups as shown in Table 3.

4 | DISCUSSION

The benefits of diet and exercise with regards to cardiovascular health and serum lipid levels have been well documented in pediatric literature.[14–16] These studies involved closely monitored or residential programs with frequent follow-up visits (Table 4).[14–18] Although ideal, such programs are difficult to mimic in the real-life setting where maintaining follow-up proves difficult and ensuring compliance to recommendations, near impossible. The Active for Life Year 5 (AFLY5) study, a 12-month school-based intervention to increase physical activity and fruit/vegetable consumption, illustrates this point. Despite intense education of teachers, students, and parents, 60% of participants reported accelerometer data and only 23% wore the accelerometer for the requested amount of time.[19]

In our clinic, over one third of patients were lost to follow after the initial visit, and of those who maintained follow-up, 11% did not participate in treatment recommendations. We found that compared to the patients who maintained follow-up, the group of patients who were lost to follow-up were predominantly male and were older in age. Interestingly, patients who did not make lifestyle changes but maintained follow-up were similar in age (median of 13 years old) to those who were lost to follow-up. Social and psychological development may play a role as early adolescence, around age 12–14 years, is associated with increasing independence from parents.[20] With this in mind, it may be helpful to consider these developmental changes while counseling the patient and family by focusing on increasing patient responsibility with regards to treatment compliance while also encouraging pro-active parental involvement.

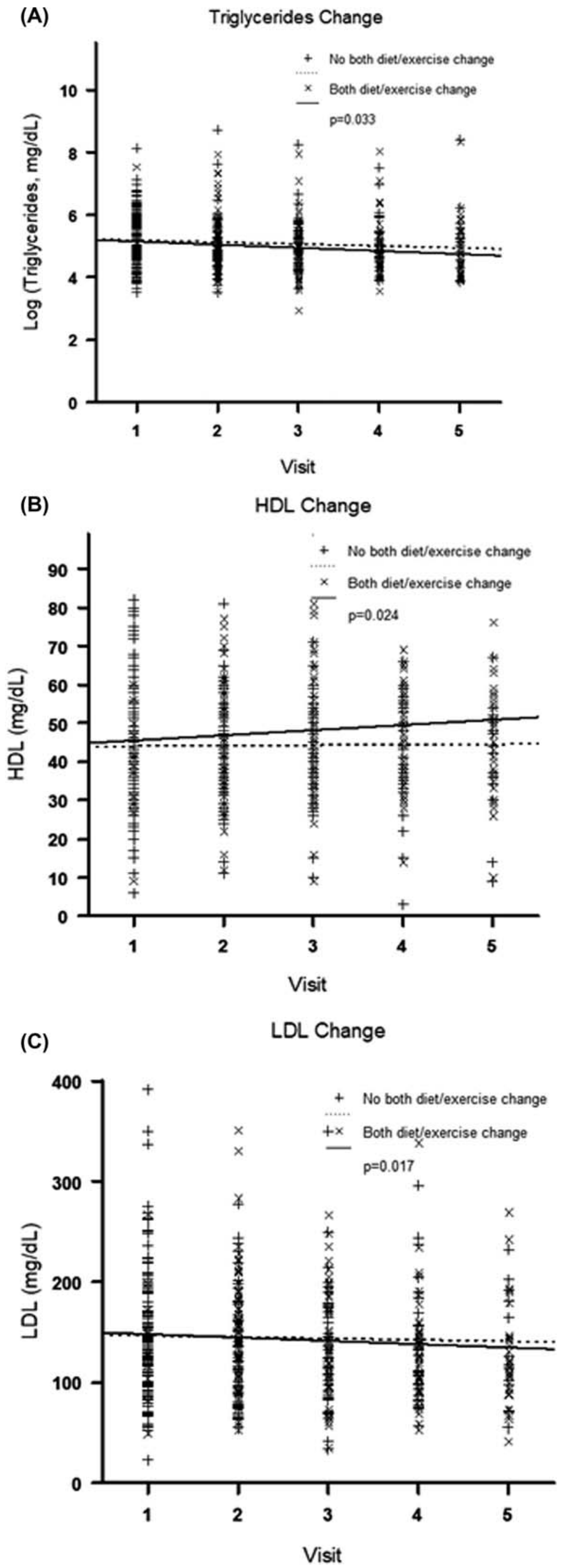

FIGURE 1 Series of graphs comparing trends in median serum lipid levels per visit between patients who participated in diet and exercise versus no lifestyle changes. **A**, Trend in serum triglycerides per visit. **B**, Trend in serum HDL cholesterol per visit. **C**, Trend in serum LDL per visit

Worldwide, children do not achieve the recommended 60 minutes of daily physical activity.[21–23] More than 2 hours of sedentary behavior per day has been associated with increased risk of hypertension.[24] In the REACH Y6 study, systolic blood pressure readings were significantly higher in inactive children than their active peers.[25] The Helena study demonstrated that increased physical activity and decreased sedentary behavior was associated with lower systolic blood pressure readings in children and adolescents with normal BMI.[26] The KLAKS study findings were similar for obese children and adolescents.[27]

The majority of our patients who maintained follow-up adhered to both diet and physical activity recommendations. This group experienced statistically significant improvement in weight, BMI, diastolic blood pressure, total cholesterol, non-HDL, LDL, and HDL cholesterol levels. Our findings are consistent with pediatric lifestyle intervention study results which demonstrate the largest improvements in serum lipid levels after institution of diet and exercise changes.

The results of our study underscore several points. First, the loss to follow-up rate was significant in our cohort of patients, and of those who maintained follow-up, a notable percentage of patients did not make lifestyle changes. Second, although our recommendations focused on institution of both diet changes and increased physical activity, nearly one fifth of patients made changes to diet alone or exercise alone. These patients showed very similar outcomes when compared to those who participated in no lifestyle changes. Third, although the first two points highlight the difficulty of outpatient lipid management, we found it promising that over two-thirds of patients who maintained follow-up made both diet and exercise changes. This group of patients had significantly different outcomes from those that did not make lifestyle changes.

5 | LIMITATIONS

The results of our study are subject to the inherent limitations of retrospective cohort studies, including self-reporting bias, and selection bias. However, the goal of this study was to evaluate outcomes utilizing a real-life patient care setting in which strict surveillance of patient compliance is not readily available. In this setting, DiMatteo and colleagues demonstrated that 26% more patients experienced a positive outcome by adhering than by not adhering to medical therapy.[28] With this in mind, it is possible that this study underestimates the benefits of lifestyle changes. Furthermore, although we saw few improvements in outcomes within the diet only and exercise only groups, this may be related to the relatively small sample size resulting in insufficient power to reach statistical significance. Although we did not adjust for multiple comparisons which could result in a Type I error, the outcomes of our study are consistent with those of previous studies which demonstrated similar improvements in serum lipid levels, weight, and BMI after institution of lifestyle changes.

TABLE 4 Methods used for lifestyle modifications in previous studies

Study	Program length	Dietary intervention/frequency of follow-up	Exercise intervention/frequency of follow-up
Woo et al. *Circulation* 2004[14]	52 wks	Scheduled dietician interviews as follows: Week 1–6: biweekly Week 7–52: bimonthly	Fitness assessment prior to program start Customized training prescribed by training physiotherapists In-hospital training sessions (75 mins) with schedule as follows: Week 1–6: biweekly Week 7–52: once weekly
Nemet et al. *Pediatrics* 2005[17]	12 wks	Age appropriate hypocaloric diet 6 dietician meetings over 3 months	Twice weekly (1 h) training sessions with a professional youth coach at a training center and extra 30–45 mins at least once per week
Jiang et al. *Arch Dis Child* 2005[18]	2 ys	Dietary counseling Pediatrician home visits once per month	20–30 mins of exercise per day four days per week. Monitored by physical education teachers after class and parents during weekends, vacations, and holidays
Chen and Barnard. *Metabolism* 2006[15]	2 wks	Residential program with prepared meals	2-2.5 h of supervised activity per day
Opina et al.	Median follow-up: 21 mo Follow-up interval: 6 mo	Dietary counseling based on the CHILD-1 diet endorsed by the AAP	Recommendations for 15–30 mins of moderate exercise daily

6 | CONCLUSION

The effects of lifestyle modifications on reducing cardiovascular risk factors has been well documented in children and adolescents who are enrolled in programs with frequent follow-up and monitoring to ensure compliance. The goal of our study was to evaluate whether lifestyle modification improved these measures in patients seen in an outpatient environment with less rigorous monitoring. We demonstrate that improvements in serum lipid levels, weight, and BMI are feasible with lifestyle modifications even when instituted in an outpatient setting. However, providers should be aware of the significant high loss to follow-up and noncompliance rate and adjust their approach to patients who are thought to be high risk for noncompliance.

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CONFLICTS OF INTEREST

None.

AUTHOR CONTRIBUTIONS

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