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Research Paper

A Prospective Cohort Pilot Study to Appraise Growth, Physiological, and Postural Disorders in Children and Adolescents

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Abstract

The purpose of this study was to assess the growth, physiological, and postural disorders in children and adolescents aged 8 to 18 years old. We planned our study based on the pilot and the main steps, via the population of school students who were invited for the MPCS screening programme. In the present study, 424 school students in Malard city were recruited for the pilot phase of the MPCS that included children (35.55%) and adolescents (63.44%). The outcomes of the study were postural disorders and impaired fasting glucose (IFG) or prediabetes. From a statistical viewpoint, HDL-c, PLT, and WBC were significantly correlated to FBS in all interred models. The rate ratio of children for the risk of IFG was 1.05. The analyses revealed that approximately 1.4 percent of participants had no postural deformity, 30.4 percent of participants had five to nine

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deformities, and the remaining subjects had at least one to four deformities. The incidence of postural disorders and pain were about one- and two-fold higher in adolescents than children. In conclusion, the MPCS indorsed that children did not have height deviations, compared to the standard norms, but adolescents had deviations compared to the CDC's norms. We found that the adolescents' mineral and protein contents were important factors to improve their health as well as to avoid the postural deformities. Accordingly, we demonstrated that several body functional variables involved curl-up, 800-meter, and pull-up were potential risks for the postural disorders.

Keywords: Cohort Study, Growth, Pediatric Pain, Postural Deformities, Prediabetes

Implications and Contribution

This study appraises growth, physiological, and postural disorders in Iranian young population aged 8 to 18. Mineral and protein nutrient status and physical activity programs are important for children and adolescents and should be implemented as risk factors to improve our adolescents' health as well as to avoid postural deformities.

Growth monitoring and follow-up (longitudinal study) are key parts of the pediatric and adolescent assessments of growth and developmental patterns. In this regard, parents, pediatricians, and health professionals would like to know more about whether children and adolescents are able to sustain growth velocity or achieve catch-up in growth compared to the healthy children and adolescents included in the growth standards (1).

Therefore, the evaluation of growth velocity in terms of body composition may also facilitate comparison through the use of standard growth norms to recognize likely deviations since deviations from standard early growth patterns are regarded as central risk factors for adult abnormalities (2). Growth deviations also may be illustrated as a SD from the standard population mean for children and adolescents of comparable age and sex; children and adolescents with height below two SD from the mean are usually categorized as a short stature (3). Nonetheless, these considerations in children and adolescents are divergent. Numerous gaps also exist in our understanding regarding the childhood or adolescence physiological developments including muscles and strength development, aerobic, anaerobic, and performance capacities (4), body composition (5), obesity, blood lipids, glucose profile (6), white blood cell (WBC), and red blood cell (RBC) counts (7).

Posture has likewise been explained as the body segment alignment of the trunk, pelvis, and thigh at a particular time and sequence and is an accentuated health indicator (8). It has been illustrated that childhood- or adolescence-related poor posture is well-recognized as an imperative risk factor for the adulthood body pain

(9). Besides, the previous studies have demonstrated a large pervasiveness of back postural deviations in the children and adolescents with head and shoulder forwarding postures being two of the most popular postural deviations. In this concern, there is likewise a robust relationship between musculoskeletal pain (MSP) and postural deviations (8). Fractures in childhood and adolescence also have long been contemplated as inescapable outcomes of growth (10).

Despite the above considerations, in our experience, the present classification of young participants into children and adolescents, and growth, developmental, physiological, functional, MSP, and postural evaluations simultaneously are obligatory to determine the optimal growth rate in satisfying both children' and adolescents' needs. Since there are important and ambiguous interrelationships between the above mentioned factors and postural disorders in children and adolescents, only a longitudinal study can afford the insight to define causality. For instance, it has also been demonstrated in previous studies that there is coevolution between WBC count and metabolic syndrome in adolescents (11), but its tracking changes from childhood to early adulthood is not entirely known or yet remains totally unknown. Moreover, only one Iranian longitudinal study (CASPIAN-2010) has investigated changes in adolescents. However, not only main developmental and physiological aspects, especially from childhood to adulthood, were not conducted, but also musculoskeletal, functional, and postural aspects of childhood and adolescence were not dealt with in that study because of some investigational problems in the study protocol and aims (12). Although the body of studies on the childhood and adolescence are growing, there are crucial requirements for studies that assess the process of children growing up using childhood to adolescence development and life-course perspectives (13). Entirely, according to the Statistical Centre of Iran, roughly 15.2% of Iran's total population is between 15 to 24 years old, so it means Iranian population is relatively young (14). Accordingly, efficient, sustainable, easy performable, and utile growth cohort studies are needed to accommodate necessary support for the special needs of the children and adolescents that the majority of these considerations were included in the MPCS as well. Therefore, the primary purpose of this cohort pilot study was to evaluate the growth, physiological, and postural disorders in children and adolescents aged 8 to 18 years old. The second goal was to assess whether growth-related factors of childhood and adolescence are related or mediated by pediatric-related disorders. The third aim was to evaluate the feasibility of this pilot cohort study and its perceived usefulness. The fourth and last goal of the MPCS was to afford a multidimensional study design to be employed in the developmental studies of cross-sectional or nested case-control investigational model.

Methods

Target Region and Population

The MPCS encompassed children and adolescents in Malard from roughly 70,000 school students in Tehran province, Iran. Malard (35°42'02"N 50°59'35"E), with a total population of approximately 400,000 inhabitants, is located in an area of 960 km^2 on roughly 50 km west of Tehran and comprises two districts, one rural district, and 56 villages. The MPCS is an Iranian cohort study that its main goal is to provide a cohort of 5,000 school students (primary, middle, and high school) in both sexes between the ages of 8 and 18 years at baseline. These school students will also be followed for at least 10 years. Unfortunately, up to now, there is no unison on the precise borders in determining children and adolescents populations. Since collecting data on these populations, for practical reasons, the extant research have also used chronological age to explain these borders; children ≤12 years and adolescents 13 to 18 years (15). Therefore, this study used the current age-related boundaries for our school student population.

Study Design

The baseline MPCS survey was accompanied in August 2015, the main data were collected between February and December 2016, and follow-up surveys have as well been planned at one and three years later (pilot study and main steps, respectively). In this regard, the core information assortment is obtained on all 5,000 school students at three-year step (based on the following calculation).

Parents of 5,000 participating children are asked to complete a central set of information on demographic factors comprising the Persian versions. Written informed consent is also provided by all participant's parents or guardians prior to the clinical interview and data collection, and for security purposes, participants' identity will be kept confidential. As well, collected data were identified and analyzed anonymously. Additionally, the MPCS's protocol was approved by the ethical and scientific committee at the authors' institution and confirmed to internationally accepted ethical standards.

The researcher planned the study based on the pilot and the main steps, via the population of school students who were invited for the MPCS screening programme. A schematic flowchart of the MPCS design and participation is illustrated in Figure 1. Prior to initiating the main steps of the MPCS, a pilot study was conducted to collect information about typical growth, developmental, physiological, functional, MSP, and postural factors in the potentially participating communities (primary, middle, and high school students). In the pilot study phase, 1108 boys took part in the MPCS for subsequent screening. In this phase, 62% of participants were excluded because of exclusion criteria, unwilling to cooperate, loss of contact, and inability to participate. As displayed in Fig.1, the pilot study was essentially conducted during the incipiency of the MPCS (Fig.1; gray box, n=424) and added to the first step of the MPCS (Fig.1, dash line). Finally, the main follow-ups are also obtained ~ 3 years - according to our investigational calendar - to follow growth trends from childhood to early adulthood (Fig.1, dot lines). In this study, 424 school students were recruited for the pilot phase of the MPCS that included children (n=155, approximately 35.55%) and adolescents (n=269, almost 63.44%).

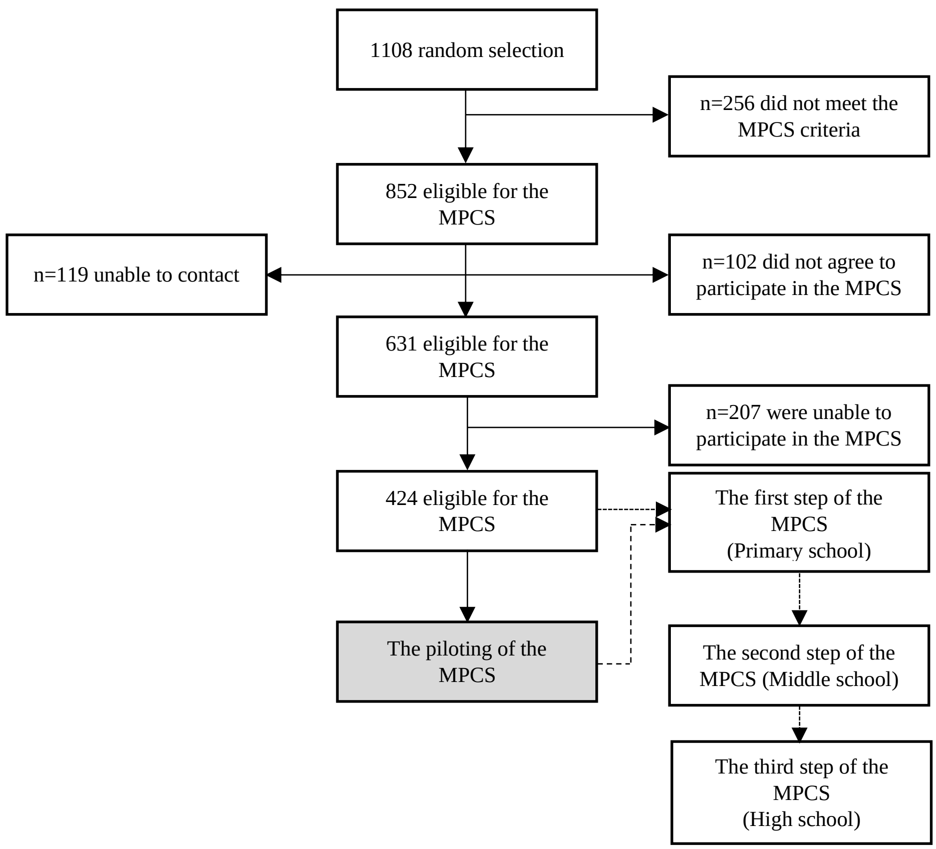

Figure 1. A schematic flowchart of the MPCS design and participation.

Exclusion Criteria

The MPCS exclusion criteria were: 1) participants aged less than 12 years or aged more than 18 years old; 2) unwritten informed consent; 3) unwillingness to participate in the study; and 4) unregistered for the schools of Malard educational region /temporary resident.

Outcomes

The postural deformities and pain during the piloting phase of the MPCS, as a first outcome, were assessed by the postural measurement tools and TNMQ-S as mentioned in the confounders section with their related specific categories. Another potential outcome in the pilot of MPCS was impaired fasting glucose (IFG) or prediabetes diagnosed as fasting plasma glucose (FPG) of 91 to 99 mg/dL (16).

Confounders

Possible confounders for the postural deformities and pain included upper- and lower-limb muscular endurance capacities, height, BMI, obesity index, skeletal muscle mass, bone mineral content, muscle protein content, ROM, and bone breadths. Besides, potential confounders for IFG or prediabetes involved BMI, obesity index, basal metabolic rate (BMR), waist circumference, hip circumference, waist-to-hip ratio (WHR), and blood lipid profile.

Body Composition Variables

Body height and sitting height of the children and adolescents in centimeters (cm) were measured to the nearest 0.1 cm using a transportable stadiometer (Soehnle; Soehnle Industrial Solutions, Germany). The children and adolescents' body weight (to the nearest 0.1 kg), total body water (TBW), mineral (TBM), and protein (TBP), body fat percent (BFP), and skeletal muscle mass (SMM) were also assessed in the morning and thermoneutral conditions on the bioelectrical impedance analyzer or BIA (InBody 270, Biospace, South Korea). According to the measured weight and height of the participants, obesity index (OI = (Current Weight / Standard Weight) × 100), body surface area (BSA =Weight0.425 [kg] × Height0.725 [cm] × 0.007184), and body mass index (BMI = Weight [kg] / Height [m] 2) were calculated. Waist circumference was also estimated using a circumference measuring tape (Seca 200, Germany). Hip circumference was also measured at the halfway between the iliac crest and the greater trochanter to the nearest 0.1 cm with a portable tape (Seca 200, Germany). Furthermore, the waist-to-hip ratio was computed by dividing the ratio of waist circumference to hip and height (cm) circumferences, respectively. Likewise, arm length and wrist circumferences were measured using a transportable tape (Seca 200, Germany).

Postural and Pain Variables

The biepicondylar humerus and femur bone widths were as well assessed using a digital caliper (INSIZE, Brazil). The ipsilateral hip and shoulder extension active-ranges of motion (Act. ROM) (17) were also measured by a 30 cm steel goniometer (Saehan, Korea). In the MPCS, foot posture was ascertained using a 2D foot scanner (Voxelcare, Spain) and defined by a foot type classification according to the method of Sneyers et al. as previously determined (18). Briefly, under working foot scanner, pes rectus, pes planus, and pes cavus were recognized through an evaluation of the midfoot contact area as well as quantification of the lower leg–heel and forefoot–heel alignments. The clinical tibiofemoral angles (TFAs) for determining of the genu varum and genu valgum were likewise measured via a goniometer (Saehan, Korea), while the participants were placed in the upright position in front of a digital video camera (Canon IXUS 185, Japan). In this regard, the children and adolescents were asked to stand assuring full extension and neutral rotation at the hips and knees while the knees or ankles reached each other closely. It must be noticed that a valgus and varus TFAs were determined as negative and positive values, respectively (19). Body posture evaluation for defining of the lordosis, kyphosis, scoliosis, uneven and rounded shoulder, and forwarding head posture were likewise measured using a computer-based system with a digital camera (Canon IXUS 185, Japan), while the participants were positioned in a standing position in front of the digital camera. In this study, the spine curvature index (CI) was used to classify the participants as with and without postural defect as described elsewhere previously (20). In the current study, we used the Teen Nordic Musculoskeletal Screening Questionnaire (TNMQ-S) to determine the prevalence of musculoskeletal and pain symptoms, in addition to the above evaluations (21).

Biochemical Variables

In addition to the body composition and postural variables, blood samples were taken at 8:00 hours in the morning from an antecubital vein in a sitting position. Blood samples were then centrifuged (5810, Eppendorf, Germany) at 2400×g (8°C, 5 min), and maintained at -80°C. Blood samples were as well defrosted at room temperature and analyzed using a Clinical Biochemistry Analyzer (Auto Analyzer Alpha Classic, Azma Co, Ir). At that moment, levels of triglyceride, total cholesterol, HDL-c, LDL-c, and finally, fasting plasma glucose (FPG) were likewise assessed by standard biochemical methods using commercial ELISA kits (Parsazmon Co, Ir). In this regard, VLDL-c, cholesterol-to-HDL ratio, and LDL-to-HDL ratio were ascertained from the following formulas: VLDL-c = TG/5, cholesterol-to-HDL ratio = TC/HDL, and LDL-to-HDL ratio = LDL/HDL (22). The ABO blood groups were also defined on the basis of agglutination reaction within 5 minutes of mixing. WBC, RBC, platelet, hemoglobin, and hematocrit levels were determined on an automatic hematology analyzer (Sysmex Co, Japan).

Body Functional Variables

On this point, we planned to acquire the functional variables of school students that were as well evaluated by functional tests included agility, lower-extremity explosive strength, upper- and lower-limb muscular endurance capacities, anaerobic power, and anaerobic capacity. In this regard, 60 m sprint test was performed in an indoor rubberized track to assess the anaerobic power of school students (23). For evaluation of anaerobic capacity, 800-meter running performance was used to appraise this capacity in the school students (24). Furthermore, upper- and lower-limb muscular endurance capacities were likewise assessed using pull-up and curl-up, respectively (25). The lower-extremity explosive strength was assessed by the standing long jump test (25). Moreover, the shuttle agility run test was accomplished to quantify the agility performance (26).

Statistical Analysis

In this study, all findings are demonstrated as mean ± SEM (continuous random variables) and percentage (discrete random variables) for each group. Statistical analysis was also accomplished using a Statistical Analysis System (SAS) software, version 9.2 (SAS Institute, USA). For the analysis of the MPCS's inferential statistics, logistic and linear regressions were done with the Enter method and adjusted for random effects to produce the odds ratios (OR), 95% confidence intervals (95% CI), and p values. In other words, in each step of the process, the most crucial variable, in a statistical point of view, was the one that created the largest change in log-likelihood in the association of the Enter model. In the MPCS, we also used the independent-sample t and chi-square tests for parametric and nonparametric variables, respectively, to illustrate what are the significant age-related growth differences between the children and adolescents' populations. The first set of analyses as well consisted of two major phases. In the first phase, FPG was set as a dependent variable while we generated three models for it. In model one, we adjusted the analyses for the blood factors such as total cholesterol, HDL-c, TG, LDL-c, VLDL-c, WBC, RBC, Hb, HCT, PLT, cholesterol to HDL-c ratio, and LDL-c to HDL-c ratio. In Model two, we furthermore adjusted the analyses for the body composition variables (such as model one + WHR, height, obesity index, percent body fat or PBF, total body mineral or TBM, body fat mass, total body protein or TBP, trunk fat percent, trunk fat mass, total body water or TBW, BMI, and skeletal muscle mass or SMM). Eventually, in model three, we additionally involved the body functional variables (such as model one + model two + 60-meter dash, 800 meters, agility, long jump, curl-up, and pull-up).

Results

The results of blood biochemical, body composition, and body functional variables in the children and adolescents populations and the findings from between-group comparisons are shown in Table 1.

The results of blood biochemical, body composition, and body functional variables in the children and adolescents populations and the findings from between-group comparisons are shown in Table 1. Regarding the blood factors, there were significantly reduced HDL-c levels in the adolescents when compared to the children ($p<0.05$; Table 1). Likewise, we observed a significant diminish in WBC in the adolescents as compared with the children ($p<0.05$; Table 1). Similarly, Hb was significantly declined in the adolescents when compared to the children ($p<0.05$; Table 1). However, hematocrit percent was significantly raised in the adolescents compared with the children ($p<0.05$; Table 1).

Concerning the body composition, the researcher besides saw a significant increase in height, weight, TBW, TBP, TBM, FFM, SMM, and BMR of the adolescents as compared with the children ($p<0.05$; Table 1). Nevertheless, there were statistically significant reductions in BFP and obesity index of the adolescents as compared with the children ($p<0.05$; Table 1). There were also significantly elevated sitting height, arm span, elbow width, and wrist circumference variables in the adolescents as compared with the children ($p<0.05$; Table 1). Moreover, there were significant increases in all body functional variables of the adolescents when compared to the children ($p<0.05$; Table 1).

Table 1. The blood biochemical, body composition, and body functional variables of the MPCS's children (n=155) and adolescents (n=269) populations.

	All (N=424)			Children (n=155)			Adolescents (n=269)		
	Mean	SEM	%*	Mean	SEM	%*	Mean	SEM	%*
Blood group									
A			34.2			27.7			37.9
B			4.5			4.5			4.5
AB			24.8			32.9			20
O			36.5			34.8			37.6
FBS (mg/dL)	91.55	0.42		91.8	0.77		91.4	0.488	
IFG			57.5			59.4			56.5
Non-IFG			42.2			40.6			43.5
Total Cholesterol (mg/dL)	143.7	1.24		146.5	2.08		142.1	1.54	
TG (mg/dL)	98.2	2.11		94.5	3.62		100.2	2.59	
HDL-c (mg/dL) †	50.99	0.61		52.59	1.11		50.06	0.72	
LDL-c (mg/dL)	73.19	1.15		75.3	1.97		71.98	1.41	
VLDL-c (mmol/L)	19.62	0.42		18.9	0.72		20.03	0.519	
Cholesterol to HDL-c ratio	2.94	0.034		2.93	0.059		2.95	0.04	
LDL-c to HDL-c ratio	1.53	0.03		1.54	0.052		1.528	0.035	
White blood cells (/mm^3) †	5.01	0.12		6.02	0.18		4.43	0.14	
Red blood cells (Mill/mm^3)	5.02	0.03		5.02	0.056		5.01	0.44	

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	All (N=424)			Children (n=155)			Adolescents (n=269)		
	Mean	SEM	%*	Mean	SEM	%*	Mean	SEM	%*
Hemoglobin (g/dL) †	15.91	0.51		17.44	1.17		15.03	0.44	
Hematocrit (%) †	43.99	0.5		41	0.68		45.7	0.67	
Platelet (1000/µL)	267.5	3.47		276.2	5.45		262.5	4.46	
Height (cm) †	156.84	0.54		151.6	0.81		159.8	0.64	
Weight (kg) †	51.08	0.68		47.59	1.03		53.09	0.87	
Total body water (L) †	28.57	0.31		25.8	0.41		53.09	0.87	
Total body protein (kg) †	7.63	0.085		6.88	0.1		8.06	0.11	
Total body mineral (kg) †	2.66	0.3		2.4	0.04		2.81	0.038	
Body fat mass (kg)	12.2	0.41		12.5	0.66		12.04	0.53	
Free fat mass (kg) †	38.87	0.43		35.09	0.56		41.05	0.56	
Skeletal muscle mass (kg) †	21.03	0.259		18.77	0.33		22.34	0.3	
Body mass index (kg/m^2)	25.52	0.2		20.42	0.34		20.58	0.265	
Body fat percent (%) †	12.2	0.41		24.08	0.86		20.99	0.66	
Basal metabolic rate (kcal) †	1209.6	9.35		1127.9	12.11		1256.7	12.1	
waist to hip ratio	0.81	0.003		0.808	0.004		0.815	0.003	
Obesity index †	110.98	1.125		114.13	1.8		109.1	1.4	
Trunk fat mass (kg)	5.5	0.22		5.6	0.36		5.43	0.288	
Trunk fat percent (%)	190.15	7.59		209.5	13.06		178.96	9.45	
60-meter dash (s) †	10.67	0.09		10.98	0.16		10.49	0.1	
800 meters (min) †	2.97	0.075		3.27	0.13		2.79	0.09	
Agility (s) †	11.66	0.01		11.82	0.083		11.57	0.055	
Long jump (m) †	1.6	0.01		1.54	0.021		1.64	0.017	
Curl-up †	33.11	0.48		31.17	0.8		34.23	0.58	

Pull-up †	14.57	0.34		13.4	0.57		15.25	0.43	
Sitting height (cm) †	81.93	0.32		79.69	0.4		83.22	0.42	
Arm span (cm) †	156.1	0.6		149.87	0.94		159.69	0.69	
Knee width (mm)	94.39	0.54		93.16	0.9		95.06	0.67	
Elbow width (mm) †	64.52	0.45		62.93	0.85		65.44	0.5	
Wrist circumference (mm) †	155.9	0.64		15.26	0.11		15.78	0.07	
Hip ROM (degree)	33.7	0.23		33.68	0.43		33.7	0.26	
Shoulder ROM (degree)	65.8	0.5		65.89	0.89		65.7	0.6	
Foot deformities †									
Yes			65.3			59.4			68.8
No			34.7			40.6			31.2
Uneven shoulder †									
Yes			47.2			39.4			51.7
No			52.8			60.6			48.3
Knee deformities									
Yes			59.7			56.1			61.7
No			40.3			43.9			38.3
Kyphosis									
Yes			76.7			72.9			78.8
No			23.3			27.1			21.2
Lordosis									
Yes			24.8			21.3			26.8
No			75.2			78.7			73.2

Table 1. The blood biochemical, body composition, and body functional variables of the MPCS's children (n=155) and adolescents (n=269) populations.

	All (N=424)			Children (n=155)			Adolescents (n=269)		
	Mean	SEM	%*	Mean	SEM	%*	Mean	SEM	%*
Forward head †									
Yes			40.8			23.9			50.6
No			59.2			76.1			49.4
Rounded shoulder									
Yes			70.8			67.7			72.5
No			29.2			32.3			27.5
Scoliosis †									
Yes			9.4			2.6			13.4
No			90.6			94.7			86.6
Neck deformities †									12.6
Yes			8.0			0.0			92.0
No			92.0			100			87.4
Pain †									
Yes			17.2			10.3			21.2
No			82.8			89.7			78.8

* Refers to percentage of the study population.
† Shows the significant differences of deformities between children, adolescents, and total populations (in %)

About the postural and pain variables, a significant increase in foot deformities of the adolescents than the children was observed ($p<0.05$; Table 1). Likewise, the uneven shoulder was significantly elevated in the adolescents than the children

($p<0.05$; Table 1). Furthermore, there were significant increases in the forwarding head, scoliosis, and neck deformities of the adolescents when compared to the children ($p<0.05$; Table 1). We also observed a significant increase in pain of the adolescents as compared with the children ($p<0.05$; Table 1).

The results of linear regression for the predictors of IFG are shown in Table 2. In the first phase of analyses, the foremost model, adjusted for blood factors, illustrated a negative statistically significant relationship between HDL-c and FBS in the adolescents (p=0.034). Although we did not see a significant relationship between HDL-c and FBS in the adolescents at the second model (p=0.052), HDL-c was significantly correlated to FBS in the adolescents at the third model (p=0.05). From a statistical viewpoint, WBC was significantly correlated to FBS in all interred models (p=0.002 for all models; Table 2). There was likewise significantly relationship between PLT and FBS in the regression models (p=0.035, p=0.035, and p=0.05 for model one, model two, and model three, respectively; Table 2). However, there were no statistically significant correlations between FBS and the other mentioned variables in the children ($p>0.05$; Table 2). The rate ratio, RR= $[a/T_e]$ / $[c/T_u]$, of the children for risk of IFG was 1.05. Using the IFG prevalence, the actual power of 80% (β=0.20) and precision of 0.05, the sample sizes were calculated to be 2567 for the children and 2514 for the adolescents using a SAS software.

Table 2- Unstandardized coefficients (B) of linear regression for the predictors of IFG in the children and the adolescents among the MPCS (n=424).

	Model 1 [a]		Model 2 [b]		Model 3 [c]	
	Unstandardized coefficients (B)	95% CI	Unstandardized coefficients (B)	95% CI	Unstandardized coefficients (B)	95% CI
HDL-c						
Children	-0.25		-0.215		-0.137	
Adolescents	-0.69	-1.3 – -0.05	-0.648		-0.664	-1.3 – -0.001
WBC						
Children	0.411		0.356		0.314	
Adolescents	0.752	0.28 – 1.22	0.785	0.3 – 1.27	0.794	0.3 – 1.29
PLT						
Children	0.002	0.001 – 0.03	0.002	0.001 – 0.03	0.006	0.0 – 0.028
Adolescents	0.014		0.015		0.014	

[a] Adjusted for total cholesterol, TG, LDL-C, VLDL-C, WBC, RBC, HDL, Hb, HCT, cholesterol to HDL-c ratio, and LDL-c to HDL-c ratio.
[b] Model 1 + adjusted for WHR, height, obesity index, PBF, total body mineral, body fat mass, total body protein, trunk fat percent, trunk fat mass, TBW, BMI, and SMM.
[c] Model 1 + model 2 + adjusted for 60-meter dash, 800 meters, agility, long jump, curl-up, and pull-up.

Regarding foot deformities, when adjusting for the body composition variables (model 1), TBM was a significant risk factor for children-related foot deformities.

It reduced slightly, when adjusting for the body functional variables and it increased remarkably, when adjusting for other related variables (model 3). In addition, height (in all models), SMM (in all models), and FFM (only in models 1 and 2) were significant risk factors for adolescents-related foot deformities. In this model, the rate ratio, RR= [a/Te] / [c/Tu], of the adolescents for risk of foot deformities was 1.169 (Table 3). Concerning the prevalence of children- and adolescents-related foot deformities, the actual power of 80% (β=0.20) and precision of 0.05, the sample sizes were calculated to be 2220 and 2548, respectively.

We likewise observed that TBP and TBM were significant risk factors only for adolescents' kyphosis in all models of the MPCS but arm span was a significant risk of kyphosis in both age groups in the MPCS. Furthermore, we found that curl-up was a significant risk factor for lordosis in both MPCS's populations. The rate ratios of the adolescents for risk of kyphosis and lordosis were 1.08 and 1.27, respectively (Table 3). About the prevalence of kyphosis and lordosis, the actual power of 80% (β=0.20) and precision of 0.05, the sample sizes were as well estimated to be 4523 and 3334 for the children and 5404 and 2883 for the adolescents.

Regarding forwarding head deformity, height was a risk of this deformity in both populations and only in the first model, but it became a significant risk of forwarding head deformity in the adolescents when adjusting for other associated variables (models 2 and 3). In addition, pull-up and 800-meter not only were significant risk factors for the children, but also they were important risks of forwarding head in both age populations, respectively (models 1 and 2). The rate ratio of the MPCS's populations for risk of forwarding head deformity was 2.12 (Table 1). Using the prevalence of children- and adolescents-related forwarding head deformity, the actual power of 80% (β=0.20) and precision of 0.05, the sample sizes were calculated to be 259 and 229, respectively.

Besides, sitting height was a significant risk of rounded shoulder for the children and the adolescents immediately after adjusting for the body composition (model 1) and the body functional (model 2) variables, respectively. In this regard, we as well observed that curl-up was a significant risk factor of the deformity, especially in both MPCS's populations, in the second and third models of the MPCS. Eventually, pull-up and knee width were unique risk factors for children's pain, only in the last model of the MPCS, and the rate ratios of both age groups for risk of rounded shoulder deformity and pain were 1.07 and 2.06, respectively (Table 3). Concerning the prevalence of rounded shoulder deformity and pain, the actual power of 80% (β=0.20) and precision of 0.05, the sample sizes were also computed to be 7914 and 862 for the children and 8732 and 507 for the adolescents using a SAS software.

Table 3- The odds ratios (OR) for the predictors of body postural deformities and pain in the children and the adolescents among the MPCS (n=424).

		N	Model 1 [a]		Model 2 [b]		Model 3 [c]	
			OR	95% CI	OR	95% CI	OR	95% CI
Foot deformities	TBM							
	Children	92	2993	7 – 12377	2209	5 – 48700	4128	8.7 – 19562
	Adolescents	184	0.205		0.136		0.205	
	Height							
	Children	92	1.042		1.05		1.035	
	Adolescents	184	0.857	0.794 – 0.98	0.844	0.736 – 0.969	0.849	0.736 – 0.98
	SMM							
	Children	92	0.793		0.853		1.26	
	Adolescents	184	0.052	0.003 – 0.936	0.039	0.002 – 0.738	0.029	0.001 – 0.58
	FFM							
	Children	92	0.239		0.243		0.24	
	Adolescents	184	5.45		7.5	1.2 – 44.6	9.06	1.4 – 55.9
Kyphosis	TBP							
	Children	113	0.47		0.955		1.99	
	Adolescents	212	0.001	0.0001 – 0.401	0.0001	0.00001 – 0.1	0.0001	0.00001 – 0.125
	TBM							
	Children	113	0.213		0.351		0.062	
	Adolescents	212	0.003	0.0001 – 0.219	0.002	0.0001 – 0.23	0.001	0.0001 – 0.15
	Arm span							
	Children	113					0.977	1.0 – 1.15
	Adolescents	212					1.08	1.03 – 1.14

Lordosis	Curl-up							
	Children	33			0.916	0.86 – 0.97	0.918	0.859 – 0.98
	Adolescents	72			0.957	0.916 – 0.999	0.958	0.916 – 1.002
Forward head	Sitting height							
	Children	37	1.11	1.0 – 1.2	1.06		1.16	
	Adolescents	136	1.14	1.01 – 1.22	1.12	1.049 – 0.999	1.122	1.0 – 1.255
	Pull-up							
	Children	37			1.099	1.01 – 1.2	1.113	1.012 – 1.224
	Adolescents	136			0.995		1.02	
	800 meters							
	Children	37			0.675	0.5 – 0.902	0.716	0.518 – 0.991
	Adolescents	136			0.755	0.639 – 0.94	0.779	0.635 – 0.955
Rounded shoulder	Sitting height							
	Children	105	0.913	0.847 – 0.984	0.918		1.08	
	Adolescents	195	0.951		0.894	0.826 – 0.967	0.985	
	Curl-up							
	Children	105			1.094	1.028 – 1.16	1.11	1.037 – 1.19
	Adolescents	195			1.099	1.042 – 1.158	1.1	1.048 – 1.17
Pain	Pull-up							
	Children	16					0.846	0.732 – 0.977
	Adolescents	57					0.967	
	Knee width							
	Children	16					0.898	0.816 – 0.989
	Adolescents	57					1.0	

[a] Adjusted for WHR, height, sitting height, obesity index, total body mineral, body fat mass, total body protein, BMI, and SMM.
[b] Model 1 + adjusted for 60-meter dash, 800 meter, agility, long jump, curl-up, and pull-up.
[c] Model 1 + model 2 + adjusted for arm span, knee width, elbow width, wrist circumference, hip ROM, and shoulder ROM.

Discussion

Our cohort pilot study among 424 children and adolescents in elementary- to high-school students indicated that the MPCS's children population did not have a growth deviation, but the MPCS's adolescents population had a growth deviation compared to the CDC's growth norms (27). However, it was not categorized as a short stature (2 SD below the mean)(3). In this regard, there were not weight deviations for the children and adolescents populations (27).

Prediabetes

In the current study, 59.4% of children, 56.5% of adolescents, and approximately 57.5% of the MPCS's populations had fasting blood glucose more than 91 mg/dL. Compared with data from the United States (2005-2014) and Nigeria, which often report yearly, the prevalence of diabetes in students aged 10 to 19 years were 28.5% and 17%, respectively (28, 29). Such alterations may be due to the differences in case of descriptions (race or ethnicity) and reporting manners (IFG definition). In this case, our results showed that both PLT and WBC counts were positively related to the levels of FBS only in the adolescent's population. Recently, it has been suggested that for every increase in 1,000 cells/mm^3 (normal range of WBC), risk for type 2 diabetes mellitus (DM2) accelerates by 7.6% (30). Besides, according to the previous studies, increased baseline activation of platelets in DM2 is common and may to a large extent be associated with biochemical factors such as insulin resistance, hyperglycemia, and hyperlipidemia (31). On the other hand, based on our findings, there is a possibility that the underlying mechanisms are more extendable for the adolescents than the children populations. We besides found a negative relationship between HDL and FBS. Importantly, there was also a reduction in the adolescents' HDL levels than the children, meaning perhaps as children progress through early and middle childhood to adolescence, HDL levels also decrease with age. Our findings were in accordance with the previous studies that showed the atherosclerotic cardiovascular diseases commence in childhood and early thickness of the intimal surface increases with age and associated with a high level of LDL-c, hypertension, obesity, low level of HDL-c, and impaired glucose tolerance (32).

Body Postural Deformities and Pain

In the MPCS, 59.4% of children, 68.8% of adolescents, and almost 65.3% of the MPCS's populations had foot deformities. The prevalence of foot deformities in the several published studies was between 5 and 92% in different study subjects (33). It has been reported that bone mineral content is an index of foot bones health and a risk factor for foot fractures (34). Based on our determined risk factors, besides calcium and vitamin D, dietary proteins reflect key nutrients for children' and adolescents' bone health (35). Regarding spine curvature disorder, 72.9% of children, 78.8% of adolescents, and nearly 76.7% of the MPCS's populations had kyphosis. In this study, it was observed that TBP and TBM, and arm span were potential risks of kyphosis. The kyphosis causes have not been totally elucidated, but there are several studies that have noted the etiology of Kyphosis. Nevertheless, musculoskeletal/neuromuscular impairments and vertebral fractures are the prominent risk factors for kyphosis (36, 37). Also, we observed that 21.3% of children, 26.8% of adolescents, and roughly 24.8% of the MPCS's populations had lordosis. There are as well several factors that may contribute to the changing of lumbar spine curvatures such as abdominal muscle weakness, obesity, and loss or lack of equilibrium in trunk muscles strength (38). It is also well-known that curl-up exercise, as a kyphosis risk factor in this study, is a light and unique exercise which stresses the lower trunk muscles and the abdominal muscles group, especially rectus abdominis muscle (39). In the MPCS, we also found that 23.9% of children, 50.6% of adolescents, and approximately 40.8% of the populations had forwarding head disorder. Furthermore, pull-up and 800 meters were feasible risks of forwarding head posture in the present study. It has reportedly been explained that exercises which help to the neck stability are most important for the accommodation of neck posture, and upholding their stability are needed to ameliorate neck-shoulder posture (40). The researcher also displayed that 67.7% of children, 72.5% of adolescents, and almost 70.8% of the MPCS's populations had rounded shoulder disorder. In the recent studies, it has also been defined that the upright sitting posture (as one of the rounded shoulder risk factor, Table 3) not only is associated with the elevated discomfort in the whole parts of back, but also different sitting postures are linked to the altered scapular positions and muscle activities, and finally, rounded shoulder (41, 42). In this regard, we correspondingly showed that curl-up was a suggestive risk of rounded shoulder. The exercise workouts such as McKenzie exercise, Kendall exercise, selected strengthening exercises, and self-stretch exercises are widely used to improve the rounded shoulder posture and strengthen the serratus anterior and lower trapezius muscles (43, 44).

In the present study, the percentage of body pain among children, adolescents, and total MPCS's populations was also 10.3%, 21.2%, and 17.2%, respectively. It has been well accepted that effective exercise with few adverse events may relieve chronic pain severity (45). So, in the current study, we reported that pull-up was a reliable risk factor for chronic pain. Additionally, arms-up and pull-down (pull-up) is a good exercise for relieving chronic pain (46). In the MPCS, knee width also was another credible risk of pain. About the recent strong literature, changes in the knee joint space width (especially the growing joints of children and adolescents) result in knee pain (47, 48). This investigation has several novelties and advantages compared to previous studies; the population was almost homogeneous, and children and adolescents were prospectively recruited and continuously analyzed by well-trained investigators. The data analysis comprised a diversity of risk factors related to the prediabetes and posture of children and adolescents, as well as those related to the IFG and postural deformities. To the knowledge of the authors, the MPCS represents the first study to investigate how the determined risk factors are causes of the postural deformities. This finding consecutively allowed the analysis to control for the possibility of the mentioned confounders. Furthermore, expressed RR in each pediatric-related disorder between children and adolescents was another advantage of the present investigation. Ultimately, this pilot cohort study confirms the feasibility of such study and its perceived usefulness. Notwithstanding probable strengths, this study has several limitations. First, although the study population of the MPCS was small, it was a pilot of the prospective cohort study and might be appropriate for this phase of the cohort study. Second, our cohort pilot study had only one arm and did not compare female children and adolescents. Third, we did not compare children and adolescents who were in the elementary, middle, and high school because the amount of data and statistical power were insufficient. Consequently, further cohort studies, especially main phases of this prospective cohort investigation, are required to illuminate the efficacy of pediatric-related disorders.

In conclusion, based on our main purposes involved prediabetes, postural deformities, and pain, the calculated sample sizes were estimated, on average, ideally as 5000 participants (Tables 1 and 3). The MPCS indicated that the adolescents had deviations compared to the CDC's norms. In the present study, half of thepopulation had FPG more than 91 mg/dL. Concerning the incidence of IFG, our findings expressed that the risk of prediabetes was one fold higher in the children than the adolescents. Regarding the body postural deformities, firstly, we found that the mineral and protein contents of our subjects were important factors to improve the children' and adolescents' health as well as to avoid the postural deformities. Therefore, it means that the mineral and protein nutrient status of children and adolescents are important and should be considered as risk factors for the postural deformities. Secondly, with social improvement and alterations in people's lifestyles, currently, school-age children are generally lack of physical activity. Based on strong results from the national Youth Risk Behavior Surveillance indicated that nearly 29% of school-age children in the United States were daily or weekly active (49). Accordingly, in this study, we demonstrated that body functional variables, especially curl-up, 800 meters, and pull-up, were potential risks of the postural disorders. The significant postural disorders, in this study, were pain status, kyphosis, lordosis, forwarding head, rounded shoulder, and foot deformities. The incidence of mentioned deformities was also between one- and two-fold upper in the adolescents compared to the children. Thirdly, the body composition or anthropometric variables included height, sitting height, arm span, SMM, FFM, and knee width were another thinkable risk factors of the postural deformities in the MPCS. Although, the current study disclosed the several mentioned findings, more research or other steps of the MPCS need to be prepared to delineate more valuable findings.

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