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Standard Guide on the Relationship of Indoor Carbon Dioxide Concentrations to Indoor Air Quality and Ventilation¹

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1. Scope

1.1 This guide describes the relationship of indoor carbon dioxide (CO₂) concentrations to indoor air quality (IAQ) and building ventilation.

1.2 This guide contains background information on the health, comfort, and performance impacts of indoor CO₂ exposure, as well as indoor CO₂ limits contained in various standards and regulations.

1.3 This guide describes the estimation of CO₂ generation rates from people as a function of sex, age, body mass, and level of physical activity.

1.4 This guide describes the relationship of CO₂ to IAQ, including how CO₂ relates to the perception of human body odor, limitations on the application of CO₂ as a metric of IAQ, and the relationship of CO₂ to the risk of infectious aerosol exposure.

1.5 This guide describes how CO₂ concentration measurements can be used to evaluate building ventilation including mass balance analysis to determine the percent outdoor air intake at an air handler, tracer gas decay measurements to estimate whole building air change rates, and use of the constant injection tracer gas technique at equilibrium to estimate whole building air change rates.

1.6 This guide discusses concentration measurement issues, such as calibration and sensor location, and continuous indoor concentration monitoring but does not include specific test methods for either application.

1.7 This guide discusses the use of indoor CO₂ concentrations for demand control ventilation (DCV) but does not contain detailed application guidance.

1.8 *Units*—The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.9 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.10 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 ASTM Standards:²

- D1356 Terminology Relating to Sampling and Analysis of Atmospheres
- D3249 Practice for General Ambient Air Analyzer Procedures
- E741 Test Method for Determining Air Change in a Single Zone by Means of a Tracer Gas Dilution

2.2 Other Documents:

- ASHRAE Standard 62.1-2022 Ventilation and Acceptable Indoor Air Quality³
- ISO 12569: 2017 Thermal performance of buildings and materials — Determination of specific airflow rate in buildings — Tracer gas dilution method⁴
- ISO 16000-26: 2012 Indoor Air – Part 26, Sampling strategy for carbon dioxide (CO₂) method⁴

3. Terminology

3.1 *Definitions*—For definitions and terms used in this guide, refer to Terminology D1356.

3.2 *Definitions of Terms Specific to This Standard:*

² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at www.astm.org/contact. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

³ Available from American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc. (ASHRAE), 1791 Tullie Circle, NE, Atlanta, GA 30329, <http://www.ashrae.org>.

⁴ Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, <http://www.ansi.org>.

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3.2.1 *single-zone, n*—an indoor space, or group of spaces, wherein the CO₂ concentration is uniform and only exchanges air with the outdoors.

4. Summary of Guide

4.1 Indoor CO₂ concentrations have been discussed in the context of building ventilation and IAQ for centuries based on their relationship with the number and activities of the occupants, links with the generation of other bioeffluents by building occupants, potential uses as a tracer gas for ventilation evaluation, and other considerations. These relationships can be useful for understanding IAQ and ventilation but only if properly applied with due consideration of key factors related to building and ventilation system configuration, occupancy patterns, non-occupant CO₂ sources, other indoor and outdoor contaminant sources, time and location of air sampling, and instrumentation for concentration measurement. This guide discusses the relationship of indoor CO₂ concentrations to building IAQ and ventilation to better inform such applications.

4.2 Section 5 (Significance and Use) includes background information on the health, comfort, and performance impacts of indoor CO₂ exposure and on indoor CO₂ limits contained in various standards and regulations.

4.3 Section 6 describes how to estimate CO₂ generation rates from people as a function of sex, age, body mass, and level of physical activity.

4.4 Section 7 discusses the relationship of CO₂ to IAQ, including how it relates to the perception of human body odor (bioeffluents), limitations on its application as a metric of IAQ, and the relationship of CO₂ to the risk of infectious aerosol exposure.

4.5 Section 8 discusses the relationship of CO₂ concentrations to building ventilation. Applications of CO₂ to evaluate building ventilation include the use of mass balance analysis to determine the percent outdoor air intake at an air handler based on measured CO₂ concentrations in the supply, return, and outdoor air intake airstreams; the use of the tracer gas decay technique to estimate building air change rates using occupant-generated CO₂ as a tracer gas under Test Method E741 as well as ISO 12569; and the use of the constant injection tracer gas technique (also covered by Test Method E741 and ISO 12569) with occupant-generated CO₂ to estimate outdoor air ventilation rates. This section also discusses the use of CO₂ concentrations for DCV but does not contain detailed application guidance as such information is available elsewhere.

4.6 Section 9 discusses CO₂ concentration measurement issues, including calibration, warm-up, interferences, the measurement of outdoor concentrations, and sample locations for indoor concentration measurements.

4.7 Section 10 discusses continuous monitoring of indoor CO₂ concentrations including the timing of such measurements and their application in assessing ventilation, occupancy, and air distribution.

5. Significance and Use

5.1 Indoor CO₂ concentrations have been used as indicators of IAQ for many years, involving both appropriate and inappropriate interpretations of indoor CO₂ concentrations (1).⁵ Appropriate uses include estimating expected levels of occupant comfort in terms of human body odor perception, studying occupancy patterns, investigating the levels of contaminants that are related to occupant activity, and screening for the sufficiency of ventilation rates. Inappropriate uses include estimating outdoor air ventilation rates per person from indoor CO₂ concentrations without properly applying mass balance methods, including verifying the assumptions upon which those methods are based, and using indoor CO₂ concentrations as a comprehensive indicator of IAQ.

5.2 Outdoor air ventilation rates affect airborne contaminant levels in buildings and occupant perceptions of the acceptability of the indoor environment. Minimum rates of outdoor air ventilation are specified in building codes and standards, for example, ASHRAE Standard 62.1 for non-residential buildings. Compliance of outdoor air ventilation rates with relevant codes and standards is often assessed as part of IAQ investigations and energy audits in buildings. Outdoor air ventilation rates of a building depend on the size and distribution of envelope air leakage sites, pressure differences induced by wind and temperature, mechanical system design and operation, and occupant behavior.

5.3 The measurement of CO₂ concentrations has been used to estimate outdoor air ventilation rates. One common approach, referred to in this guide as equilibrium analysis, is based on a steady-state, single-zone mass balance of CO₂ in the building but is too often presented with little or no discussion of its limitations and the assumptions on which it is based. As a result, the technique has been misused and misinterpreted. However, when the assumptions upon which equilibrium analysis is based are valid and the technique is applied properly, it can yield reliable estimates of outdoor air ventilation rates.

5.4 Indoor CO₂ concentrations can be used to determine other aspects of building ventilation when used properly. For example, by applying a mass balance at an air handler, the percent outdoor air intake in the supply airstream can be determined based on the CO₂ concentrations in the supply, return, and outdoor air. This percentage can be multiplied by the supply airflow rate of the air handler to yield the outdoor air intake rate of the air handler. In addition, the decay of indoor CO₂ concentrations can be monitored in a building after the occupants have left to determine the outdoor air change rate of the building.

5.5 Continuous monitoring of indoor CO₂ concentrations can be used to study some aspects of ventilation system performance, the quality of outdoor air, and building occupancy patterns. Continuous monitoring has been used to evaluate overall IAQ. However, at best, indoor CO₂ concentrations can serve as indicators of indoor contaminants emitted

⁵ The boldface numbers in parentheses refer to a list of references at the end of this standard.

at rates that depend on the number of occupants. They do not serve as a comprehensive indicator of IAQ given the many contaminants that do not depend on the number of occupants, such as those entering from outdoors and those emitted by materials, furnishings, cleaning agents, and personal care products.

5.6 Indoor CO₂ regulations and guideline values have been promulgated by multiple organizations, however the justifications for the limits are not necessarily included with the values. They are likely based on either CO₂ as an indicator of ventilation rates, or on the health and performance impacts of CO₂ exposure. There is some evidence of the latter impacts at commonly observed indoor CO₂ concentrations, but it is not consistent and requires further study.

5.7 Measurement of indoor CO₂ concentrations is being promoted as a ventilation indicator in guidance to reduce the risk of infectious aerosol exposure in response to the COVID-19 pandemic. In most cases, this application is based on the equilibrium approach to estimating outdoor air ventilation rates per person, although the technical basis for the values is not always well explained. In other cases, CO₂ is proposed as an indicator of exposure to infectious aerosols emitted by other occupants and the associated risk of disease, although such applications involve numerous assumptions regarding the similarity between the fate and transport of airborne CO₂ and infectious aerosols.

5.8 *Health and Performance Impacts of CO₂ Exposure:*

5.8.1 Indoor CO₂ concentrations have been prominent in discussions of ventilation and IAQ since the 18th century when Antoine Lavoisier suggested that CO₂ build-up rather than oxygen depletion was responsible for “bad air” indoors. About one hundred years later, Max Joseph von Pettenkofer suggested that biological contaminants from human occupants were the source of bad indoor air, not CO₂ (2). More recent research, starting in the 1930s, showed the relationship of indoor CO₂ concentrations to occupant perceptions of odor intensity associated with human bioeffluents as discussed in 7.1 (3).

5.8.2 Indoor CO₂ concentrations are typically on the order of 1000 ppm(v) in non-industrial spaces with excursions up to about 3000 ppm(v) when outdoor air ventilation rates are low relative to the number of occupants. CO₂ is considered to be non-toxic at these levels, with occupational limits of 5000 ppm(v) over a 40 h workweek (4) and 30 000 ppm(v) for short term (15 min) exposures (5). These and other limits are discussed in more detail in 5.9. Toxicological studies have been conducted on the effects of CO₂ exposure in humans and animals, including respiratory, neurologic, reproductive, and cardiovascular impacts, with these studies showing impacts at concentrations of tens of thousands or even hundreds of thousands of ppm(v).

5.8.3 Research results from the 1980s and later found associations between indoor CO₂ levels and occupant health symptoms (in some cases referred to as sick building syndrome symptoms) and school absenteeism. These studies often highlight increases in symptom prevalence and absenteeism at concentrations above 1000 ppm(v). However, these studies did not control for other contaminants that were presumably

elevated in association with the reduced per person ventilation rates that led to elevated CO₂ concentrations. Thus, while elevated CO₂ correlated with symptoms and absenteeism, elevated concentrations of other chemicals or biological agents may be the actual cause. More recent studies have examined the impacts of pure CO₂ at concentrations from 600 ppm(v) to 5000 ppm(v) on cognitive performance. For example, some studies have shown reduced cognitive function at concentrations on the order of 1000 ppm(v), while others have not. Based on these inconsistencies, further investigation is merited, including research on potential mechanisms for these impacts.

5.9 *Indoor CO₂ Limits in Existing Standards and Building Regulations:*

5.9.1 Several organizations have issued indoor CO₂ concentration limits over the years, though in many cases the rationales for the limits are not documented. In some cases, published limits are based on CO₂ being an indicator of low outdoor air ventilation rates per person and the corresponding exposure to elevated concentrations of other indoor-generated contaminants. An online database of indoor environmental quality guidelines⁶ contains several national and organizational limits for indoor CO₂ ranging from about 500 ppm(v) above outdoor concentrations to much higher limits for occupational environments. A Canadian residential indoor CO₂ guideline also contains a table of guidelines and standards for indoor CO₂ concentrations (6). Occupational exposure limits for CO₂ in the U.S. are 5000 ppm(v) for an 8 h time weighted average (4) and 30 000 ppm(v) for a 15 min exposure (5). However, these limits are of limited applicability to general indoor environments as they are intended to control exposure to levels that protect worker health, they are not intended to eliminate all effects such as unpleasant odors and irritation and are not based on consideration of the general population that covers a range of age and health status.

5.9.2 More recently, in response to the COVID-19 pandemic, additional CO₂ limits have been promulgated as recommendations and in some cases requirements. For example, the U.S. Centers for Disease Control and Prevention (7), the Federation of European Heating, Ventilation and Air Conditioning Associations (8) in Europe; and Environmental Modelling Group and Scientific Pandemic Insights Group on Behaviours (9) in the United Kingdom have issued recommended indoor CO₂ limits to assess the adequacy of ventilation rates for infection control, with technical rationales for these recommendations discussed in these references to varying degrees of detail. The Belgian Federal Government has issued mandated CO₂ concentration limits (10). The relationship of indoor CO₂ concentrations to infectious aerosol exposure are discussed in 7.3.

5.9.3 In the context of these indoor CO₂ limits, it is important to note that ASHRAE Standard 62.1, Ventilation and Acceptable Indoor Air Quality, contains no such limit and has not since 1989. The 2016 version of the standard did note, in an informative appendix that is not part of the standard, that for an outdoor air ventilation rate of 7.5 L/s per person, the steady-state indoor CO₂ concentration will be about 700 ppm(v) above

⁶ Available from <https://ieqguidelines.org>.

outdoors and that maintaining indoor concentrations at or below this level “will indicate that a substantial majority of visitors entering a space will be satisfied with respect to human bioeffluents (body odor).” The relationship between indoor CO₂ concentrations and the perception of bioeffluents is discussed in 7.1. While ASHRAE Standard 62.1 does not contain indoor CO₂ limits, it does “specify minimum ventilation rates and other measures intended to provide IAQ that is acceptable to human occupants and that minimizes adverse health effects.”

6. CO₂ Generation Rates

6.1 Human metabolism consumes oxygen and generates CO₂ at rates that depend on the level of physical activity, body mass, and diet.

6.2 The rate of CO₂ generation of an individual V_{CO_2} in mL/s per person, at an air temperature of 273 K and an air pressure of 101 kPa, is given by Eq 1, the derivation of which is described in detail in Ref (11):

$$V_{CO_2} = RQ \times BMR \times M \times 0.569 \quad (1)$$

where:

RQ = respiratory quotient, dimensionless (defined in 6.3),
 BMR = basal metabolic rate, MJ/day, and
 M = metabolic rate per unit of surface area, met (dimensionless).

For other values of air temperature T and pressure P , V_{CO_2} is given by Eq 2.

$$V_{CO_2} = RQ \times BMR \times M \times \left(\frac{T}{P} \right) \times 0.211 \quad (2)$$

6.3 The respiratory quotient, RQ , is the ratio of the volumetric rate at which CO₂ is produced by an individual to the rate at which oxygen is consumed. The value of RQ depends primarily on diet (12). Based on data on human nutrition in the United States, primarily the ratios of fat, protein, and carbohydrate intake, RQ equals about 0.85 (13).

6.4 Values of BMR are a function of sex, age, and body mass. Equations for the calculation of BMR are given in Table 1 (14).

6.5 The variable M (in dimensionless units of met) is used to describe the ratio of the human energy use associated with a particular physical activity to the BMR of an individual as discussed in detail in Ref (11). There are three primary references for obtaining met levels for different physical activities, the last one specifically covering youth (15-17).

Tables 2 and 3 contain met levels for many common indoor activities drawn from the first two references. These tables and the cited references contain met levels as high as 8 for specific activities but do not address met levels for occupied spaces, which generally are associated with a range of activities of varying durations. Given the duration of space occupancy of interest to this standard (on the order of hours or less) and the expectation that occupants do not generally maintain the higher met levels continually over such time frames, none of the CO₂ generation rates presented in Tables 2 and 3 cover met rates over 4. This is the same approach employed in Ref (11).

6.6 Table 4 lists CO₂ generation rates for ranges of ages and met levels estimated using the body mass data for males and females in the EPA Exposure Factors Handbook (18), assuming RQ is equal to 0.85.

6.7 To reflect the importance of variations in body size, that is, mass, in estimating CO₂ generation rates, Fig. 1 and Fig. 2 show the variation in V_{CO_2} with age and body mass for females and males, respectively. Each plot displays V_{CO_2} for 13 age ranges from <1 y to ≥80 y and for six met levels from 1 to 4. The plotted generation rates are calculated using RQ equal to 0.85. Each vertical box-whisker plot displays the range of CO₂ generation rates from the 10th percentile value of body mass up to the 90th as indicated in the key to each figure.

6.8 In using Eq 1 and Table 4 to estimate CO₂ generation rates for the occupants in a given building, it is important to consider the ages, masses, and met levels of the individual occupants, as well as the ranges in each of these variables for the building population. When applying these calculations to occupied buildings, this information should be obtained by observations of the occupants to achieve more accurate estimates of the CO₂ generation rates. There are no standard approaches for collecting this information on a population of building occupants, but there are tools to record activity budgets such as the coding used in the U.S. Bureau of Labor Statistics American Time Use Survey (19). This survey provides information on the fraction of time people spend on various activities per day but does not break it down by the categories in Tables 1 and 2. Nevertheless, such activity codes could possibly be used to develop a protocol for collecting activity data on building occupants, which may prove useful for generating representative met levels and calculating CO₂ generation rates during occupancy periods of interest. However, research would need to be conducted to develop and validate such an approach.

TABLE 1 Equations for Calculating BMR (14)

NOTE 1— m is body mass in units of kg.

Age (y)	BMR: MJ/day	
	Males	Females
<3	0.249 m – 0.127	0.244 m – 0.130
3 to 10	0.095 m + 2.110	0.085 m + 2.033
10 to 18	0.074 m + 2.754	0.056 m + 2.898
18 to 30	0.063 m + 2.896	0.062 m + 2.036
30 to 60	0.048 m + 3.653	0.034 m + 3.538
≥60	0.049 m + 2.459	0.038 m + 2.755

TABLE 2 Metabolic Rates (*M* in Met) for Various Physical Activities (15)

Activity	M (Met)	Range
Calisthenics – light effort	2.8	2.0 to 3.0
Calisthenics – moderate effort	3.8	
Calisthenics – vigorous effort	8.0	
Child care		
Cleaning, sweeping – moderate effort	3.8	1.0 to 1.3
Custodial work – light	2.3	
Dancing – aerobic, general	7.3	
Dancing – general	7.8	
Health club exercise classes – general	5.0	
Kitchen activity – moderate effort	3.3	
Lying or sitting quietly		
Sitting reading, writing, typing	1.3	
Sitting at sporting event as spectator	1.5	
Sitting tasks, light effort (for example, office work)	1.5	
Sitting quietly in religious service	1.3	
Sleeping	0.95	
Standing quietly	1.3	
Standing tasks, light effort (for example, store clerk, filing)	3.0	
Walking, less than 2 mph, level surface, very slow	2.0	
Walking, 2.8 mph to 3.2 mph, level surface, moderate pace	3.5	

TABLE 3 Metabolic Rates (*M* in Met) for Additional Physical Activities (16)

Activity	Males		Females	
	Average	Range	Average	Range
Aerobic dancing – low intensity	3.51		4.24	
Aerobic dancing – high intensity	7.93		8.31	
Calisthenics	5.44			
Child care (unspecified)			2.5	
Climbing stairs	5.0			
Dancing	5.0		5.09	
Eating and drinking	1.4		1.6	
Housework (unspecified)			2.8	2.5 to 3.0
Office worker – Filing	1.3		1.5	
Office worker – Reading	1.3		1.5	
Office worker – Sitting at desk	1.3			
Office worker – Standing/moving around	1.6			
Office worker – Typing	1.8		1.8	
Office worker – Writing	1.4		1.4	
Reading	1.22		1.25	
Sleeping	1.0		1.0	
Sitting quietly	1.2		1.2	
Sitting on a bus/train	1.2			
Standing	1.4		1.5	
Walking around/strolling	2.1	2.0 to 2.2	2.5	2.1 to 2.9
Walking quickly	3.8			
Walking slowly	2.8	2.8 to 3.0	3.0	

7. CO₂ and Indoor Air Quality

7.1 CO₂ as an Indicator of Body Odor Acceptability:

7.1.1 While people are generating CO₂ they are also producing bioeffluents, some of which are associated with odors and irritation. Similar to CO₂ generation, the rate of bioeffluent generation depends on individual characteristics (sex, age, and body mass), the level of physical activity, and personal hygiene. Because both CO₂ and bioeffluent generation rates depend on individual characteristics and physical activity, the concentrations of CO₂ and the odor intensity from human bioeffluents in a space exhibit a similar dependence on the number of occupants and the outdoor air ventilation rate.

7.1.2 Experimental studies have been conducted in chambers and in occupied buildings in which people evaluated the acceptability of the air in terms of body odor (20-24). These experiments studied the relationship between outdoor air

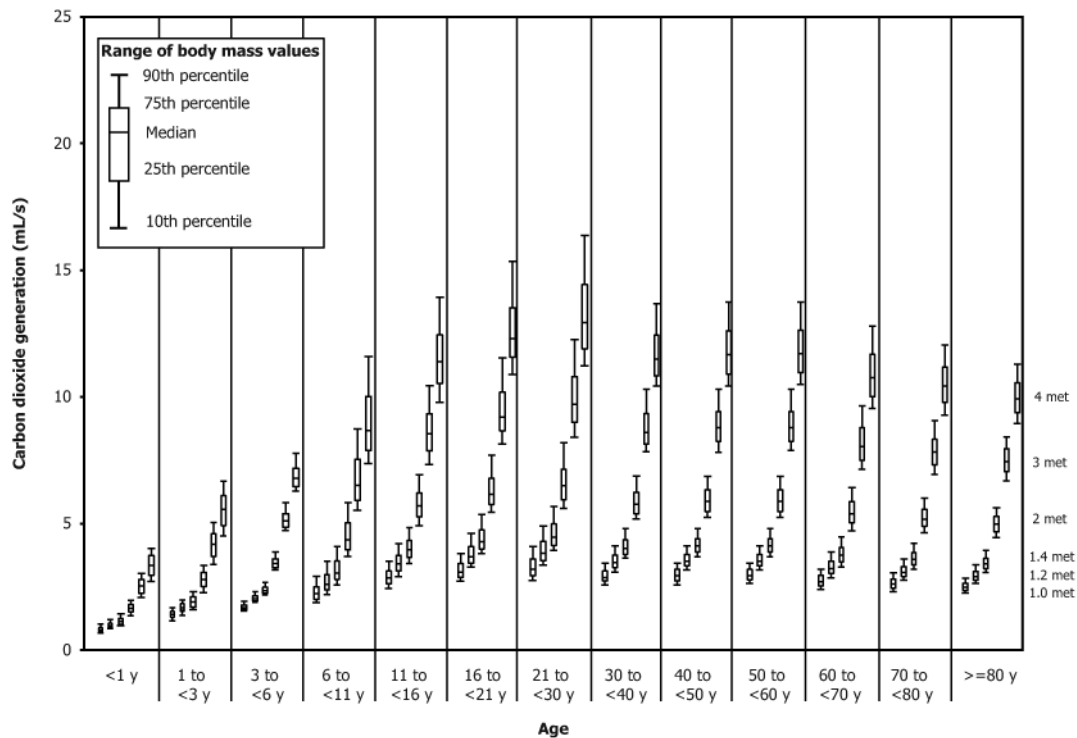
ventilation rates and odor acceptability, and the results of these studies were considered in the development of most ventilation standards and guidelines (including ASHRAE Standard 62.1). While these studies did not define body odor precisely, they describe it generically as originating from sweat and sebaceous secretions from the skin, foul breath, and gases from the digestive tract. More recent work has focused on more specific definitions of body odor (25).

7.1.3 These studies concluded that about 7.5 L/s of outdoor air ventilation per person will control human body odor such that roughly 80 % of unadapted persons (visitors) will find the odor at an acceptable level. These studies also showed that the same level of body odor acceptability was found to occur at a CO₂ concentration that is about 700 ppm(v) above the outdoor concentration.

TABLE 4 Carbon Dioxide Generation Rates as a Function of Occupant Sex, Age, and Met Level (Based on Body Mass Data in (18))

NOTE 1—These CO₂ generation rates are based on an air temperature of 273 K and an air pressure of 101 kPa.

Age (y)	Mean Mass (kg)	BMR (MJ/day)	CO ₂ Generation Rate (L/s)						
			Level of Physical Activity (met)						
			1.0	1.2	1.4	1.6	2.0	3.0	4.0
Males									
<1	8.0	1.86	0.9	1.1	1.3	1.4	1.8	2.7	3.6
1 to <3	12.8	3.05	1.5	1.8	2.1	2.4	3.0	4.4	5.9
3 to <6	18.8	3.90	1.9	2.3	2.6	3.0	3.8	5.7	7.5
6 to <11	31.9	5.14	2.5	3.0	3.5	4.0	5.0	7.5	10
11 to <16	57.6	7.02	3.4	4.1	4.8	5.4	6.8	10	13.6
16 to <21	77.3	7.77	3.7	4.5	5.3	6.0	7.5	11	15
21 to <30	84.9	8.24	3.9	4.8	5.6	6.4	8.0	12	16
30 to <40	87.0	7.83	3.7	4.6	5.3	6.1	7.6	11	15
40 to <50	90.5	8.00	3.8	4.6	5.4	6.2	7.7	12	16
50 to <60	89.5	7.95	3.8	4.6	5.4	6.2	7.7	12	15
60 to <70	89.5	6.84	3.3	4.0	4.6	5.3	6.6	9.9	13
70 to <80	83.9	6.57	3.1	3.8	4.5	5.1	6.4	9.5	13
≥80	76.1	6.19	3.0	3.6	4.2	4.8	6.0	9.0	12
Females									
<1	7.7	1.75	0.8	1.0	1.2	1.4	1.7	2.5	3.4
1 to <3	12.3	2.88	1.4	1.7	2.0	2.2	2.8	4.2	5.6
3 to <6	18.3	3.59	1.7	2.1	2.4	2.8	3.5	5.2	7.0
6 to <11	31.7	4.73	2.3	2.7	3.2	3.7	4.6	6.9	9.2
11 to <16	55.9	6.03	2.9	3.5	4.1	4.7	5.8	8.8	11
16 to <21	65.9	6.12	2.9	3.6	4.2	4.7	5.9	8.9	12
21 to <30	71.9	6.49	3.1	3.8	4.4	5.0	6.3	9.4	13
30 to <40	74.8	6.08	2.9	3.5	4.1	4.7	5.9	8.8	12
40 to <50	77.1	6.16	2.9	3.6	4.2	4.8	6.0	9.0	12
50 to <60	77.5	6.17	3.0	3.6	4.2	4.8	6.0	9.0	12
60 to <70	76.8	5.67	2.7	3.3	3.8	4.4	5.5	8.2	11
70 to <80	70.8	5.45	2.6	3.2	3.7	4.2	5.3	7.9	11
≥80	64.1	5.19	2.5	3.0	3.5	4.0	5.0	7.5	10



NOTE 1—Each age bin contains box-whisker plots at 1 met, 1.2 met, 1.4 met, 2 met, 3 met, and 4 met. (Based on body mass data in (18).)

NOTE 2—These CO₂ generation rates are based on an air temperature of 273 K and an air pressure of 101 kPa.

FIG. 1 Variation in Carbon Dioxide Generation Rate Associated with Age, Body Mass, and Level of Physical Activity for Females