BMI, Health Behaviors, and Quality of Life in Children and Adolescents: A School-Based Study

WHAT’S KNOWN ON THIS SUBJECT: Existing literature indicates relationships between BMI, physical activity, sleep patterns, eating behavior, and health-related quality of life in children and adolescents. However, many previous studies have used non-preference-based instruments, which are not suitable for application within economic evaluation.

WHAT THIS STUDY ADDS: The Child Health Utility 9D, a new preference-based health-related quality of life instrument for application in economic evaluation in children and adolescents, revealed stronger associations between utilities and sleep patterns or eating behavior than with BMI, physical activity, or sedentary behavior.

abstract

OBJECTIVE: To explore the relationship between weight status (BMI) and health-related quality of life in children and adolescents through application of the Child Health Utility 9D, a new generic preference-based instrument.

METHODS: Data were collected from primary and high school students in rural and metropolitan regions of South Australia. Consenting participants (2588 in grades 4–6 and 765 in grades 9–10) were weighed and measured and categorized as underweight, healthy weight, overweight, or obese according to International Obesity Taskforce BMI cutoff points (primary outcome). Participants also completed a questionnaire including the Child Health Utility 9D and standardized measures of physical activity, sedentary behavior, sleep patterns, and eating behavior (secondary outcomes). Descriptive and multivariate linear regression analyses were undertaken to calculate mean utility differences.

RESULTS: In comparison with healthy-weight primary school students, adjusted mean utilities were lower for overweight (−0.016, P = .02) or obese (−0.039, P = .001) students. For high school students, the adjusted mean utilities were also lower for overweight and obese students but were nonsignificant (−0.018, P > .10). Physical activity, sedentary behavior, sleep patterns, and eating behavior were all found to be significantly associated with utilities.

CONCLUSIONS: Irrespective of BMI, young people engaging in more physical activities or less sedentary behavior, and having healthier sleep patterns or eating behavior exhibited higher utilities. Associations between utilities and sleep patterns or eating behavior were stronger than the associations with BMI. Future economic evaluations for obesity interventions should more formally investigate the relationship between changes over time in weight status and health-related quality of life for children and adolescents.

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Australia

The Child Health Utility 9D

HRQol—health-related quality of life

ICSEA—Index of Community Socio-Educational Advantage

MCID—minimum clinically importance difference

NCNPAS—National Children’s Nutrition and Physical Activity Survey

OPAL—Obesity Prevention and Lifestyle

Dr Chen carried out the initial analyses, drafted the initial manuscript, and revised the manuscript; Professor Ratcliffe conceptualized and designed the study, designed the data collection instruments, and reviewed and revised the manuscript; Professor Olds and Associate Professor Magarey designed the data collection instruments and reviewed and revised the manuscript; Dr Jones coordinated ethics applications, selection of Obesity Prevention and Lifestyle intervention program intervention and comparison communities, and data collection and reviewed and revised the manuscript; Dr Leslie prepared ethics applications, coordinated and supervised data collection and data management, and reviewed and revised the manuscript; and all authors approved the final manuscript as submitted.

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(Continued on last page)
Population overweight and obesity is a key public health issue, with prevalence in Australian children between 20% and 25%, and in the United States, it is 35%. Childhood obesity is associated with a range of medical complications and psychological conditions, such as diabetes, cardiovascular disease, gallbladder disease, obstructive sleep apnea, social stigmatization, and low self-esteem.

Health-related quality of life (HRQoL) is a multidimensional construct that measures the impact of health or disease on physical and psychosocial functioning. Previous studies suggest there may be relationships between BMI, physical activity, sedentary behavior, sleep patterns, eating behavior, and HRQoL in children and adolescents, with unhealthy weight or behaviors being associated with a lower HRQoL in general.

Utilities are the most widely used mechanism for measuring and valuing HRQoL, within economic evaluation. Utilities reflect cardinal values that usually range between 0 (dead) and 1 (full health) on the quality-adjusted life years scale. Therefore, higher utilities are associated with higher HRQoL and vice versa. Depending on the preference-based instrument to be applied, negative utilities may exist to reflect health states considered to be worse than death. The key advantage of adopting the utility approach lies in its generic nature and its comprehensiveness, facilitating the broad comparison of public health prevention and health care interventions in terms of value for money, as represented by their respective cost per quality-adjusted life year ratios.

This study adds to the existing literature by providing a detailed examination of the relationships between utilities and a series of indicators including BMI and health behaviors of children and adolescents. To our knowledge, this is also the first study internationally to report utilities associated with sedentary behavior and sleep patterns for children and adolescents.

**METHODS**

**Design**

The Obesity Prevention and Lifestyle (OPAL) program is a system-wide, multistrategy community-based public health intervention program funded by the Australian, South Australian, and select local governments in 2009. The aim of OPAL is to improve eating and activity patterns of South Australian children and increase the proportion of 0- to 18-year-olds in the healthy weight range. Communities with higher populations of children, higher levels of disadvantage, higher levels of childhood overweight and obesity, and community and local government readiness were chosen. In regional areas, communities are intact geographic communities (defined by the boundaries of the local government area, whereas metropolitan communities are subsets of suburbs within the local government area. Comparison communities were selected on the basis of matching characteristics (eg, maternal education, the Index of Relative Socioeconomic Disadvantage, and proportion of 0- to 18-year-olds). A serial cross-sectional design was used. This study uses combined baseline data from Phase 1 and 2 collected between October 2011 and May 2012.

The OPAL project was approved by the Flinders University Social and Behavioral Sciences Ethics Committee, South Australian Department of Health Human Research Ethics Committee, Aboriginal Health Council Human Research Ethics Committee, the Department of Education and Child Development, and Catholic Education, SA.

**Sample**

Schools from 10 OPAL communities and 12 comparison communities were invited by the South Australian Department for Health and Ageing to participate in the evaluation. Within participating schools, students in grades 4 to 6 and grades 9 to 10 were recruited to complete self-report surveys and anthropometric measures.

**Recruitment and Procedures**

Consent for school involvement was sought from principals in the first instance. Parents and guardians gave informed consent (hard copy or online form), and children gave written and verbal assent at the time of administration of the survey and before being measured.

**Anthropometry Measures and Classification (Primary Outcome)**

Each consenting student was measured in a private and screened area out of view of other students by a trained researcher. Height and weight were determined as the mean of 2 measures or the median if 3 measures were taken. BMI was calculated as weight (in kilograms) divided by height (in meters) squared. Participants were categorized as underweight, healthy weight, overweight, or obese using the International Obesity Taskforce BMI cutoff points, which vary with age and gender and are designed to match adult equivalents of 25 and 30 kg/m².

**RESULTS**

**Baseline Data**

Baseline data from Phase 1 and 2 collection were used. This study uses combined baseline data from Phase 1 and 2 and community readiness were chosen. In regional areas, communities are intact geographic communities (defined by the boundaries of the local government area, whereas metropolitan communities are subsets of suburbs within the local government area. Comparison communities were selected on the basis of matching characteristics (eg, maternal education, the Index of Relative Socioeconomic Disadvantage, and proportion of 0- to 18-year-olds). A serial cross-sectional design was used. This study uses combined baseline data from Phase 1 and 2 collected between October 2011 and May 2012.
Behavior Measurements (Secondary Outcomes)

Self-reported information about children’s and adolescents’ demographics, eating behavior, body image, health status, physical activity, sedentary behavior, perceptions of the environment (school, neighborhood, and family), and sleep patterns were captured through an online or paper questionnaire. The physical activity and sedentary behavior questions have previously been validated, with a test–retest reliability of 0.77 and validity relative to accelerometry of 0.40.23 The National Physical Activity Guidelines of Australia recommend that children and adolescents are physically active for a minimum of 60 minutes every day and that they limit screen time to no more than 2 hours a day.24,25 Variables were coded as “physically active days” (number of days on which participants were physically active for a minimum of 60 minutes per day over the last 7 days), “sedentary days” (number of days on which students experienced 2 or more hours of screen time [television, computers, video games] per day outside school hours over the past week), and “average screen hours” (average screen hours spent across school and non-school days).

School-aged children and adolescents reported school day wake-up and bed times. Data are reported separately for school days and non–school days because sleep patterns vary radically across day types. School day wake times were culled to permit only times between 03:00 and 09:00 (based on school start times and data from the 2007 Australian National Children’s Nutrition and Physical Activity Survey [NCNPAS]). School day bed times after 02:00 and before 19:00 were culled; on non–school days, wake up times before 03:00 and after 14:00 and bed times after 02:00 and before 19:00 were culled (based on NCNPAS). Sleep pattern was measured by the average bedtime. Sleep duration, calculated as the difference between bed time and wake-up time, was also included in the data analysis as a secondary measure for sleep pattern. Bed times and sleep durations were averaged across school and non–school days, equally weighted, based on the fact that Australian children spend about 1 day in 2 in school over the course of a year. Frequency of eating fast food or takeaway (including burgers, pizza, fried chicken, and fish and chips) was used as a proxy for unhealthy eating behavior and coded as “rarely/sometimes” or “often/a lot.”

HRQoL Measurement

The Child Health Utility 9D (CHU9D) is a new generic preference-based measure of HRQoL, specifically designed for application within cost-effectiveness analyses of health care treatment and public health preventive programs targeted at young people.19 In contrast to other generic preference-based measures of HRQoL recently developed for application with child and adolescent populations, including the EQ-5D-Y,26,27 and the Assessment of Quality of Life 6D (AQoL-6D),28 which represent adaptations of existing instruments originally developed for adults, the CHU9D was developed from its inception with young people.29

The CHU9D has 9 dimensions: worried, sad, pain, tired, annoyed, schoolwork, sleep, daily routine, and ability to join in activities, with 5 responses representing increasing levels of severity within each dimension. The dimensions were originally identified from in-depth qualitative interviews with young people with a variety of chronic and acute health problems, to explore how their health affects their lives.30 The practicality and face and construct validity of the CHU9D have been reported.31–33 The instrument was scored by using the newly developed Australian adolescent-specific scoring algorithm.32

Sociodemographic Variables

Sociodemographic variables included in the data analysis were gender, age, region (metro or rural), and Index of Community Socio-Educational Advantage (ICSEA) quartiles (a proxy for socioeconomic position). ICSEA is a school-level measure developed in Australia that represents level of education advantage, with a median value of 1000 and an SD of 100; higher values represent schools with students from more advantaged backgrounds.34

Statistical Analyses

Because the Shapiro–Francia test indicated that utilities were not normally distributed, 2 nonparametric tests (Mann–Whitney U and Kruskal–Wallis) were used to compare utilities between groups. Linear regression analysis was conducted to study the potential associations between BMI and health behaviors (core independent variables) and the utility score (dependent variable) after controlling for sociodemographic variables. Considering the 2-level nature of the survey data, that students (level 1) are nested within schools (level 2), a 2-level random intercept model was used.35 BMI is included as a set of dummy variables, with the healthy-weight group as the reference level. Physical activity, sedentary behavior, and sleep pattern measures are included as continuous variables and eating takeaway or fast food as a dummy variable. Primary and high school data were analyzed separately. All analyses were performed in Stata version 12.1 (Stata Corp, College Station, TX).

RESULTS

Of the 205 primary (elementary) and 47 high (secondary) schools approached, 96 (52%) primary and 16 (38%) high schools agreed to participate. Of a total of 17 847 students (63.1% primary) approached within the participating
schools, 3386 students (77.1% primary) consented to participate in the survey, and 3357 students (99.1%) completed the CHU9D instrument. The mean (range) CHU9D utilities were 0.87 (0.4–1.0) and 0.81 (0.3–1.0) for primary and high school students, respectively, and the mean (range) ages were 10.6 (7.9–13.0) and 15.1 (13.6–16.9) years for primary and high school students, respectively. Overall, 51% of the sample was girls, and 63.7% resided in the metro region. Characteristics of participants by school setting are shown in Table 1.

Mean utilities classified according to BMI and behavior domains for each school sample are presented in Table 2. Because of the limited number of observations, the overweight and obese categories were pooled for the high school sample. A negative relationship was evident between BMI and utilities adjusted for sociodemographic variables (hereafter adjusted mean utilities) are reported in Table 3. For the primary school sample (Panel A), being overweight or obese was significantly associated with a difference in adjusted mean utility of −0.016 (P = .02) or −0.039 (P = .001) compared with being a healthy weight. Because the mean utility of healthy-weight primary school students was 0.872 (Table 2), the magnitudes of above-utility reductions suggest that overweight or obese children were willing to forgo 1.8% (0.016/0.872) or 4.5% (0.039/0.872) of their life in exchange for healthy weight. These figures are slightly lower than those reported in a recent Australian-based

<table>
<thead>
<tr>
<th>TABLE 1 Characteristics of Respondents</th>
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<tbody>
<tr>
<td><strong>Primary School Sample</strong></td>
</tr>
<tr>
<td>Age, years</td>
</tr>
<tr>
<td>Gender</td>
</tr>
<tr>
<td>Boys, n (%)</td>
</tr>
<tr>
<td>Girls, n (%)</td>
</tr>
<tr>
<td>Region</td>
</tr>
<tr>
<td>Metro, n (%)</td>
</tr>
<tr>
<td>Rural, n (%)</td>
</tr>
<tr>
<td>ICSEA scoresa</td>
</tr>
<tr>
<td>n (mean ± SD)</td>
</tr>
<tr>
<td>CHU9D utility scores</td>
</tr>
<tr>
<td>n (mean ± SD)</td>
</tr>
<tr>
<td>BMI</td>
</tr>
<tr>
<td>n (mean ± SD)</td>
</tr>
<tr>
<td>Physically active days in the last 7 d</td>
</tr>
<tr>
<td>n (mean ± SD)</td>
</tr>
<tr>
<td>Sedentary days in the last 7 d</td>
</tr>
<tr>
<td>n (mean ± SD)</td>
</tr>
<tr>
<td>Average screen hours</td>
</tr>
<tr>
<td>n (mean ± SD)</td>
</tr>
<tr>
<td>Average bedtime (hours past previous midnight) in the last 7 d</td>
</tr>
<tr>
<td>n (mean ± SD)</td>
</tr>
<tr>
<td>Average sleep duration hours on school days</td>
</tr>
<tr>
<td>n (mean ± SD)</td>
</tr>
<tr>
<td>Eat fast food or takeaway</td>
</tr>
<tr>
<td>Never or sometimes, n (%)</td>
</tr>
<tr>
<td>Often or a lot, n (%)</td>
</tr>
</tbody>
</table>

* Higher ICSEA values represent a more advantaged background.

<table>
<thead>
<tr>
<th>TABLE 2 Mean Scores of HRQoL Utility Scores by Weight Status and Behavior Domains</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Panel A: Primary School Sample</strong></td>
</tr>
<tr>
<td>N</td>
</tr>
<tr>
<td>All sample</td>
</tr>
<tr>
<td>Underweight</td>
</tr>
<tr>
<td>Healthy</td>
</tr>
<tr>
<td>Overweight</td>
</tr>
<tr>
<td>Obese</td>
</tr>
<tr>
<td>Overweight or obese</td>
</tr>
<tr>
<td>Physical activity for at least 1 h in the last 7 d</td>
</tr>
<tr>
<td>6–7 d</td>
</tr>
<tr>
<td>3–5 d</td>
</tr>
<tr>
<td>0–2 d</td>
</tr>
<tr>
<td>Screen time of at least 2 h in the last 7 d</td>
</tr>
<tr>
<td>0 d</td>
</tr>
<tr>
<td>1–2 d</td>
</tr>
<tr>
<td>3–7 d</td>
</tr>
<tr>
<td>Average bedtime</td>
</tr>
<tr>
<td>≤Median timeb</td>
</tr>
<tr>
<td>&gt;Median timeb</td>
</tr>
<tr>
<td>Eat fast food or takeaway</td>
</tr>
<tr>
<td>Never or sometimes</td>
</tr>
<tr>
<td>Often or a lot</td>
</tr>
</tbody>
</table>

* Mann–Whitney U test for 2 groups; Kruskal–Wallis test for >2 groups.

b Median bedtime was calculated within each age group.
The adjusted mean utilities for each of the behavior domains are reported in Table 3. Each additional day of being overweight or obese was associated with lower adjusted mean utilities, with a range of behavior indicators in young people. The association between frequently eating fast food or takeaway and HRQoL is reported in Panel G. Compared with those who never or sometimes eat fast food or takeaway, unhealthy eating behavior was associated with lower adjusted mean utilities of $-0.040 (P < .001)$ and $-0.036 (P = .004)$ for primary and high school students, respectively.

**DISCUSSION**

This study adds to existing knowledge on the utilities associated with BMI and a range of behavior indicators in young people. Compared with healthy-weight children and adolescents, mean CHU9D utilities were lower for underweight and overweight or obese children and adolescents. These relationships were found to be statistically significant for the children sample but not for the adolescent sample. However, it is important to note that the adolescent sample was small and not representative of the wider adolescent population. It is quite possible that a large number of overweight and obese adolescents with poor HRQoL chose not to volunteer to participate in this study, thereby weakening the associations between BMI and HRQoL. For the behaviors studied, the absolute magnitudes of reductions or gains in utility were largest in eating behavior, followed by sleep pattern, sedentary behavior, and physical activity and were statistically significant for both children and adolescents.

Comparing our study sample with approximately matching age groups in the 2007 NCNPAS South Australian booster sample, we found that the proportions of overweight and obesity for the primary school sample were similar (22% from OPAL data vs. 23% for children 9 to 13 years old from NCNPAS); however, the proportions were much lower for high school sample (16% vs. 29% for adolescents 14–16 years old). Our figures were also lower than the counterparts in the full 2007 NCNPAS sample (27% and 24% for 9–13 and 14–16 years old, respectively).

The results of this study have highlighted the important relationships between behaviors (especially eating behavior and sleep pattern) and utilities in young people. A previous study of high school students (aged 11–15 and in grades 7, 9, and 10) in the United Kingdom also reported adjusted mean utilities (based on the EQ-5D instrument and its corresponding scoring algorithm using adult values) for different categories of BMI, physical activity, and eating behaviors. In contrast to our study, the UK study found that the adjusted EQ-5D utilities in physical activity and eating behaviors were insignificant ($P > .10$). However, as noted previously, using adult values for the derivation of utilities for young people is problematic because evidence
indicates that the attributes of importance in defining health and their respective weightings are different for young people and adults.\textsuperscript{36}

Compared with the other behavioral indicators, the association between sleep pattern and HRQoL has been the least studied in the general population. In the main results presented in Table 3, 2 sleep pattern variables were included in the regression model separately. However, it may be that it is not when one goes to sleep but rather sleep duration that matters.\textsuperscript{37} When both variables (ie, average bedtime and average sleep duration hours) were included as explanatory at the same time, only average bedtime was still found to be significant ($P \leq .001$).

Two caveats are worth mentioning that may warrant future investigation when additional data become available. First, it would be ideal to ascertain the extent to which differences in mean CHU9D utilities are clinically significant. To address this issue, it is necessary to identify the minimum clinically important difference (MCID). The CHU9D is a newly developed instrument, indicators that the attributes of importance in defining health and their respective weightings are different for young people and adults.\textsuperscript{36}

However, it is unclear whether a utility difference of 0.03 could be readily translated and used as a MCID for this study because the aforementioned criterion was derived from adults sampled using different instruments (15D and HUI). Additional research derived from child and adolescent samples to identify the MCID and to compare the findings from this study with general population norm data for the CHU9D is therefore warranted.

Second, the results based on the regression analysis should be explained in terms of association rather than a causal relationship. Both reverse causality (ie, HRQoL may influence BMI or health behaviors) and omission of variables (eg, personality traits) may occur; and the issue of endogeneity cannot be ruled out in this cross-sectional study. Furthermore, BMI and the various health behaviors are all potentially interrelated in complex ways. Each may exert an independent effect on HRQoL or may work through any number of interactions. The nature of the cross-sectional data impeded additional exploration of the potential causal pathways.

**CONCLUSIONS**

The results from this study indicate that in comparison with healthy-weight people, in general utilities are lower for overweight or obese people, and these relationships are statistically significant for children. Among 4 health behaviors studied in this article, the reductions or gains in utility were largest in eating behavior, followed by sleep pattern, sedentary behavior, and physical activity. The relationships identified between utilities, BMI, and health behaviors indicate that OPAL and other public health interventions for the prevention and treatment of childhood overweight and obesity may have a longer-term impact in improving the HRQoL of younger people through changes in weight over time. Future economic evaluations for obesity interventions should more formally investigate the relationship between changes in BMI and HRQoL for children and adolescent populations.

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