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Original Research

Obesity and Insulin Resistance Screening Tools in American Adolescents: National Health and Nutrition Examination Survey (NHANES) 1999 to 2010

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ABSTRACT

Objective: To identify which feasible obesity and insulin resistance (IR) screening tools are most strongly associated in adolescents by using a nationally representative sample.
Methods: Adolescents aged 12.0 to 18.9 years who were participating in the National Health and Nutrition Examination Survey (NHANES) (n=3584) and who were measured for height, weight, waist circumference (WC), triceps and subscapular skinfold thickness, glycated hemoglobin, fasting glucose (FG) and fasting insulin (FI) level were included. Adolescents were split by gender and grouped by body mass index (BMI) percentile. Age- and gender-specific classifications were constructed for each obesity screening tool measure to account for growth and maturation. General linear models were used to establish groups objectively for analysis based on when IR began to increase. Additional general linear models were used to identify when IR significantly increased for each IR measure as obesity group increased and to identify the variance accounted for among each obesity-IR screening tool relationship.
Results: As the obesity group increased, homeostasis model assessment-insulin resistance (HOMA-IR) and FI significantly increased, while FG increased only (above the referent) in groups with BMI percentiles ≥95.0, and glycated hemoglobin level did not vary across obesity groups. The most strongly associated screening tools were WC and FI in boys (R^2=0.253) and girls (R^2=0.257). FI had the strongest association with all of the obesity measures. BMI associations were slightly weaker than WC in each in relation to IR.
Conclusions: Our findings show that WC and FI are the most strongly associated obesity and IR screening tool measures in adolescents. These feasible screening tools should be utilized in screening practices for at-risk adolescents.

Mots clés :
indice de masse corporelle
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surcharge pondérale
tour de taille
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RÉSUMÉ

Objectif : Déterminer quels sont les outils de dépistage de l'obésité et de l'insulinorésistance (IR) réalisables les plus fortement associés aux adolescents en utilisant un échantillon représentatif à l'échelle nationale.
Méthodes : Nous avons inclus les adolescents âgés de 12,0 à 18,9 ans qui participaient à l'enquête NHANES (National Health and Nutrition Examination Survey) (n=3584) et dont la taille, le poids, le tour de taille (TT), les triceps et l'épaisseur du pli cutané sous-scapulaire, les taux d'hémoglobine glyquée, de glycémie à jeun (GJ) et d'insuline à jeun (IJ) avaient été mesurés. Nous avons ventilé les adolescents selon le sexe et le percentile de l'indice de masse corporelle (IMC). Nous avons élaboré les classifications selon l'âge et le genre pour chacune des mesures de dépistage de l'obésité afin de tenir compte de la croissance et de la maturation. Nous avons utilisé des modèles linéaires généraux pour établir objectivement les groupes pour l'analyse au moment où l'IR commençait à augmenter. Nous avons utilisé des modèles linéaires généraux complémentaires pour déterminer le moment où l'IR augmentait de manière significative pour chaque mesure de l'IR à mesure que le groupe d'adolescents obèses augmentait et pour déterminer la variance de chaque relation de l'outil de dépistage de l'IR liée à l'obésité.

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Résultats : À mesure que le groupe d'adolescents obèses augmentait, l'évaluation du modèle d'homéostasie de l'insulinorésistance et l'IJ augmentaient de manière significative, alors que la GJ augmentait seulement (au-dessus du groupe de référence) dans les groupes dont les percentiles de l'IMC étaient ≥95,0, mais le taux d'hémoglobine glyquée ne variait pas entre les groupes d'adolescents obèses. Les outils de dépistage les plus fortement associés étaient le TT et l'IJ chez les garçons (R^2=0,253) et les filles (R^2=0,257). L'IJ montrait l'association la plus forte avec toutes les mesures de l'obésité. Les associations de l'IMC étaient légèrement plus faibles que le TT pour chacune par rapport à l'IR.
Conclusions : Nos conclusions montrent que le TT et l'IJ sont les mesures de dépistage de l'obésité et de l'IR chez les adolescents les plus fortement associées. Ces outils de dépistage réalisables devraient être utilisés dans les pratiques de dépistage chez les adolescents exposés au risque.

Introduction

Over the past 35 years, the prevalence of overweight and obesity among adolescents has risen to nearly 1 in 3 in the United States (1). Similarly, the prevalence of type 2 diabetes has increased among adolescents. Although beta cell dysfunction plays a critical role in the development of type 2 diabetes (2), the parallel rise in obesity and type 2 diabetes is due in part to the link between obesity and insulin resistance (IR) (3). Narasimhan and Weinstock (4) outlined the rapid progression of type 2 diabetes in youth compared to adults along with the increased rate of comorbidities once youth are diagnosed with type 2 diabetes. This dilemma of rapidly compounding health conditions in adolescents underscores the need for optimal screening practices for elevated IR in order to facilitate early intervention or, preferably, to employ preventive strategies prior to the onset of type 2 diabetes.

Previous research has shown that both central and total obesity are linked with IR in adolescents (5–7). Although several feasible measures of central—e.g. waist circumference (WC), subscapular skinfold thickness (subscap SF) and total obesity (e.g. body mass index [BMI], and triceps skinfold thickness [triceps SF])—are available, none of these is considered the gold standard for identifying adolescents at risk for elevated IR. Likewise, numerous methods are available for screening adolescents who are identified as being at risk for elevated IR and other metabolic maladies, including fasting insulin (FI), fasting blood glucose (FG), homeostasis model assessment-insulin resistance (HOMA-IR) and glycated hemoglobin (A1C) levels. It is important to consider the limitations of each measure. For FI, there is a lack of insulin assay standardization, which results in difficulty in establishing a range or definition of elevated IR (8). For FG, the large amount of day-to-day variability within the individual and between or within laboratories can be problematic. FG also has low sensitivity for diagnosing diabetes (i.e. failing to diagnose a condition when the condition is present) (9). HOMA-IR is a model of glucose and insulin interaction that estimates IR and beta cell function that has been reported to be an effective surrogate marker for IR but may not be ideal for assessing IR in those with severe beta cell impairments or those taking insulin (10,11). Limitations in using A1C levels are that they are secondary phenomena that occur subsequent to elevated blood glucose levels, and there is a lack of a global standardization for normal and elevated conditions (12). Additionally, A1C levels have also been reported as having poor sensitivity for diagnosing diabetes (13). For these reasons, such tools are often used as screening measures, not criteria measures.

In order to optimize the screening process for adolescents who may be at risk for having or developing type 2 diabetes, the need to identify which obesity and IR screening tools are most strongly associated has emerged. This identification can assist with determining the best cost-effective approach to aid in identifying which adolescents may need additional testing that is more invasive, labour intensive and costly (e.g. hyperinsulinemic euglycemic glucose clamp or oral glucose tolerance tests) to determine whether type 2 diabetes is present. Research examining screening methods in adults has resulted in varying conclusions. For example, Elbassuoni (14) found that both WC and BMI were correlated with FI, FG and HOMA-IR, but the associations were stronger when using WC in a sample of normal-weight and obese women. A study by Mamtani et al (15) reported that WC outperformed BMI as a predictor of future risk for type 2 diabetes and had higher associations with FG, FI and other markers of the metabolic syndrome in Mexican American families. Khunti et al (16) also showed that WC outperformed BMI and waist:hip ratio as a predictor of metabolic syndrome. Conversely, the results of the Data from an Epidemiological Study on the Insulin Resistance syndrome (D.E.S.I.R.) study showed no differences among BMI, WC and waist:hip ratio in predicting FG and dyslipidemia (17). Fewer studies are available concerning the associations between screening measures for obesity and IR in adolescents, and the conclusions stemming from that limited body of research vary. For instance, some studies have reported that WC and BMI are similarly associated with HOMA-IR in youth (7,18). Jiménez-Pavón et al (19), for example, found BMI, WC and skinfold measurements were associated with HOMA-IR and FI but not with FG in European adolescents. Further research by Misra et al (20) reported that subscap SF was a better predictor of high FI than BMI and WC in a sample of male Asian Indian youth 14 to 18 years of age. The use of alternative obesity and IR screening tools, along with variations among sample populations, obfuscates the ability to compare findings among studies.

Previous research has used various approaches to stratify subjects by obesity status for their analyses, including the use of arbitrary grouping methods (e.g. top third of the sample based on WC). However, being in the top third of a sample may not necessarily indicate increased risk for IR. Further, in adolescents, the obesity-status classification of these measures (i.e. BMI, WC, triceps and subscap SF) varies by age and gender due to growth and maturation. This is a confounding factor that has not always been appropriately accounted for in previous research into this topic (19,21). To our knowledge, no study of this topic has employed age- and gender-specific classifications for WC, subscap SF or triceps SF. Thus, the purpose of this study was to identify which obesity and IR screening tools are most strongly associated in a nationally representative sample of US adolescents.

Methods

Sample

Data combined from the 1999 to 2010 waves of the continuous National Health and Nutrition Examination Survey (NHANES) were analyzed. Samples are weighted to represent the US population so national estimates can be inferred. A subset of adolescents underwent laboratory testing, which included fasting blood samples. A description of the examination and the fasting and laboratory procedures has been published elsewhere (22). The final sample con-