Health Insurance Moderates the Waist Circumference and Cardiorespiratory Fitness Relationship in U.S. Adolescents

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Abstract Background: Abdominal obesity is a cardiometabolic risk factor and shown to be related to cardiorespiratory fitness (CRF). The purpose of this study was to examine the moderating effects of health insurance (HI) on the waist circumference (WC) and CRF relationship in U.S. adolescents. Methods: Data from youths 12 to 15 years of age participating in the 2012 NHANES National Youth Fitness Survey (NNYFS) were used. Both WC (cm) and CRF (ml/kg/min) were measured by trained medical personnel with HI status assessed via questionnaire by proxy. Binary variables were created at the median for WC and CRF. Multivariate logistic regression was used to examine the relationship between WC, HI and CRF while controlling for confounding variables. Results: The overall prevalence of no HI was 6.5% (95% CI: 2.78 - 10.20). Findings from the fully adjusted model predicting low CRF showed a significant (p = .020) WC-by-HI interaction. Slicing the model by HI status showed a significant decreased risk of low CRF for adolescents with HI and low WC (OR = 0.25, 95% CI: 0.19 - 0.33). Additionally, a significant decreased risk of low CRF was seen among those with no HI and low WC (OR = 0.50, 95% CI: 0.28 - 0.88). Slicing the model by WC status showed a significant increased risk of low CRF for adolescents with low WC and no HI (OR = 2.44, 95% CI: 1.22 - 5.32). However, no significant HI and CRF relationship was observed among adolescents with high WC. Conclusion: This study showed that HI moderates the WC and CRF relationship in U.S. adolescents. Specifically, having low WC appears to protect adolescents against low CRF. Whereas having HI looks as if to protect against low CRF only for those with low WC.

Keywords: body composition, waist circumference, cardiorespiratory fitness, adolescent health

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1. Introduction

Abdominal obesity is a major cardiometabolic risk factor associated with hypertension, diabetes, metabolic syndrome, heart disease, and all-cause mortality [1,2]. Waist circumference (WC) is a common measure of abdominal obesity due to its ability to measure excess fat distributed around the abdomen and its simplistic application [3,4]. Measures of abdominal obesity and WC in U.S. adolescents have increased in past decades, with current estimates (2011-2012) of abdominal obesity surpassing 30% and mean WC estimates surpassing 80 cm [5]. Cardiorespiratory fitness (CRF) is another risk factor for premature morbidity and mortality with known associations with abdominal obesity [6,7,8].

Health insurance (HI) coverage is itself a protective factor for many early onset chronic diseases and premature death [9]. In adolescent populations, those with no HI are more likely to be overweight as compared to those with HI [10]. However, no research to date sheds light on the HI and CRF relationship in adolescents. Moreover, the moderating role that HI may play on the abdominal obesity and CRF relationship is even less understood. The purpose of this study was twofold. The first purpose was to examine the relationship between WC, HI and CRF in U.S. adolescents. The second purpose was to examine the extent to which HI moderates the WC and CRF relationship.

2. Materials & Methods

2.1. Study Procedures

Data for this research came from the 2012 National Health and Nutrition Examination Survey’s (NHANES) National Youth Fitness Survey (NNYFS). The goal of NNYFS was to assess physical activity and physical fitness levels in U.S. youth aged 3 to 15 years [11]. The NNYFS design included a four-stage probability sample of noninstitutionalized civilian U.S. residents with 1,640 youth interviewed and 1,576 youth examined. NNYFS data are publicly available and organized by Demographics,
Dietary, Examination, Questionnaire, and Limited Access. For this study, Demographic and Examination data only were used from adolescents aged 12 to 15 years.

2.2. Study Variables

WC and CRF were both examination variables used in this study, each assessed by trained medical personnel using standardized methods. WC was measured in centimeters (cm) at a horizontal plane, using a mirror, just above the iliac crest [12]. CRF was measured using one of five submaximal exercise treadmill protocols varying in speed and grade [13]. Participants were assigned to a specific four-stage protocol based on their age, sex, BMI, and self-reported physical activity readiness (PAR) score. Submaximal heart rate and predicted submaximal oxygen consumption (VO2) during each of the middle two stages were used to estimate participant maximal oxygen consumption (VO2max) in ml/kg/min. Binary variables were created at the sex-specific median for both WC and CRF. Those in the lower 50% were considered “low” and those in the upper 50% were consider “high” in WC and CRF. HI status was a questionnaire variable and assessed by adolescent proxy using the following question: Are you (Is the sample person) covered by health insurance or some other kind of health care plan? Those answering “yes” were considered to have HI and those answering “no” were considered to have no HI. In order to describe the sample and control for possible demographic confounding, sex, age, race, and income were used in this study. Sex was a categorical variable represented by two groups: 1) Non-Hispanic White, 2) Non-Hispanic Black, 1) Mexican/Hispanic, and 4) Other Races / Multi-racial. Finally, income was a numeric variable, collected as a numeric variable, collected as

2.3. Statistical Analyses

The first part of the statistical analysis consisted of describing the sample in terms of HI status and sociodemographic characteristics. Cross-tabulation and the Rao-Scott chi-square statistic ($\chi^2$) provided prevalence estimates, 95% confidence intervals (CIs), and probabilities associated with variable independence. Multivariate logistic regression was used to estimate the WC-related and HI-related odds of being in the low CRF group while controlling for confounding variables. Finally, predicted probabilities were outputted from the fully adjusted logistic regression model and used for group comparisons. All analyses were weighted to produce generalizations representative of noninstitutionalized U.S. adolescents aged 12-15 years. SAS version 9.4 was used for all analyses [14,15,16,17].

3. Results

A total of $N = 491$ adolescents were included in the analysis with a loss of 9, 1, and 42 youth with missing income, WC, and CRF data, respectively. Table 1 contains descriptive estimates of HI status by sociodemographic characteristics and related study variables. The overall prevalence of no HI was 6.5% ($p < .001$) with no sex ($p = .408$) or age ($p = .091$) relationship seen. HI status was also significantly related to race ($p = .005$) and income ($p = .001$). However, no significant dependence was observed between HI status and WC ($p = .995$) or CRF ($p = .161$). Table 2 contains results from the initial multivariate logistic regression models. Interesting, adjusting for sociodemographic confounders did not significantly alter the WC and HI relationship with CRF (Model 1 vs. Model 2). Additionally, the adjusted model saw a significant lower odds of low CRF among those with low WC ($OR = 0.26, 95\% CI: 0.20 - 0.34$) - with HI not significantly contributing to the relationship. Regardless of these findings, the fully adjusted model showed a significant ($p = .20$) WC-by-HI interaction, requiring analysis of simple effects. Table 3 contains the final set of logistic regression models with the WC-by-HI interaction sliced by HI status and then sliced by WC status. Among those with HI, a significant decreased odds of low CRF was seen for those with low WC ($OR = 0.25, 95\% CI: 0.19 - 0.33$). Similarly, among those with no HI, a significant decreased odds of low CRF was seen for those with low WC ($OR = 0.50, 95\% CI: 0.28 - 0.88$). Conversely, among those with low WC, a significant increased risk of low CRF was seen for those with no HI ($OR = 2.44, 95\% CI: 1.22 - 5.32$). However, among those with high WC, no significant HI and CRF relationship was observed. Figure 1 displays the predicted probabilities of low CRF by HI and WC status. This graph clearly shows the moderating effect (WC-by-HI interaction $p < .001$) that HI status has on the likelihood of being classified as low CRF relative to WC status.

Table 1. Prevalence of HI status by sociodemographic characteristics and study variables in adolescents 12 to 15 years of age, 2012 NNYFS

| Variable | No HI | | | | Has HI | | | |
|----------|------|---|---|---|------|---|---|---|
| Overall | 6.5 | 1.73 | 2.78 | 10.20 | 93.5 | 1.73 | 89.80 | 97.22 |
| Sex | | | | | | | | | |
| Male | 40.6 | 13.41 | 11.82 | 69.32 | 51.9 | 1.66 | 48.38 | 55.48 |
| Female | 59.4 | 13.41 | 30.68 | 88.18 | 48.1 | 1.66 | 44.52 | 51.62 |
| Age (yr) | | | | | | | | | |
| 12 | 28.7 | 9.76 | 7.77 | 49.64 | 29.3 | 2.23 | 24.47 | 34.05 |
| 13 | 40.0 | 9.73 | 19.12 | 60.86 | 22.9 | 2.72 | 17.10 | 28.78 |
| 14 | 21.9 | 5.35 | 10.37 | 33.34 | 26.8 | 2.53 | 21.42 | 32.28 |
| 15 | 9.4 | 4.01 | 0.85 | 18.04 | 21.0 | 1.44 | 17.86 | 24.05 |

$\chi^2$ $p$
Table 2. Odds of low CRF in relation to WC status and HI status in adolescents 12 to 15 years of age, 2012 NNYFS

| Variables | Model 1 | Model 2 | Model 3 |
|-----------|---------|---------|---------|
| WC        | OR      | LL      | UL      | OR      | LL      | UL      | OR      | LL      | UL      |
| High      | 1.00    | 1.00    | 1.00    |
| Low       | 0.29    | 0.22    | 0.37    | 0.26    | 0.20    | 0.34    | 0.25    | 0.19    | 0.32    |
| HI        | 1.00    | 1.00    | 1.00    |
| Yes       | 1.75    | 0.81    | 3.81    | 1.77    | 0.77    | 4.03    | 1.21    | 0.53    | 2.74    |
| No        | 2.02    | 1.19    | 3.41    |
| WC * HI   |         |         |         |

Note. HI is health insurance. WC is waist circumference. CRF is cardiorespiratory fitness. OR is odds ratio estimate. LL is lower limit of the 95% CI. UL is upper limit of the 95% CI. \( \chi^2 \) is the Rao-Scott chi-square test of independence statistic. Low WC < 77.4 cm (female) & < 76.8 cm (male). Low CRF < 36.5 ml/kg/min (female) & < 41.9 ml/kg/min (male).

Models are adjusted for age, sex, race, and income.

Table 3. Odds of low CRF in relation to WC status by HI status and in relation HI status by WC status in adolescents 12 to 15 years of age, 2012 NNYFS

| Variables | Has HI | No HI |
|-----------|--------|-------|
| WC        | OR      | LL    | UL    | OR      | LL    | UL    |
| High      | 1.00   | 1.00  |
| Low       | 0.25   | 0.19  | 0.33  | 0.50    | 0.28  | 0.88  |
| HI        | 1.21   | 0.49  | 2.96  | 2.44    | 1.12  | 5.32  |

Note. HI is health insurance. WC is waist circumference. CRF is cardiorespiratory fitness. OR is odds ratio estimate. LL is lower limit of the 95% CI. UL is upper limit of the 95% CI. Low WC < 77.4 cm (female) & < 76.8 cm (male). Low CRF < 36.5 ml/kg/min (female) & < 41.9 ml/kg/min (male). Models are adjusted for age, sex, race, and income.
4. Discussion

One purpose of this study was to examine the relationship between WC, HI and CRF in U.S. adolescents. Results indicated that WC is an independent predictor of CRF in adolescents while HI was a non-predictor of CRF in both univariate and multivariate analyses. The second purpose of this study was to examine the extent to which HI moderates the WC and CRF relationship. Results clearly showed that the relationship between WC and CRF in adolescents differed according to HI status. Specifically, WC was a stronger predictor of CRF among adolescents with some type of medical coverage. Moreover, medical coverage provided no CRF benefit among adolescents with high WC. These findings are particularly insightful because, on the surface, HI does not appear to be related to adolescent fitness. However, with HI and WC considered jointly, the relationship surfaces. Adding to this complexity is the fact that HI coverage seems to benefit adolescent fitness only for those with low WC. The mechanism behind these findings is unknown and beyond the scope of this research. However, other studies have reported similar interactions between medical coverage and other health outcomes. One such study examined the moderating effect of HI on the relationship between length of stay in the U.S. and self-reported changes in health status in a large national immigrant population [18]. Results from this study showed that immigrants with HI were almost twice as likely (compared to the uninsured) to received secondary prevention medical care (such as screenings). Similar to these findings, the moderating effect of HI in the current study may in part be explained by access to preventive medicine. That is, adolescents with HI may be more likely to receive recommendations from health care professionals to meet current physical activity guidelines. This mechanism is also supported by a different study that showed U.S. adults without HI were more likely to participate in inadequate amounts of physical activity, as compared to their insured counterparts [19]. Additionally, it is conceivable that families with HI are more likely to endorse physical activity and fitness recommendations from health professionals. A study of African American women found that participants were three times more likely to endorse breast cancer screening, as compared to their uninsured counterparts [20]. Albeit, these studies were not specifically researching adolescents and this mechanism overall does not explain the lack of HI protection in adolescents with high WC. Therefore, future research should focus on the body composition-related disparities in health information given to adolescents, as provided by health care professionals.

One strength regarding this study is its use of a nationally representative sample of U.S. adolescents ages 12 to 15 years. Therefore, generalizations from this study have strong external validity. Another strength worth mentioning is the use of objectively measured WC and objectively measured CR, each assessed by trained medical professionals. This strength distinguishes the study’s findings from other studies utilizing self-reported measures and non-standardized protocols. Despite these strengths, there are some limitations worth declaring. The
NNYFS is not a longitudinal study but rather cross-sectional and therefore these findings should only be considered correlational. Another limitation of this study was its inability to control for puberty. It is possible that some adolescents of the same WC differed in CRF due to differences in natural hormones. However, age was controlled for in the models and likely minimized the confounding effect of hormone levels. Given these limitations, these results should be considered with caution.

5. Conclusions

This study showed that HI moderates the WC and CRF relationship in U.S. adolescents. Specifically, having low WC appears to protect adolescents against low CRF. Whereas having HI looks as if to protect against low CRF only for those with low WC. Health promotion professionals should be aware that adolescents with abdominal obesity may suffer from low CRF, regardless of their medical coverage status.

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