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RESEARCH

Clinical utility of the SPISE index as an indicator of insulin resistance in pediatric obesity

Pediatrik obezitede insülin direncinin bir göstergesi olarak SPISE indeksinin klinik değeri

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Abstract

Purpose: Single Point Insulin Sensitivity Estimator (SPISE) index is a lipid-based marker of insulin sensitivity, but data on its role in pediatric obesity are limited. This study evaluated its performance in identifying metabolic syndrome (MetS) and related metabolic risk factors in children and adolescents with obesity.

Materials and Methods: In this retrospective study, anthropometric and laboratory data were collected, and the SPISE index was calculated based on BMI, triglyceride, and HDL cholesterol levels. Correlation analyses and receiver operating characteristic (ROC) analyses were performed to assess the association of SPISE with metabolic parameters and its performance, compared with HOMA-IR, in detecting MetS.

Results: A total of 213 participants (58.7% female) with a mean age of 12.6 ± 3.2 years were included. The SPISE index showed inverse correlations with BMI SDS (r = −0.714), TG/HDL ratio (r = −0.559), TyG index (r = −0.457), HOMA-IR (r = −0.395), and age (r = −0.327). Lower SPISE values were observed in participants with severe obesity, elevated HOMA-IR, hepatic steatosis, hypertension, and metabolic syndrome. For the detection of MetS, the SPISE index demonstrated an AUC of 0.833 (95% CI: 0.767–0.886), with 96.7% sensitivity and 62.0% specificity at a cut-off value of <5.09, whereas HOMA-IR showed an AUC of 0.709.

Conclusion: The SPISE index appears to be a practical and reliable insulin-independent marker associated with metabolic risk in pediatric obesity and may represent a useful screening tool for identifying children and adolescents at risk for metabolic syndrome.

Keywords: SPISE index, pediatric obesity, insulin resistance, metabolic syndrome, HOMA-IR.

Öz

Amaç: Single Point Insulin Sensitivity Estimator (SPISE) indeksi, insülin duyarlılığını gösteren lipid temelli bir belirteçtir; ancak pediatrik obezitedeki rolüne ilişkin veriler sınırlıdır. Bu çalışmada, obezitesi olan çocuk ve adölesanlarda metabolik sendromu (MetS) ve ilişkili metabolik risk faktörlerini belirlemede SPISE indeksinin performansı değerlendirildi.

Gereç ve Yöntem: Bu retrospektif kesitsel çalışma için antropometrik ve laboratuvar parametreleri kaydedildi ve SPISE indeksi BKİ, trigliserid ve HDL kolesterol düzeyleri kullanılarak hesaplandı. SPISE'nin metabolik parametrelerle ilişkisini ve MetS'i saptamadaki performansını HOMA-IR ile karşılaştırmak amacıyla korelasyon analizleri ve alıcı işletim karakteristiği (ROC) analizleri yapıldı.

Bulgular: Çalışmaya yaş ortalaması 12,6 ± 3,2 yıl olan 213 katılımcı (%58,7 kız) dahil edildi. SPISE indeksi ile BKİ SDS (r = −0,714), TG/HDL oranı (r = −0,559), TyG indeksi (r = −0,457), HOMA-IR (r = −0,395) ve yaş (r = −0,327) arasında ters yönlü korelasyon saptandı. Şiddetli obezitesi, yüksek HOMA-IR düzeyi, hepatik steatozu, hipertansiyonu ve metabolik sendromu olan katılımcılarda SPISE değerleri daha düşüktü. Metabolik sendromun saptanmasında SPISE indeksinin eğri altında kalan alanı (AUC) 0,833 (%95 GA: 0,767–0,886) olup, <5,09 kesim noktasında duyarlılığı %96,7 ve özgüllüğü %62,0 olarak bulundu. Buna karşılık HOMA-IR için AUC değeri 0,709 olarak saptandı.

Sonuç: SPISE indeksi, pediatrik obezitede metabolik risk ile ilişkili, pratik ve insülinden bağımsız güvenilir bir belirteç gibi görünmektedir ve metabolik sendrom açısından risk altındaki çocuk ve adölesanların belirlenmesinde yararlı bir tarama aracı olabilir.

Anahtar kelimeler: SPISE indeksi, pediatrik obezite, insülin direnci, metabolik sendrom, HOMA-IR.

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INTRODUCTION

Childhood obesity is a growing global health challenge, with an increasing prevalence worldwide[1]. Identifying obesity-related comorbidities in children is essential for guiding preventive strategies aimed at reducing long-term metabolic complications[2]. In this context, insulin resistance represents a key pathophysiological link between obesity and the development of type 2 diabetes, metabolic syndrome, and cardiovascular disease[2,3].

Consequently, practical indices based on fasting insulin and glucose levels, particularly the homeostasis model assessment of insulin resistance (HOMA-IR), are commonly used to estimate insulin resistance[4]. However, reference methods for assessing insulin resistance in children remain limited, and insulin-based indices may be influenced by methodological and biological factors such as assay variability, pulsatile insulin secretion, fasting status, pubertal stage, and ethnicity[2,5,6].

In recent years, lipid-based indices derived from routine biochemical parameters have gained attention as convenient markers of insulin resistance and cardiometabolic risk[7]. Among these, the triglyceride–HDL cholesterol (TG/HDL-C) ratio and the triglyceride–glucose (TyG) index have been associated with insulin resistance in both adult and pediatric populations[7,8]. These indices are particularly useful in clinical and epidemiological settings because they rely on routinely measured laboratory parameters and do not require insulin determination[9].

Several studies have supported the use of lipid-derived markers such as the TyG index and TG/HDL-C ratio as simple and practical indicators of insulin resistance and cardiometabolic risk in pediatric obesity[7-9]. These findings support the growing interest in simple, and clinically practical markers that can be derived from routinely available anthropometric and laboratory measurements, without the need for insulin determination.

More recently, the single-point insulin sensitivity estimator (SPISE), calculated using triglycerides, HDL cholesterol, and body mass index, has been proposed as a novel non-invasive indicator of insulin sensitivity[10]. Growing evidence also suggests the potential clinical value of SPISE in pediatric populations[11,12]. Song et al.[11] reported that SPISE performed comparably to other insulin resistance markers in identifying insulin resistance and elevated liver transaminases among children and adolescents. In adults, lower SPISE values have also been associated with an increased risk of cardiovascular disease, suggesting that this index may reflect broader cardiometabolic risk beyond glucose metabolism alone[12].

Previous studies have shown that SPISE correlates with established indices of insulin resistance and may predict metabolic syndrome, non-alcoholic fatty liver disease, cardiovascular disease, and dysglycemia in both pediatric and adult populations with overweight or obesity, highlighting its growing clinical relevance across different age groups[10-12].

Despite increasing interest in lipid-based markers of insulin resistance, the clinical utility of the SPISE in pediatric populations remains incompletely defined, with heterogeneous findings across studies, likely reflecting the influence of pubertal maturation and population-specific metabolic characteristics, highlighting the need for validation of such indices across different clinical settings[10,11].

This study provides additional evidence regarding the clinical utility of SPISE by evaluating its association with obesity-related metabolic complications and its performance in identifying metabolic syndrome in children and adolescents with obesity. Furthermore, we investigated its relationship with other lipid-derived markers of insulin resistance, including the triglyceride/glucose ratio and the triglyceride-to-HDL cholesterol ratio. In addition, we sought to determine a clinically relevant SPISE cut-off value for the detection of metabolic syndrome. The findings of this study may support the use of the SPISE index as a simple, non-invasive, and clinically applicable marker for the identification of metabolic syndrome in pediatric obesity.

MATERIALS AND METHODS

Study design

This retrospective cross-sectional study included 213 children aged 6–18 years with obesity who were evaluated at the Pediatric Endocrinology Outpatient Clinic of Adana City Training and Research Hospital between May 2024 and February 2026. Demographic, clinical, anthropometric, and laboratory data were obtained from electronic medical records. The study was approved by the Scientific Research Ethics

Committee of Adana City Training and Research Hospital (Approval Number: 1144; Date: February 19, 2026) and was conducted in accordance with the Declaration of Helsinki. Informed Consent: Written informed consent was not obtained from the patients due to retrospective design of the study.

Sample

Inclusion criteria for thstudy were children and adolescents who were diagnosed with obesity according to age- and sex-specific BMI percentiles (≥95th percentile based on national reference standards) and who were evaluated at the pediatric endocrinology outpatient clinic during the study period were eligible for inclusion[13]. Participants were required to have complete anthropometric measurements and laboratory data necessary for the calculation of the SPISE index. Patients were excluded if they had genetic or syndromic forms of obesity (e.g., Prader–Willi syndrome), known endocrine disorders that could influence body weight or glucose metabolism (such as Cushing syndrome or untreated hypothyroidism), previously diagnosed type 1 or type 2 diabetes mellitus, or chronic systemic diseases including renal, hepatic, or inflammatory conditions. Individuals with known disorders of lipid metabolism or those receiving medications that could affect glucose or lipid metabolism, including oral antidiabetic agents, systemic glucocorticoids, or antipsychotic drugs, were also excluded. In addition, patients with incomplete clinical or laboratory records were not included in the analysis.

A total of 287 children and adolescents with obesity were assessed for eligibility. Exclusions included 46 participants with incomplete biochemical data, 18 with a diagnosis of type 2 diabetes mellitus, 6 with hypothyroidism, and 4 with syndromic obesity. Consequently, 213 participants met the eligibility criteria and were included in the final analysis.

Procedure

Clinical and anthropometric assessment

Demographic, clinical, anthropometric, and laboratory data were obtained from the hospital electronic medical record system. Data completeness and consistency were reviewed before analysis, and only patients with complete records required for the study were included. Anthropometric measurements and pubertal assessments were performed by pediatric endocrinologists as part of routine clinical practice.

Obesity was defined as a body mass index (BMI) above the 95 th percentile for age and sex[13]. Severe obesity was defined as a BMI at or above the 99th percentile, corresponding to ≥120% of the 95th percentile, a BMI standard deviation score (BMI SDS) >3, or a BMI exceeding 35 kg/m² [14]. Pubertal status was evaluated according to Tanner staging; the onset of puberty was defined as Tanner stage II or higher based on breast development in girls and a testicular volume of ≥4 mL measured with a Prader orchidometer in boys[15].

Laboratory measurements and metabolic assessment

Blood samples were obtained in the morning after an overnight fast of at least 8 hours according to the institutional clinical protocol. Biochemical parameters were analyzed in the institutional clinical laboratory using standard automated analyzers, while enzyme activity assays were performed with commercially available kits in accordance with the manufacturers' protocols.

The Homeostasis Model Assessment of Insulin Resistance (HOMA-IR) was calculated to the following formula: fasting glucose (mg/dL) × fasting serum insulin (μU/mL) / 405[4]. Insulin resistance was defined based on pubertal stage–specific thresholds, with a HOMA-IR value >2.5 in prepubertal individuals and >4.0 in pubertal individuals[6,16].

Metabolic syndrome (MetS) in children aged ≥10 years was defined, as the presence of at least three of the following: waist circumference ≥90 th percentile, triglycerides ≥100 mg/dL, HDL cholesterol <40 mg/dL, blood pressure ≥90th percentile for age, sex, and height, and fasting glucose ≥100 mg/dL[3]. For the assessment of metabolic syndrome, 168 patients aged 10 years and older were evaluated[3].

Calculation of insulin resistance indices

The Single Point Insulin Sensitivity Estimator (SPISE) index was calculated using BMI, triglyceride, and HDL cholesterol levels according to the following formula: SPISE= [600×HDL-C (mg/dL)0.185]/[TG (mg/dL) 0.2×BMI (kg/m2)1.338]; with triglyceride and HDL cholesterol values expressed in mg/dL and BMI in kg/m²[10]. Lower SPISE values indicate reduced insulin sensitivity and increased metabolic risk[10,11].

The triglyceride–glucose (TyG) index was calculated as the natural logarithm of the product of fasting triglyceride and fasting plasma glucose levels divided by two: TyG = Ln [fasting triglycerides (mg/dL) × fasting plasma glucose (mg/dL) / 2][17]. Higher TyG values are considered indicative of greater insulin resistance[17].

The triglyceride-to–high-density lipoprotein cholesterol ratio (TG/HDL-C) was calculated by dividing fasting triglyceride levels by HDL cholesterol levels, with both parameters expressed in mg/dL[10]. Higher TG/HDL-C ratios have been associated with increased cardiometabolic risk and insulin resistance[10]. Blood samples were obtained in accordance with our clinical protocol, in the morning after an overnight fast of at least 8 hours. Hepatic steatosis was evaluated by ultrasonography, and findings consistent with moderate-to-severe hepatic steatosis were recorded[18].

Statistical analysis

Statistical analyses were performed using the SPSS (Statistical Package for the Social Sciences) version 25.0 software. Categorical variables were presented as frequencies and percentages, whereas continuous variables were summarized as mean ± standard deviation (and median when necessary). After descriptive analyses, the Shapiro–Wilk test was applied to evaluate whether the variables followed a normal distribution. For groups that did not meet the assumption of normality, the Mann–Whitney U test was used for comparisons.

The continuous variables did not demonstrate a normal distribution non-parametric methods were preferred. Comparisons of SPISE index values between two independent groups (e.g., sex, pubertal status, obesity classification, presence of hypertension, steatohepatitis, elevated HOMA-IR, and metabolic syndrome) were performed using the Mann–Whitney U test. Associations between the SPISE index and continuous variables, including age, BMI SDS, HOMA-IR, TyG index, and TG/HDL-C ratio, were evaluated using Spearman's rank correlation analysis. In addition, ROC curve analysis was conducted to evaluate the ability of the SPISE index and HOMA-IR values to predict the presence of MetS. A two-sided p-value < 0.05 was considered statistically significant.

Post-hoc power analysis was performed using G*Power version 3.1.9.7 to assess the adequacy of the sample size[19]. A total of 213 obese patients were enrolled. Of these, 168 patients aged ≥10 years were included in the metabolic syndrome analysis of whom 32 were diagnosed with metabolic syndrome[3].The analysis demonstrated a statistical power of >99% at a two-sided α level of 0.05.

RESULTS

A total of 213 participants were included, of whom 58.7% were female and 41.3% were male. The mean age was 12.6 ± 3.2 years, and the mean BMI SDS was 2.72 ± 0.7. Severe obesity was present in 20.2% of the cohort. Steatohepatitis, hypertension, and metabolic syndrome were present in 31.9%, 11.3%, and 15.0% of the cohort, respectively (Table 1).

Correlation analyses between the SPISE index and clinical, anthropometric, and laboratory parameters, together with group comparisons, are presented in Table 2 (all $p < 0.001$).

The strongest negative correlation was observed with BMI SDS ($r = -0.714$), followed by the TG/HDL ratio ($r = -0.559$), TyG index ($r = -0.457$), HOMA-IR ($r = -0.395$), and age ($r = -0.327$), indicating that higher values of these parameters were associated with lower SPISE index values. SPISE index was significantly negatively correlated with age ($r = -0.327$, $p < 0.001$).

No significant difference in SPISE index values was observed between sex groups ($p = 0.452$). In contrast, individuals in Tanner stages III–V had significantly lower SPISE index values than those in Tanner stages I–II (5.19 ± 1.2 vs. 5.68 ± 1.2, $p = 0.012$).

In terms of obesity classification and related complications, participants with severe obesity exhibited markedly lower SPISE index values compared with those classified as obese (3.87 ± 0.7 vs. 5.71 ± 1.0, $p < 0.001$). Similarly, mean SPISE index values were significantly lower in participants with elevated HOMA-IR, ultrasonographic hepatic steatosis, hypertension, and MetS than in those without these conditions (4.90 ± 1.1, 4.66 ± 0.9, 4.44 ± 1.2, and 4.11 ± 0.8, respectively; all $p < 0.001$) (Table 2).

The results of the ROC analysis evaluating the diagnostic performance of the SPISE index and HOMA-IR for detecting MetS are presented in Table 3. Both parameters demonstrated statistically

significant predictive performance for MetS ($p < 0.001$).

For the SPISE index, a cut-off value of <5.09 yielded an area under the curve (AUC) of 0.833 (95% CI: 0.767–0.886), indicating strong discriminatory ability. At this threshold, the sensitivity and specificity were 96.7% and 62.04 %, PPV 36.6%, and NPV 98.8 %. respectively. For HOMA-IR, a cut-off value of >5.87 was identified, corresponding to an AUC of 0.709 (95% CI: 0.634–0.777). At this threshold, the sensitivity was 51.6%, specificity 85.4 %, PPV 44.4 %, and NPV 88.6 %.

Overall, both the SPISE index and HOMA-IR demonstrated significant diagnostic performance for identifying MetS; however, the SPISE index showed superior discriminatory capacity, reflected by higher AUC, specificity, and PPV values (Table 3).

Table 1. Demographic, clinical, and biochemical characteristics of the study population.

Variables	**Number (n)**	**Percentage (%)**
Sex		
Female	125	58.7
Male	88	41.3
Tanner I-II	65	30.5
Tanner III-V	148	69.5
Obesity classification		
Obesity	170	79.8
Severe obesity	43	20.2
Ultrasonographic hepatic steatosis	68	31.9
Hypertension	24	11.3
MetS	32	15.0
	Mean ± SD	**Median (Min–Max)**
Age	12.6±3.2	
BMI SDS	2.72±0.7	
VA SDS	2.87±1.1	
Height SDS		0.5 (-1.8-3.8)
Glucose (mg/dL)	86.3±10.3	
Insulin (μU/mL)	20.3±16.9	
SPISE index	5.34±1.2	
TG/HDL ratio	2.45±1.4	
HOMA-IR	4.31±3.7	
TyG index	8.35±0.5	
Total cholesterol (mg/dL)		155 (78-254)
HDL cholesterol (mg/dL)		47 (15-133)
Triglycerides (mg/dL)		96 (37-464)

Data are presented as number (n) and percentage (%) for categorical variables, and as mean ± standard deviation (SD) or median (minimum–maximum) for continuous variables. BMI SDS: body mass index standard deviation score; SPISE: single-point insulin sensitivity estimator; HOMA-IR: homeostasis model assessment of insulin resistance; TyG index: triglyceride–glucose index; TG/HDL ratio: triglyceride to high-density lipoprotein cholesterol ratio; MetS: metabolic syndrome.

Table 2. Correlation of the SPISE index with clinical and demographic variables

Variables	SPISE Index	
	r	p
Age	-0.327**	<0.001
BMI SDS	-0.714**	<0.001
TG/HDL ratio	-0.559**	<0.001
HOMA-IR	-0.395**	<0.001
TyG index	-0.457**	<0.001
	Mean ± SD (Med)	p
Sex		
Female	5.28±1.2 (5.26)	0.452
Male	5.43±1.2 (5.29)	
Puberty		
Tanner I-II	5.68±1.2 (5.66)	0.012*
Tanner III-V	5.19±1.2 (5.13)	
Obesity classification		
Obesity	5.71±1.0 (5.67)	<0.001**
Severe obesity	3.87±0.7 (3.76)	
HOMA-IR		
High	5.81±1.1 (5.82)	<0.001**
Normal	4.90±1.1 (4.93)	
Steatohepatitis		
No	5.66±1.2 (5.70)	<0.001**
Yes	4.66±0.9 (4.55)	
Hypertension		
No	5.46±1.17 (5.49)	<0.001**
Yes	4.44±1.2 (4.12)	
MetS		
No	5.56±1.1 (5.53)	<0.001**
Yes	4.11±0.8 (4.23)	

Data are presented as number (n) and percentage (%) for categorical variables, and as mean ± standard deviation (SD) or median (minimum–maximum) for continuous variables. BMI SDS: body mass index standard deviation score; SPISE: single-point insulin sensitivity estimator; HOMA-IR: homeostasis model assessment of insulin resistance; TyG index: triglyceride–glucose index; TG/HDL ratio: triglyceride to high-density lipoprotein cholesterol ratio; MetS: metabolic syndrome; *p < 0.05, **p < 0.01; Spearman's rho correlation coefficient.

Table 3. Diagnostic performance of the SPISE index and HOMA-IR for detecting metabolic syndrome

Measure	Cut-off	AUC	Sensitivity %95 CI	Specificity %95 CI	PPV %95 CI	NPV %95 CI	p
SPISE index	≤5.09	0.833 (0.767-0.886)	96.77 (83.3-99.9)	62.04 (53.4-70.2)	36.6 (31.6-41.9)	98.8 (92.5-99.8)	**<0.001****
HOMA-IR	>5.84	0.709 (0.634-0.777)	51.61 (33.1-69.8)	85.40 (78.4-90.8)	44.4 (32-57.6)	88.6 (84.3-91.9)	**0.001****

*p<0.05, **p<0.01, SPISE, Single Point Insulin Sensitivity Estimator; HOMA-IR, Homeostasis Model Assessment of Insulin Resistance; AUC, area under the curve; PPV, positive predictive value; NPV, negative predictive value; CI, confidence interval.
Cut-off values were determined using receiver operating characteristic (ROC) curve analysis. Metabolic syndrome was defined according to the specified criteria in the Methods section. PPV and NPV values are dependent on the prevalence of metabolic syndrome in the study population.

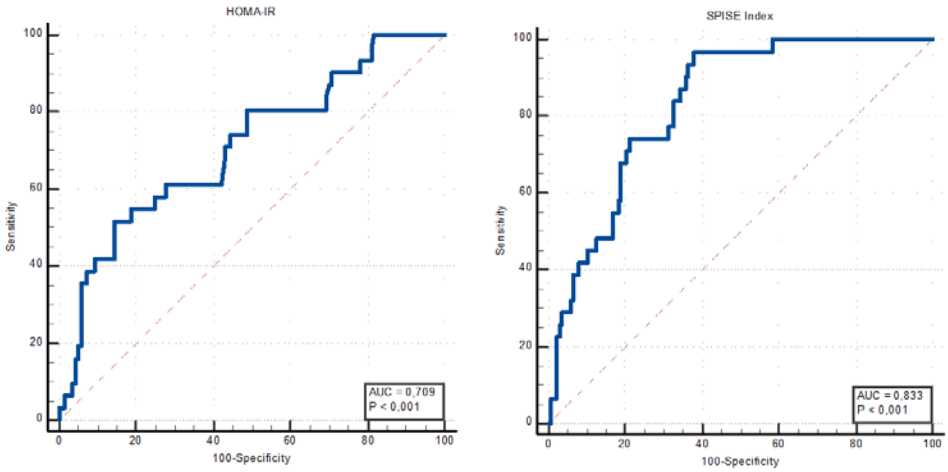

Figure 1. ROC curves comparing the diagnostic performance of the SPISE index and HOMA-IR for identifying metabolic syndrome

SPISE, Single Point Insulin Sensitivity Estimator; HOMA-IR, Homeostasis Model Assessment of Insulin Resistance; AUC, area under the curve; Metabolic syndrome was defined according to the specified criteria in the Methods section.

DISCUSSION

This study evaluated the diagnostic utility of the SPISE index in a cohort of children and adolescents with obesity, examining its associations with anthropometric parameters, metabolic comorbidities, and its performance relative to HOMA-IR in detecting MetS. The results demonstrate that SPISE is strongly associated with markers of adiposity and insulin resistance and shows substantial discriminatory capacity for identifying MetS. Our findings support the use of SPISE as an insulin-independent tool for assessing insulin resistance in pediatric clinical practice.

A notable finding of this study was the strong inverse association between the SPISE index and BMI SDS, which showed the strongest correlation among all examined variables. This relationship is consistent with the structure of the SPISE formula, in which BMI carries the dominant exponent, and with findings by Paulmichl et al.[10] showing that the incorporation of BMI into the lipid-based TG/HDL ratio, the conceptual precursor of SPISE, improves the index's discriminatory performance. In addition, we found the presence of severe obesity was also significantly associated with lower SPISE values. These findings suggest that increasing adiposity is closely linked to declining insulin sensitivity and are consistent with the established metabolic consequences of excess adiposity, particularly visceral fat accumulation, including lipotoxicity, adipokine dysregulation, and chronic low-grade inflammation[20]. In this context, the strong correlation observed in our cohort indicates that the SPISE index is closely related to metabolic alterations accompanying increasing obesity severity in children and adolescents. This pattern has also been reported by Tantari et al.[21], who observed stepwise declines in SPISE across overweight, obesity, and severe obesity categories within each Tanner stage group.

The lower SPISE values observed in pubertal compared with prepubertal participants are consistent with the well-described physiological decline in insulin sensitivity during puberty. This reduction is largely attributed to hormonal changes, particularly increased growth hormone secretion and the effects of gonadal steroids, which influence insulin signaling and body fat distribution[22]. Consistent with our findings, Correa-Burrows et al.[23] reported lower SPISE values in pubertal compared with prepubertal obese children and showed that the diagnostic performance of SPISE for MetS and insulin resistance was similar across pubertal stages.

The SPISE index also showed significant inverse correlations with the TG/HDL ratio, age, TyG index, and HOMA-IR. Evidence from euglycemic

hyperinsulinemic clamp studies further indicates that these lipid alterations may occur before overt disturbances in glucose metabolism[24]. Elevated triglycerides and reduced HDL cholesterol represent early lipid manifestations of insulin resistance, reflecting increased hepatic VLDL production and impaired lipid metabolism[8]. Similarly, Stein et al.[25] reported that the age-related decline in SPISE among children. In line with these findings, SPISE in our cohort also showed a significant inverse correlation with age.

The SPISE index showed a moderate inverse correlation with HOMA-IR ($r = -0.395$), consistent with findings from previous validation studies. Similar correlations have been reported by Barchetta et al. [26] and Stein et al.[25] in pediatric cohorts. The moderate strength of this association likely reflects that SPISE and HOMA-IR capture related but distinct aspects of insulin homeostasis. While HOMA-IR primarily reflects hepatic insulin resistance based on fasting glucose and insulin concentrations[4] , SPISE incorporates lipid parameters and therefore reflects broader metabolic alterations associated with insulin resistance in obesity[21]. In addition, insulin measurements are subject to pre-analytical variability due to the pulsatile nature of insulin secretion, its short half-life, and the lack of standardized assays, limitations that are avoided by the SPISE index[2,21].

The observed associations between lower SPISE values and the presence of hepatic steatosis, hypertension, and metabolic syndrome underscore the clinical relevance of the index. Consistent with our findings, subsequent studies have demonstrated its applicability across a range of insulin resistance–related conditions, including metabolic syndrome, coronary heart disease risk, non-alcoholic fatty liver disease, and type 2 diabetes risk[17,21,26]. These findings suggest that SPISE index reflects broader metabolic disturbances beyond excess adiposity.

Another key finding was the strong diagnostic performance of the SPISE index for identifying metabolic syndrome. In the present study, participants with MetS had significantly lower SPISE values compared with those without MetS. ROC analysis identified a cut-off value of <5.09 for SPISE, yielding an AUC of 0.833 with a sensitivity of 96.7 % and a specificity of 62.0 %. The particularly may the potential clinical utility of SPISE for identifying children and adolescents with obesity at increased risk of MetS. Moreover, SPISE demonstrated superior discriminatory performance compared with HOMA-IR (AUC 0.833 vs. 0.709), suggesting a ability to distinguish individuals with and without MetS in this cohort. These findings are consistent with those reported by Correa-Burrows et al.[23], Azarboo et al.[27] who similarly showed that SPISE outperformed HOMA-IR and other insulin-based indices in identifying both MetS and insulin resistance in pubertal adolescents with obesity.

The moderate discriminatory ability between these two indices likely reflects their different methodological and biological bases, as HOMA-IR primarily reflects insulin-based measures of hepatic insulin resistance, whereas SPISE incorporates lipid parameters and BMI. Barchetta et al.[26] reported that lower baseline SPISE independently predicted the development of impaired glucose regulation. Similarly, Stein et al.[25] demonstrated in a long-term cohort that individuals in the lowest SPISE index had a markedly higher risk of developing dysglycemia, outperforming HOMA-IR and QUICKI-IR as prognostic markers.

These findings suggest that SPISE may serve as a useful screening marker for identifying children and adolescents with obesity at increased metabolic risk, including metabolic syndrome, before overt glucose dysregulation develops. This may provide an opportunity for early lifestyle-based interventions aimed at improving insulin sensitivity[28]. In addition, the complementary relationship between SPISE and HOMA-IR may further enhance metabolic risk stratification when both indices are considered together in clinical assessment.

Several limitations of this study should be acknowledged. The cross-sectional design precludes causal inference, and the sample size may limit the precision of subgroup analyses, particularly across Tanner stages. In addition, the gold standard method for assessing insulin resistance, the euglycemic hyperinsulinemic clamp, was not performed, and HOMA-IR was used as the reference index. Future longitudinal studies in Turkish pediatric populations are needed to determine whether the identified SPISE cut-off values predict the development of type 2 diabetes or cardiovascular disease and whether population-specific thresholds are required. SPISE includes triglyceride and HDL-C, which are also components of the metabolic syndrome definition. This overlap may have overestimated its diagnostic performance, and the findings should be interpreted with caution.

The present study highlights the potential utility of the SPISE index as a simple and informative marker of metabolic risk in pediatric obesity. Its strong associations with obesity severity, markers of insulin resistance, and obesity-related comorbidities, together with its favorable diagnostic performance for metabolic syndrome, suggest that SPISE may provide clinically relevant information in the evaluation of children and adolescents with obesity. Prospective longitudinal studies are warranted to determine whether SPISE can predict the future development of metabolic complications and to further clarify its role in risk stratification and early preventive strategies.

In conclusion, the findings of this study support the potential clinical utility of the SPISE index as a simple, insulin-independent marker for identifying metabolic risk in children and adolescents with obesity. Given its reliance on routinely available anthropometric and biochemical parameters, SPISE may represent a practical tool for screening and risk stratification in pediatric obesity. Future prospective multicenter studies with larger and more diverse populations are needed to validate the proposed cut-off value, establish population-specific reference ranges, and determine the ability of SPISE to predict long-term metabolic outcomes.

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