Validity of a Single-Factor Model Underlying the Metabolic Syndrome in Children

A confirmatory factor analysis

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OBJECTIVE — We used confirmatory factor analysis to test whether a single factor might explain the clustering of the metabolic syndrome (MS) components in children.

RESEARCH DESIGN AND METHODS — We studied 1,020 children aged 10–13 years from 20 schools in Cuenca, Spain. The single-factor model included: waist circumference (WC), fasting insulin, triglyceride to HDL cholesterol ratio (Triglyl/HDL-C), and mean arterial pressure (MAP). The standardized scores of the four variables in the model were used to develop a continuous MS index.

RESULTS — Factor loadings were 0.67 for WC, 0.68 for fasting insulin, 0.57 for Triglyl/HDL-C, and 0.37 for MAP. The single-factor model also showed a good fit to the data. As compared with Adult Treatment Panel III criteria, the MS index showed strong validity in the diagnosis of MS (area under the receiver operating characteristic curve = 0.98, 95% CI 0.96–0.99).

CONCLUSIONS — A single underlying factor has acceptable validity to represent MS in children.

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Among children, classic cardiovascular risk factors tend to cluster into metabolic syndrome (MS). Whether the clustering of MS components is attributable to only one or to multiple determinants is a matter of debate (1). In adults, confirmatory factor analysis (CFA) studies have suggested that there are four factors underlying MS (2–4). In contrast, Pladevall et al. in adults (5), and Li and Ford in U.S. adolescents (6), observed that a single-factor model validly represented MS.

A single-factor model with a few clinically relevant variables could facilitate diagnosis of MS in children. Accordingly, we used CFA to test a single-factor model representing MS in children. This model includes a single variable for each of the four core components usually accepted in MS: waist circumference (WC) for abdominal obesity, fasting insulin for insulin resistance, triglyceride/HDL cholesterol ratio (Triglyl/HDL-C) for dyslipemia, and mean arterial pressure (MAP) for hypertension. In contrast to Pladevall et al. (7), who used the homeostasis model assessment of insulin resistance (HOMA-IR), we used fasting insulin because it can be a sensitive indicator of insulin resistance even in children without elevated glycemia. Furthermore, unlike Li and Ford's model (8), which only used triglycerides, ours also incorporates HDL-C because it has antithrombotic and antiplatelet effects, which influence cardiovascular risk within MS.

RESEARCH DESIGN AND METHODS

The study methods have been reported elsewhere (9). We studied 1,020 children aged 10–13 years from 20 schools in Cuenca, Spain. Anthropometry, blood pressure readings, and laboratory determinations were performed with standard procedures. Also, the Child Health and Illness Profile-Child Edition (CHIP-CE) questionnaire was used to assess physical activity (10). The Clinical Research Ethics Committee of the Virgen de la Luz Hospital in Cuenca approved the study protocol.

To examine the construct validity of our model for MS, and those of Pladevall et al. and of Li and Ford, we calculated the factor loadings of the variables in each model with AMOS 16.0 software (11). Factor loadings were required to be >0.3 and statistically significant ($P < 0.05$) to accept that any variable was part of the MS construct (12).

The χ^2 test is prone to show a significant lack of model fit in studies with large sample size, so its results cannot be assessed in isolation. Also, the higher the comparative fit index (CFI) and the lower the root mean square residual (SRMR), the better the fit. A model was deemed to have a good fit when the CFI was >0.96 and the SRMR <0.08 (13).

Because the MS components are continuous variables, we estimated the likelihood of having MS with an MS index calculated as the sum of the standardized scores of the four variables comprising our model. We built a receiver operating characteristic (ROC) curve to obtain the sensitivity and specificity of the different cut-points for the MS index in the diagnosis of MS. As gold standard for MS, we

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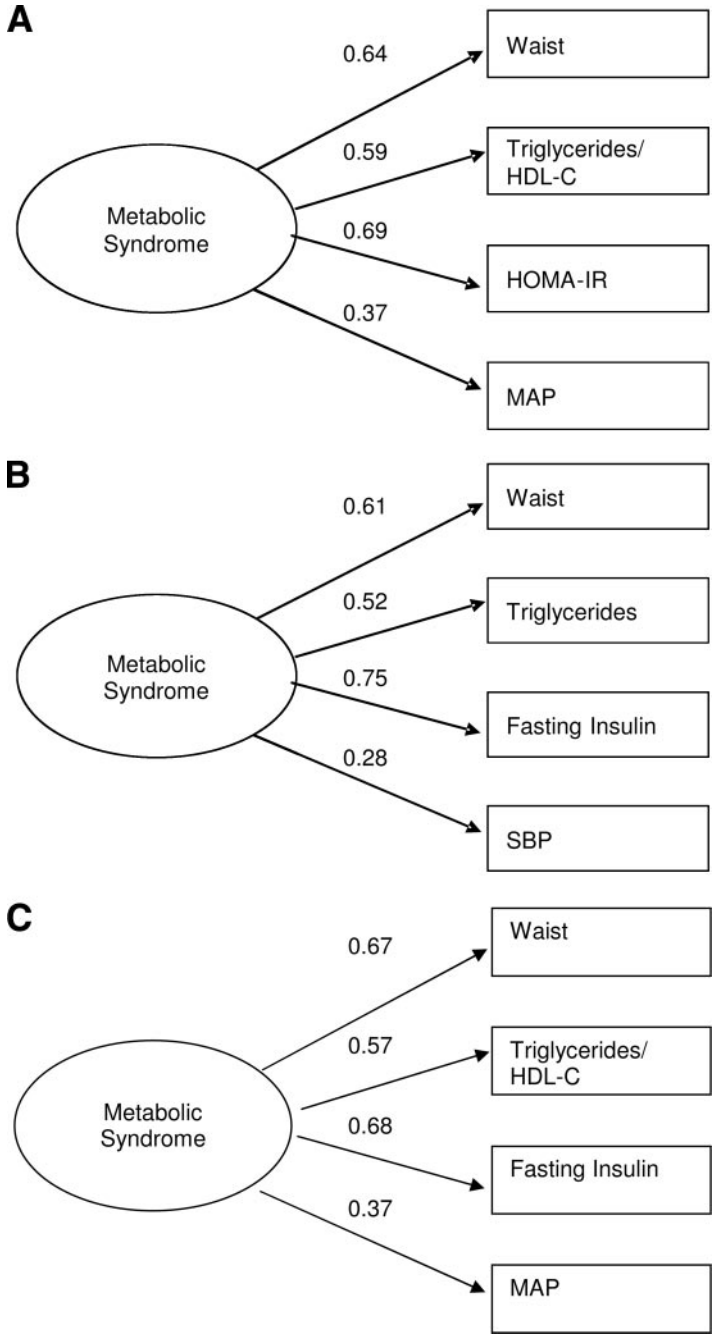

Figure 1—*Factor loading and goodness-of-fit indexes of one-factor models for the metabolic syndrome.* A*: Model proposed by Pladevall et al. (5):* $\chi^2 = 17.53$*, df = 2,* P *= 0.001; CFI = 0.97; and SRMR = 0.029.* B*: Model proposed by Li and Ford (9):* $\chi^2 = 5.40$*, df = 2,* P *= 0.067; CFI = 0.99; and SRMR = 0.018. C: Our model:* $\chi^2 = 14.3$*, df = 2,* P *= 0.001; CFI = 0.98; and SRMR=0.026. SBP, systolic blood pressure.*

used Adult Treatment Panel III criteria modified for age (14).

RESULTS — Figure 1 depicts the CFA results for the three single-factor MS models in our population. The goodness of fit was fairly good for the model by Pladevall et al. (Fig. 1*A*) and the model by Li and Ford (Fig. 1*B*). Yet for the latter, the factor loading of systolic blood pressure was below 0.3, indicating a poor validity. Our model displayed a somewhat better fit than that of Pladevall et al., and the factor loading of all variables was >0.3, indicating acceptable construct validity (Fig. 1*C*). Similar results were observed when fasting insulin was replaced by R-HOMA (factor loading: 0.67).

Our model also showed a good fit in each sex and physical activity group. The factor loading of the MS components did not differ between boys and girls ($P = 0.682$) or between active and sedentary children ($P = 0.187$).

The median of the MS index was −0.3 (range −8.349–9.64). No difference was observed in the mean MS index between boys (mean = −0.019) and girls (mean = −0.019; $P = 0.998$). In contrast, active children registered a lower MS index (mean = −0.355) than sedentary children (mean = 0.229; $P < 0.001$), validating the benefit of physical activity on the MS.

The area below the ROC curve was 0.98 (95% CI 0.96–0.99). The best cut point for the MS index was 4.2, with a sensitivity of 94.1% (95% CI 91.11–97.13) and a specificity of 93.5% (95% CI 93.46–93.58).

CONCLUSIONS — Our study may lead to improvements in the understanding and diagnosis of MS. First, it confirms that a single factor may underlie the MS construct in children and suggests that there could be some pattern of common causation for the core components of MS. Second, it provides an MS index that may be useful for identifying MS in children. To assist practicing physicians in obtaining immediate results based on crude patient data, we have developed a software application that gives the value of the child's MS index (15).

Our results must be confirmed in other populations and in children of different ages. In addition, future research should test if inflammatory and procoagulant variables, proposed components of MS, should be incorporated into the single-factor model of MS.

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