Building the Methods

Reliability and Validity of Two Instruments Designed to Assess the Walking and Bicycling Suitability of Sidewalks and Roads

James Emery, MPH; Carolyn Crump, PhD; Philip Bors, MPH

Abstract

Purpose. *Public health professionals hypothesize that when community environments provide suitable walking and bicycling conditions, community members will be more active. Measurement indicators and assessment instruments are needed to evaluate suitability. This study determined the reliability and validity of two instruments to assess the suitability of sidewalks for walking and roads for bicycling.*

Methods. *Two data collectors used walking and bicycling suitability assessment instruments to collect data on 31 road segments. In addition, three transportation experts used a 7-point Likert response system to subjectively evaluate walking and bicycling conditions for the same segments. Intraclass correlations determined the reliability of each assessment instrument and the reliability of the Likert response system. Pearson correlations (research staff assessments with expert assessments) were calculated to determine the criterion-related validity of the suitability measures.*

Results. *Intercoder reliability (intraclass) correlations for the walking and bicycling assessment instruments were* $r = .79$ *and .90, respectively. Intercoder reliability of the experts' Likert response system was* $r = .73$ *for the walking form and* $r = .77$ *for the bicycling form. Criterion-related validity (Pearson) correlations for the walking and bicycling assessment instruments were* $r = .58$ *and .62, respectively.*

Conclusion. *Although some variables have lower reliability and validity than is ideal, the walking and bicycling suitability assessment instruments appear promising as instruments for community members and professionals to systematically assess key aspects of the physical environment. (Am J Health Promot 2003;18[1]:38–46.)*

Key Words: Physical Activity, Walking, Pedestrian, Bicycling, Community Design, Active Living, Active Transportation, Prevention Research

James Emery, MPH, is a research associate in the School of Public Health, the University of North Carolina at Chapel Hill, Chapel Hill, North Carolina. Carolyn Crump, PhD, is a research assistant professor in the School of Public Health, the University of North Carolina at Chapel Hill, Chapel Hill, North Carolina. Philip Bors, MPH, is a project officer for Active Living by Design, School of Public Health, the University of North Carolina at Chapel Hill, Chapel Hill, North Carolina.

Send reprint requests to James Emery, MPH, Research Associate, Department of Health Behavior and Health Education, School of Public Health, The University of North Carolina at Chapel Hill, CB# 7506, Chapel Hill, NC 27599-7506.

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INTRODUCTION

The 1996 U.S. Surgeon General's report recommends accumulating 30 minutes of regular moderate physical activity on most days of the week, since moderate levels of physical activity can help reduce the risk for chronic disease.[1] However, almost 60% of adults are still not sufficiently active to achieve health benefits, and close to 30% report no leisure-time physical activity in the past month.[2] Moderate physical activity may be more easily initiated and sustained when activities can be incorporated into daily routines, such as walking and bicycling for transportation and leisure. The physical environment surrounding and connecting residential, school, and business locations may determine the extent to which community members can incorporate walking and bicycling into their daily routines. Public health proponents hypothesize that when community environments are designed to provide suitable facilities for walking and bicycling, community members will be more active.[3,4]

Within the last decade, transportation and public health program goals have focused attention on walking and bicycling behavior and have begun studying the physical environment that supports or challenges these healthy behaviors. In 1994 the U.S. Department of Transportation established a goal to double adult walking and bicycling trips. The recent Task Force on Community Preventive Services recommended increasing environmental opportunities for physical activity.[5] Healthy People 2010 enhanced the Healthy People 2000 community-environment objective addressing community walking and bicycling opportunities and added objectives 22-14 and 22-15 to increase the number of walking and bicycling trips. Interdisciplinary professional collaborations have increased research into how the built environment influences people's travel decisions.[6–13]

Transportation planners and engineers have been studying pedestrian and bicycling environmental design issues since the 1970s.[9–11,14–18] However, it was not until the 1980s that instruments were developed to assess the ''suitability'' of sidewalks and roads for walking and bicycling. Most instruments focused on urban streets and rural roads, although a few assessed the suitability of trails for walking and bicycling.[14,19–21] Suitability assessment instruments for quantitative data collection generally group the design variables into five basic transportation environment categories: traffic volume, traffic speed, facility width, surface factors, and location factors.[14,22–35] To our knowledge only two studies have developed audit methods for use by community residents.[28,36]

Public interest in more ''livable'' communities designed to promote walking and bicycling has encouraged new alliances between professionals from various disciplines and community members interested in improving the opportunities for physical activity.[37–43] Community members can advocate more effectively for increased opportunities for walking and bicycling if they have tools for assessing the walkability and bike-ability of their neighborhood, leisure, school, retail, and work environments. Despite the increased promotion of walking and bicycling behavior and the need for supportive physical environments, ''gold standard'' tools with known psychometric properties for assessing the suitability of those environments for physical activity do not yet exist. Valid indicators to assess the progress of community support for the recommended behaviors or to evaluate built environment suitability for compliance with recommendations for activity have yet to be identified.[2,44–48]

In previous research we identified 22 potential bicycling suitability assessment instruments in the professional and internet literature but found no appropriate pedestrian suitability assessment instruments.[49] Therefore, the previous study concluded by developing an instrument for assessing the walking suitability of sidewalks (Appendix 1) and analyzed the 22 methods for assessing the bicycling suitability of roads to determine the most desirable assessment tool for future community use (Appendix 2).

The purpose of the current study was to test the reliability and validity of the two assessment instruments.

METHODS

Assessment Instruments

Each assessment instrument is one page in length and is completed by traveling a road segment under 2 miles in length. Overall walking or bicycling conditions from both sides of the road are observed. The rater marks appropriate response categories for each variable and then uses a simple algorithm to calculate the final suitability score. For this project, the unit of analysis was the road segment.

The walking suitability assessment instrument (Appendix 1) is comprised of 11 variables that measure basic transportation environment characteristics including traffic volume, traffic speed, sidewalk and buffer width, surface quality, and supportive amenities such as curb ramps and street lighting.[49] Recorded numeric values are summed to produce the overall walking suitability score for that road segment. If no sidewalk exists for the segment, the instrument produces a minimum score of 99 to denote the lack of pedestrian facilities. The one-page form also includes dichotomous questions about intersection characteristics encountered while assessing the sidewalk segment and provides space for recording isolated problem spots. The intersection information is not part of the final suitability score, but helps to identify design problems.

The Eddy bicycling suitability assessment instrument (Appendix 2) includes 27 variables grouped into three main categories on a one-page form (e.g., general road factors, pavement factors, and location factors).[30] The general road factors include traffic volume, number of through lanes, traffic speed, width of the outside lane, and width of any striped bicycle lane. An algorithm graphic at the bottom of the form provides clearly designated boxes to record several values from the scoring sheet, and then provides the formula for calculating the final bicycling suitability score. In this study, the Eddy instrument was adapted by developing a ''no'' check box for each dichotomous variable to ensure that data collectors had to record a response for every variable and by moving the algorithm graphic to the bottom of the page.

Data Collection

In order to test the reliability and validity of the two assessment instruments, 31 urban and rural road segments ranging in distance from .1 to 2.0 miles in length were identified within 10 miles of the University of North Carolina at Chapel Hill. Road segments were purposefully selected to equally represent major and minor arterial highways, neighborhood collectors, and local streets. Two research staff members used the instruments to assess the sampled road segments. One person had extensive experience using both instruments in prior research; the other had never used either form. Based on earlier assessment experience, the research staff decided to complete the assessments using a motor vehicle, rather than walking or bicycling the road segments. The assessment staff traveled the sampled road segments together in the same motor vehicle from 8:00 A.M. until 7:00 P.M. over several nonholiday weekdays during fair weather in the autumn of 2001. From within the car, they drove the road segment once while observing the environmental characteristics of interest. Parking the vehicle off road, the researchers independently completed the assessment forms. They then traveled each road segment again to observe any characteristics necessary to complete the assessment forms. The assessors left the vehicle at least once per segment in order to measure the width of the sidewalk or travel lane, observe or ''feel'' the grade of the hill, or experience the physical effects (e.g., the surface condition) of the road segment characteristics. They used a steel measuring tape to determine the width of the outside travel lane, the sidewalk, and the buffer area between the sidewalk and road.

Because no gold standard tools exist for criterion-validity comparisons, we created a proxy standard using the opinions of three experts to independently assess the same road segments. Two were transportation engineers with extensive research experience in bicycle and pedestrian design, and one was a county-level coordinator of bicycle and pedestrian transportation planning. The transportation experts subjectively assessed the same walking and bicycling suitability characteristics using new forms designed specifically for the project. The two forms did not restrict the experts' assessment to specific design prompts. Instead, each variable was measured on a 7-point Likert scale ranging from ''conducive'' to ''inhibitive'' with a neutral midpoint.[50]

Due to an oversight, the transportation experts' walking suitability did not include traffic volume, speed, and number of lanes. Therefore, in order to calculate the criterion-validity correlations for those variables, we used the values from the transportation experts' bicycling suitability assessments as proxy measures for the walking suitability form. We assumed that the validity correlations would be similar between walking and bicycling, although possibly weaker for the walking assessment because pedestrians do not share the travel lane with motor vehicles.

Analysis

The two assessment instruments each applied an algorithm that combines the assessed values to produce a final suitability score for the road segment. Intercoder reliability correlations were calculated using SPSS 10.1.0 for Windows (SPSS, Inc., Chicago, Ill) to compute one-way analysis of variance intraclass correlations for each variable. The reliability and validity scores of the two research staff members and the three transportation experts were averaged for each variable and for the overall suitability scores to provide an estimate of the ''true'' scores by each group. Criterion-related validity was defined as the strength of the association between the research staff's and the transportation experts' averaged suitability scores. Pearson product-moment correlations were calculated to determine the validity for both the walking suitability assessment instrument and the bicycling suitability assessment instrument. Because only 17 of the 31 road segments had sidewalks, the walking instrument's validity could only be meaningfully estimated with the reduced sample of road segments. Validity testing of the bicycling instrument was performed on the entire sample of 31 segments.

RESULTS

Walking Suitability Assessment

For the 17 road segments with sidewalks, the intercoder reliability was acceptable for both the overall walking suitability assessment score ($r = .79$) and the transportation experts' overall ratings ($r = .73$). The criterion-related validity correlation for the overall walking suitability assessment score was $r = .58$.

Criterion-related validity for individual variables from the 17 segments ranged from $r = .15$ to .84, with half the variables demonstrating validity correlations greater than $r = .60$ (e.g., presence of sidewalk, presence of streetlights, sidewalk material, traffic volume, and posted speed limit). Table 1 lists the variables in order of validity correlations from most to least robust.

Only two of the five variables with validity correlations greater than $r = .60$ had low reliability. Sidewalk presence and sidewalk material had low intraclass correlations among the transportation experts. The five variables with weaker validity correlations also demonstrated weaker reliability by one or both assessment groups. They were buffer width, number of through lanes, sidewalk condition, sidewalk width, and presence of curb ramps.

Bicycling Suitability Assessment

Intercoder reliability was high for the research staff's overall bicycling suitability assessment score ($r = .90$) and acceptable for the transportation experts ($r = .77$). The criterion-related validity correlation for the overall bicycling suitability score was $r = .62$. Reliability and validity correlations for individual variables ranged from $r = .004$ to .82; over one third of the variables demonstrated validity correlations greater than $r = .60$. Table 2 lists the variables in order of validity correlations.

For both groups, variables that were more reliable tended to have higher validity correlations. Objective observations (e.g., measured width, posted speed limit, type of on-street parking, street curb or shoulder, and types of turn lanes) were more reliably assessed than subjective assessments by the Eddy instrument. Reliability correlations for these variables ranged from $r = .77$ to $r = 1.0$. Less reliable variables were derived from the data collector's subjective rating of physical characteristics such as steepness of grade, quality of railroad crossing, difficulty of intersection crossing, and density of driveways and intersections. Their correlations ranged from $r = .03$ to .58. The transportation experts disagreed with one another on the suitability of the through lanes, center turn lane, parking, curbing, drainage, and shoulders of the road segments. Their disagreement was reflected in their low intraclass correlations and the subsequent low validity for the associated variables. This disagreement suggests that the experts consider the impact of complex design characteristics on walking and bicycling suitability in unique ways.

DISCUSSION

This study is a continuation of research meant to provide community members and professionals with tools to determine the suitability of local sidewalks and roads for walking and bicycling. Because no systematic data

Table 1

Intercoder Reliability and Validity Results for Walking Suitability Assessment Instrument (n = 17 Road Segments)

		Criterion-Related Validity (Pearson Product-Moment)	Reliability (Intraclass Correlation)	
No.	**Walking Variable**	**Research Staff and Transportation Experts**	**Research Staff (n = 2)**	**Transportation Experts (n = 3)**
1	Sidewalk presence	−0.84**	0.99***	0.16
2	Light	0.81**	0.70***	0.63***
3	Sidewalk material	0.66**	1.0***	0.45**
4	AADT†	0.65**[1]	Secondary data source	0.82*** (Bicycling proxy)
5	Speed†	0.63**[1]	1.0***	0.80*** (Bicycling proxy)
6	Buffer width	0.57*	0.87***	0.31*
7	Number thru lanes†	0.52*[1]	0.78***	0.22* (Bicycling proxy)
8	Sidewalk condition	0.49*	−0.10	0.50***
9	Sidewalk width	0.34	0.53*	0.57***
10	Ramp	−0.15	0.89***	0.42**
	Final walking suitability score	0.58*	0.79***	0.73***

† Walking instrument did not originally include these three variables, which were included after the transportation experts had completed the Likert-response assessments. For this analysis, proxy scores were used from the transportation expert's bicycle assessments.
* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.

collection tools previously existed for assessing the walking suitability of sidewalks, this study advances the field by determining that a new assessment instrument has acceptable reliability even if it is only moderately valid. Confirmation in a larger sample is necessary before criterion validity can be established. The Eddy bicycling suitability assessment instrument does not require data collectors to have engineering expertise or apply logarithmic transformations during the final suitability algorithm. Its ease of use together with its strong reliability scores are pluses, although the instrument's validity is weaker than desirable for final acceptance of the measure.

The modest reliability and validity of the overall walking suitability scores, the low validity of the bicycling instrument, and the low reliability or validity of some individual variables on both instruments may be partly explained by sampling and variable characteristics. The sample size for the bicycling suitability assessment analyses was 31 road segments, but only 17 road segments (with sidewalks) for the walking suitability assessment analyses.

Although limited variability of the sampled suitability scores could be another explanation for suppressed reliability correlations, our purposive sample results did not demonstrate those conditions. For the walking instrument, the final group suitability scores ranged from 5 (good) to 13 (poor) with a mean of 8.32 (fair). Approximately 35% of scores were poor or worse, and 65% were fair or better. For the bicycling instrument, the final group suitability scores ranged from 1.75 (very good) to 10.35 (very poor) with a mean of 6.09 (poor). Approximately 60% of bicycling scores were poor or worse, and 40% were fair or better. In general, our sample included slightly more suitable walking conditions and less suitable bicycling conditions. These findings correspond with our informal observations of usual sidewalk and road conditions.

Some variables in each instrument relied on more subjective assessments that may have contributed to the lower reliability scores. Attempts were made to reduce subjectivity by providing clear definitions of values (e.g., surface condition values were defined using descriptions by the Federal Highway Administration) and photographs of examples.

Low reliability and validity could also be due to challenges experienced by the assessment staff. During data collection, staff reported that it was difficult to assess permanent suitability characteristics of the built environment without being unduly influenced by temporary conditions related to maintenance. For example, debris accumulated on a sidewalk may have impacted the rating for that segment. Although coding guidelines attempted to anticipate and clarify these issues, a better approach might be to modify the assessment forms to provide scoring for temporary maintenance conditions.

Another challenge for both the research staff and the transportation experts was to rate the suitability for an entire segment of sidewalk or roadway when variations existed within the segment, such as slight changes in sidewalk or lane width. Data collectors were instructed to rate the overall condition of the segment and subdivide it into additional segments for assessment when gross characteristics changed (e.g., speed limit, number of travel lanes, outside lane

Table 2

Intercoder Reliability and Validity Results for N. Eddy Bicycle Level of Service (n = 31 road segments)

No.	Bicycle Variable	Criterion-Related Validity (Pearson Product-Moment)	Reliability (Intraclass Correlation)	
		Research Staff and Transportation Experts	Research Staff (n = 2)	Transportation Experts (n = 3)
1	Speed	0.82**	1.0	0.80***
2	Bike lane	0.82*	1.0	0.47***
3	Frequent curves	0.82**	0.56***	0.73***
4	Severe grades	0.76**	0.49**	0.68***†
5	Annual average daily traffic	0.74**	Secondary data	0.82***
6	No sidewalks	0.70**	0.74***	0.49***‡
7	Number of through lanes	0.60**	0.87***	0.22*
8	Outside lane width	−0.55**	1.0	0.44***
9	Restricted sight distance	0.53**	0.53***	0.64***
10	Pavement condition	0.49**	0.58***	0.59***
11	Numerous driveways	0.49**	0.58***	0.52***
12	Difficult crossings	0.44*	0.17	0.58***§
13	Center turn lane	0.41	1.0	0.11
14	Parallel parking	0.38	1.0	0.39***‖
15	Moderate grades	−0.37*	0.08	0.68***†
16	Angle parking	0.29	1.0	0.39***‖
17	Numerous stops	0.14	0.43**	0.58***§
18	Right turn lane	0.13	0.77***	0.65***
19	Paved shoulder	−0.13	0.80***	0.39***¶
20	Storm drain grate	0.07	0.81***	0.39***¶
21	Curb and gutter	0.01	0.93***	0.39***¶
22	One sidewalk only	−0.004	0.74***	0.49***‡
23	Physical median	Unable to correlate because research staff mean value is constant	0.84***	0.74***
24	Bike lane width	N/A	1.0	Experts did not collect this variable
25	Commercial land use	N/A	0.62***	Experts did not collect this variable
26	Rough railroad crossing	N/A	−0.03	Experts did not collect this variable
27	Industrial land use	N/A	0	Experts did not collect this variable
	Final bicycle suitability score	**0.62****	**0.90*****	**0.77*****

† Planners assessed the suitability impact of the ''grade,'' which for validity testing was compared with both types of grade collected by research staff.
‡ Planners assessed the suitability impact of any ''sidewalks,'' which for validity testing was compared with both types of sidewalk presence collected by research staff.
§ Planners assessed the suitability impact of ''Intersections,'' which for validity testing was compared with both ''difficult crossings'' and ''numerous stops'' as collected by research staff.
‖ Planners assessed the suitability impact of any ''on-street parking,'' which for validity testing was compared with both types of parking collected by research staff.
¶ Planners assessed the suitability impact of ''curb/gutter/drain or shoulder,'' which for validity testing was compared with each of these characteristics collected by research staff.
* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.

width). The challenge arose when changes occurred in isolated spots. For example, a half-mile sidewalk 5 feet in width was generally quite suitable for pedestrian use. However, utility poles located in the center of the sidewalk could compromise the segment's suitability score. One rater might conservatively rate the entire sidewalk width as 2 feet, since a wheelchair could not easily use the sidewalk. Another rater might consider such poles to be isolated problem spots and note them separately. Observer training can provide guidance for determining the ''tipping point'' when the entire segment's suitability rating for a particular variable is significantly changed by the cumulative effect of isolated problem spots.

Finally, low reliability and validity among the transportation experts may have been partly due to the open-ended structure of the form, which attempted to capture the expertise of the transportation engineers and planners without prompting them about what to consider important for each variable. The experts' form provided a 7-point Likert scale for subjectively assessing the walking and bicycling environment. Because the variables did not prompt for specific design details, respondents could consider multiple aspects at once. For example, characteristics of the travel lanes had very low reliability among the experts (e.g., number of through lanes, center turn lane, and curb/gutter/drain/shoulder). Comments written on the forms revealed that some experts assessed the impact not only of the intended design feature but of its physical condition, placement, striping, and appropriateness, thus unequally influencing their assessment.

Although the walking and bicycling suitability assessment instruments cannot substitute for careful engineering of streets and intersections to design improvements, they can provide community members and local planning staff with systematic data to identify streets in need of design improvements. These assessment tools can help people provide significant input to public officials on ways to improve the local built environment in order to increase active transportation opportunities. Future research should assess predictive validity by considering the environmental suitability for walking and bicycling compared with observable transportation behavior.

Limitations

This research was limited by its use of a relatively small sample of road segments. This small sample produced several unstable reliability and validity correlations, especially for the less prevalent variables (e.g., industrial land-use and rough railroad crossings), making it harder to draw firm conclusions about the instruments' utility.

The data on traffic volume were annualized average daily counts. These do not provide a perspective on the specific travel stress induced during high-volume times of day, such as morning and evening commute hours. Hourly traffic volume variability is hidden within the average daily count, but it provides a simpler estimate of the impact of traffic volume.

Although the data collectors traveled each road segment two or more times, limitations prevented them from walking or bicycling the segments, rather than observing them from an automobile. Some rural road segments were 2 miles in length. The data collectors believed that only two variables (grade and surface condition) required assessment by disembarking from the vehicle at appropriate locations. If time and funding permit, however, implementing assessments by foot and bicycle should improve reliability and validity. Another method could include one community volunteer driving while a second assessed the environmental conditions.

The research staff who assessed the road segments were between 25 and 40 years of age. A more diverse group of assessors might capture walking and bicycling suitability perspectives of youth, older adults, and people with physical or visual disabilities. Broader representation of perspectives might increase the generalizability of these tools across diverse groups of users.

A final limitation of these instruments is their failure to account for supportive environmental characteristics (e.g., benches, water fountains, and even nearby destinations with showers and changing facilities) and aesthetic characteristics (e.g., landscaping, shady trees, scenery, or absence of fumes). Future tools might consider including an assessment of these characteristics.

Future Research

Transportation experts or engineers may be highly trained observers of pedestrian or bicycling physical activity conditions. However, their observations may differ greatly from what untrained ''end-users'' think about the suitability of sidewalks and roads. If one of the goals of public health is to increase walking and bicycling in the general population, the opinions of diverse community members should also be incorporated into the development of assessment instruments. Our study lacked sufficient funding to provide for recruiting and training community members as observers. Future research could invite community members to help identify additional variables for study (e.g., supportive amenities and the aesthetics of the environment). Additional research could also expand the sample of ''experts'' used for testing validity to include community members who walk and bicycle. We are aware of three instrument-development studies that have been validated using community members' opinions about walking and bicycling suitability characteristics.[24,25,36] Future research could use similar methods to validate the instruments in this study.

The Eddy bicycling assessment instrument contains individual variables that may be part of larger constructs (e.g., types of parking, severity of grade, curb/shoulder zone of pavement). Further research might determine whether some of these specific constructs might be more reliably or validly assessed as broader variables.

Intersections present complicated conditions for assessment. The walking suitability instrument records basic intersection data to highlight significant problem areas, but does not quantitatively compare intersections. Currently, the authors are collaborating on formative research to develop an intersection suitability assessment instrument to enhance collaboration between community members and planning professionals, and provide a scientific basis for advocacy efforts by community groups wishing to improve design.

CONCLUSION

The two assessment instruments described in this article, despite their moderate psychometric properties, appear promising for promoting community assessments of sidewalk and road suitability for walking and bicycling. With these instruments, community members and professionals can compile data on the walking and bicycling environment and use those data to identify areas for improvement that will ultimately create supportive environments for more physically active lifestyles. The assessment instruments and a project guidebook are available for download via the internet at http://www.unc.edu/~jemery/WABSA.

SO WHAT? Implications for Health Promotion Practitioners and Researchers

This study suggests that two instruments developed to assess the walking and bicycling suitability of local sidewalks and roads are acceptable for use by community members and professionals. If confirmed by others, these instruments will be useful in helping communities perform simple, reliable, and valid assessments of local environments for walking and bicycling. Professionals and trained volunteers can use the two instruments to assess road conditions for walking and bicycling and highlight areas for improving the built environment. Ideally, in collaboration with local government officials, health promotion practitioners can coordinate volunteer-led assessment projects that result in advocacy for improvements. Health promotion researchers can use the assessment instruments for cross-sectional and longitudinal research on the impact of the built environment on physical activity.

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Appendix 1

Walking Suitability Assessment Form (developed by J. E.)

Data Collector Name: Jim **Date:** April 4, 2002

Road Segment ID#: 101 **Road Name:** Sample St. **Boundary Streets:** Walnut/Tulip **AADT:** 16,500

Annual Average Daily Traffic (AADT) <8,000 = 0 8,000-14,999 = 1 15,000-24,999 = 2 25,000 or more = 3	Posted Speed (mph) <30 = 0 30-44 = 1 45 or more = 2	# of Thru Lanes <3 = 0 3-4= 1 5-8= 2	Sidewalk/Path Both sides continuous = 0 One side continuous and one side partial = 1 One side continuous = 2 Both sides partial = 3 One side partial = 4 None = 99 (STOP HERE)	Material Asphalt = 0 Concrete = 0 Brick = 1 Sand/Dirt = 2 Gravel = 3 Woodchip = 3	Surface Condition Good = 0 Fair = 1 Poor = 4	Sidewalk Width 8' or more = -1 5' – 7' 11" = 0 4' – 4' 11" = 1 <4' = 2	Buffer Width 4' or more = 0 <4' = 0.25 None = 0.50	Curb Ramps All = 0 Some = 2 None = 4	Adequate Lighting Plenty = 0 Some = 0.50 None = 1	Isolated Problem Spots? Y = Yes N = No	Total Score
2	1	0	2	0	1	1	0.50	2	1	N	10.5

Do any busy intersections need marked crosswalks?	Do any busy intersections need traffic signals lights?	Do any busy intersections need pedestrian "Walk" signals?	Do any wide intersections need a refuge island for safer crossing?
(Y) N	(Y) N	Y (N)	Y (N)
(if Yes, record below)	*(if Yes, record below)*	*(if Yes, record below)*	*(if Yes, record below)*

Use this table to record Intersection Details, Isolated Problem Spots, and General Comments about needed design improvements:

Nearest Intersecting Street	Describe Intersection Details	Describe Isolated Problem Spots	General Comments (For example: How are transit stops? Is the walk pleasant? Etc.)
Walnut	Crosswalk faded. Need signal light		The transit stop at Walnut needs a bench for waiting.
Pine	Need crosswalk for Pine walkers		

J. Emergy Walking Suitability Assessment Scores:

- Very good (less than 3.0): Color blue. These sidewalks are generally good for walking and wheelchair use.
- Good (3.0–5.9): Color Green. These sidewalks provide basic walking access, but could be upgraded to make them better walking and wheelchair environments. Improvements might include enhancing the surface material or condition and installing more lighting.
- Fair (6.0–8.9): Color yellow. These sidewalks need improvements to the walking environment. Improvements might include lowering the posted speed limit, improving the surface material or condition, or installing or widening buffers.
- Poor (9.0–26.0): Color orange. These sidewalks need major improvements to enable safe use. These types of improvements include replacing unfirm surfaces (e.g., gravel, dirt, heaving bricks); repairing broken sidewalk sections; constructing curb ramps for wheelchair access; or constructing a continuous sidewalk on at least one side of the street.
- No sidewalk on quiet street (99.0): Color pink.
- No sidewalk on busy street (more than 99.0): Color Red. When there is no sidewalk, travel beside the road on foot or wheelchair is not safe or comfortable (especially if the street has frequent, high-speed traffic). If these roads provide links between residential areas and frequent destinations, the need for sidewalks is greater.

Appendix 2

Bicycling Suitability Assessment Form (adapted from Nils Eddy[30])

Date: April 4, 2002	Comments/Suggested Improvements:
Data Collector Name: Jim	
Segment ID Number/Name: 101 - Sample	
Boundary streets: Walnut / Tulip	

A) General Road Factors	Measures
1) Annual Avg. Daily Traffic (AADT)	16,500
2) Total number of through lanes	2
3) Speed (mph)	35
4) Outside lane width (e.g., 11.5')	12.5
5) Bike lane or paved shoulder width (e.g., 4.5') (Note - a **marked** bike lane.)	Ø

Record these measures in the formula below

B) Pavement Factors		Score
1) (*circle one pavement description*)		(*record score*)
Very Good	= 0.25	
Good	(= 0.75)	0.75
Fair	= 1.50	
Poor	= 2.25	
Very Poor	= 3.75	
2) Presence of a Curb	(Y) N	Yes = (0.25)
3) Rough RR Crossing	Y (N)	Yes = 0.50
4) Storm Drain Grate	(Y) N	Yes = (0.75)
TOTAL Scores *Record score in formula below*		1.75

C) Location Factors	Yes/No (*circle*)	Score for "Yes"
1) Angle Parking	Y (N)	0.75
2) Parallel Parking	(Y) N	(0.50)
3) Right-Only Turn Lanes	(Y) N	(0.25)
4) Center (Both)Turn Lane	Y (N)	*-0.25*
5) Physical Median	Y (N)	*-0.50*
6) Paved Shoulder	Y (N)	*-0.75*
7) Marked Bike Lane	Y (N)	*-1.00*
8) Severe Grades	Y (N)	0.50
9) Moderate Grades	(Y) N	(0.25)
10) Frequent Curves	(Y) N	(0.25)
11) Restricted Sight Distance	(Y) N	(0.50)
12) Numerous Driveways	(Y) N	(0.50)
13) Numerous Intersections	Y (N)	0.75
14) Difficult Intersections	Y (N)	1.00
15) Industrial Land Use	Y (N)	0.50
16) Commercial Land Use	(Y) N	(0.25)
17) Sidewalk Only One Side	(Y) N	(0.25)
18) Sidewalks do not exist	Y (N)	0.50
TOTAL all "YES" points *Record score in formula below*		2.75

$$\frac{\text{AADT } [16{,}500]}{\# \text{ of thru Lanes } [2] \times 2500} + \frac{\text{Speed (mph) } [35]}{35} + \frac{14 - \text{Outside Lane Width } [12.5] - \text{Bike Lane or Paved Shoulder Width } [\varnothing]}{2} + \text{Pavement Factors } [1.75] + \text{Location Factors } [2.75] = \text{Bicycle Suitability Score } [9.6]$$

Note: The form was adapted from the original. We created a ''yes/no'' assessment-marking process to ensure that every variable would be rated by data collectors. We moved the algorithm to the bottom of the sheet and the comments area to the top right corner, and deleted the brief sidewalk assessment.

N. Eddy Bicycle Suitability Assessment Scores:

- Very good (less than 3.00): Color blue. A road that is bicycle friendly and usable by all levels of bicyclists. There are few improvements needed.
- Good (3.00–3.99): Color Green. A road that can be used safely by most bicyclists. Minimal improvements may be needed.
- Fair (4.00–4.99): Color yellow. A road that has some hazards, but still can be used by adults for bicycling. Not recommended for children. Specific improvements are needed.
- Poor (5.0–6.99): Color orange. This road has many hazards and would require adult bicyclists to be very careful. Not safe for children. Many improvements are needed.
- Very poor (higher than 6.99): Color Red. This road has many hazards, heavy traffic, and bad road conditions. Not safe for any bicyclists. Improvements are greatly needed.

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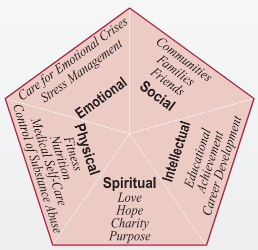

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(O'Donnell, *American Journal of Health Promotion,* 1989, 3(3):5.)

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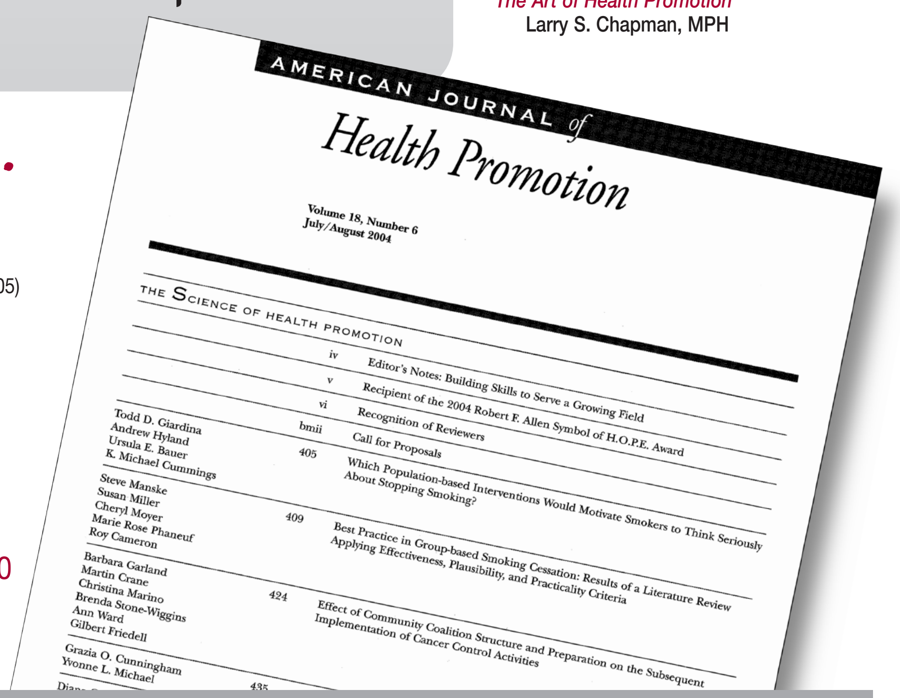
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