ORIGINAL ARTICLE

Determining the intensity and energy expenditure during commuter cycling

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Objectives: To determine the intensity and energy expenditure during commuter cycling, and to investigate whether cycling to work at a self-chosen intensity corresponds to recommendations of the Centers for Disease Control and Prevention (CDC) and American College of Sports Medicine (ACSM) for health improvement and ACSM recommendations for fitness improvement.
Methods: 18 healthy, untrained middle-aged people, who did not cycle to work, underwent two maximal exercise tests (MT and MT2) in order to measure their maximal heart rate and oxygen consumption (VO_2). MT2 was performed 24 weeks after MT. Participants were asked to cycle at least three times a week to their workplace over a one-way minimum distance of 2 km. Data on cycling were recorded in a diary. 12 weeks after MT, a field test was conducted, where participants had to cycle to or from their workplace. The same measurements were taken as during MT as markers of exercise intensity. Metabolic equivalents (METs) and energy expenditure were calculated.
Results: The intensity during the field test was >75% of their maximal aerobic capacity. The mean (SD) MET value was 6.8 (1.9). The energy expenditure during the field test was 220 (115) kcal or 540 (139) kcal/h and 1539 (892) kcal/week. Men consumed significantly ($p<0.01$) more energy per hour than women.
Conclusion: Commuter cycling at a self-selected intensity meets the CDC and ACSM recommendations for health improvement and the ACSM recommendations for improvement of cardiorespiratory fitness. However, as the participants cycled faster during the field test than during daily cycling, the results should be interpreted with caution.

Despite warnings about the potentially negative health consequences of a sedentary lifestyle, a large proportion of adults are physically inactive.[1] Compelling evidence suggests that physical inactivity is a contributing factor in several chronic diseases. People of all ages, both men and women, can improve their general health, fitness and mental health by becoming even moderately active.[1]

At the population level, the substantial health-enhancing potential of physical activity can be accomplished preferentially by incorporating physical activity into the daily routine. Physically active commuting to work provides a promising mode for such activity.[2] Daily cycling to work has been shown to improve physical performance[3 4] and health[5] in men and women.

Reliable estimates of self-selected intensity in cycling are essential to exercise research on epidemiology for two reasons. Firstly, self-selected exercise intensity must be determined to assess energy expenditure accurately. Secondly, information about self-selected cycling can be used in conjunction with prospective health data on cycling to help clarify the relationship between exercise intensity and health.[6]

Many of the health and fitness benefits are related to the total amount of work (volume) performed.[1 7–9] The American College of Sports Medicine (ACSM) Position Stand[8] makes the following recommendations for the quantity and quality of exercise for developing and maintaining cardiovascular fitness: frequency, 3–5 days/week; intensity, 55–90% of the maximal heart rate; and duration, 20–60 min of continuous or intermittent aerobic activity. Lower levels of physical activity (particularly intensity) may reduce the risk of certain chronic degenerative diseases and improve metabolic fitness, and yet may not be of sufficient quantity or quality to improve maximal oxygen uptake capacity. Many of the health benefits from physical activity can be achieved at lower intensities of exercise if frequency and duration are increased appropriately.[8] According to the recommendations of the Centers for Disease Control and Prevention (CDC) and the ACSM,[1] considerable health benefits can be achieved by engaging in physical activity of moderate intensity for at least 30 min per session on most, and preferably all, days of the week. Moderate physical activity is defined as activities performed at an intensity of 3–6 metabolic equivalents (METs; 3.5–7 kcal/min). For people who are quite unfit, the lower intensity values—that is, 55–64% of the maximum heart rate—are most applicable.[8]

The interaction of intensity, duration and frequency of physical activity determines the net energy expenditure from the activity. The ACSM[8] views exercise or physical activity for health and fitness in the context of an exercise dose continuum. Benefits are derived through varying quantities of physical activity ranging from about 700 to 2000 kcal per week.[8] The lower end of this range represents a minimal energy threshold of about 1050 kcal/week, which is associated with a considerable (20%–30%) reduction in risk of all-cause mortality[7 9 10]; this should be the initial goal for previously sedentary people.

Little is known about the self-selected intensity and energy cost of unsupervised cycling, and least of all about commuter cycling. Therefore, the primary purpose of this study was to measure the cycling intensity and energy expended by healthy untrained volunteers during a typical cycling trip to work. The second purpose was to examine whether commuter cycling meets both the recommendations of the ACSM[8] and the CDC and those of the ACSM recommendations[1] regarding exercise

Abbreviations: ACSM, American College of Sports Medicine; CDC, Centers for Disease Control and Prevention; MET, metabolic equivalent; MT, maximal exercise test; RER, respiratory exchange ratio; RPE, rate of perceived exertion; VO_2, oxygen consumption; VO_{2peak}, the highest VO_2 attained during MT over a time interval of 30 s intensity for the improvement of cardiovascular fitness and health, respectively. Heart rate and oxygen uptake, measured during cycling to work at a self-chosen intensity, were used as markers of exercise intensity, and compared with previous in-house maximal graded exercise test data. Energy expenditure and METs were calculated as additional markers of exercise intensity.

METHODS

Participants

From a group of 80 people, who were involved in an intervention study, 10 men and 8 women (aged 33–54 years) were randomly selected. During this intervention study, those who had commuted by motorised transport and not by bicycle for the past 6 months were asked to cycle a minimum distance of 2 km at least three times a week to go to work. None of the participants practiced cycling as a sport or recreational hobby before the start of the study. All 18 participants were healthy and untrained. Untrained is defined as participation in <3 h of intensive physical activity per week in the past 6 months and VO_{2peak} (the highest VO_2 attained during maximal exercise test (MT) over a time interval of 30 s) below the 50th percentile when matched for age and sex.[11] The baseline fitness level was assessed during a MT. Before the start of the study, all participants read and signed an informed consent statement. The study protocol was approved by the Vrije Universiteit Brussel ethics committee. Table 1 lists the descriptive characteristics of the participants.

Study design

Before participation, all participants underwent a medical examination. During the same day, an MT was performed. Afterwards, they were asked to cycle at least three times a week to and from their workplace over a one-way minimum distance of 2 km. The field test was carried out 12 weeks after the MT to measure the intensity at which the participants cycled to and from work. Twenty four weeks after the MT, a second maximal test (MT2) was conducted to investigate whether a possible training effect had biased the results of the field test (ie an overestimation of the intensity of the field test).

To quantify the cycling volume, all participants kept a daily diary in which they reported frequency, distance and duration of cycling during the whole study. The distance and duration of each trip was registered with a distance recorder (CicloMaster CM206; KW Hochschorner, Krailling, Germany). To preclude bias, the total amount of kilometres displayed on the distance recorder was compared with the diary data.

The maximal exercise test

Maximal physical performance was determined by a maximal incremental exercise test on an electrically braked cycle ergometer (Excalibur Lode, Groningen, The Netherlands). The saddle and handle bars were repositioned to suit each participant. MT2 was conducted in the same way as MT.

After resting measurements had been collected, the MT began with an initial workload of 50 W for men and 40 W for women at a pedalling rate of 70–80 rev/min. A ramp protocol was chosen with a workload increase of 15 W/min for men and 10 W/min for women. Participants were encouraged to exert themselves until volitional exhaustion. The decision to stop was based on signals of extreme fatigue and was confirmed by a heart rate that approximated the theoretical maximum heart rate (220−age) or a respiratory exchange ratio >1.10. After reaching exhaustion, participants had to continue cycling (50 W for men and 40 W women) until the heart rate reached <120 beats/min, according to the ACSM guidelines.[11]

Oxygen uptake was measured using a portable cardiopulmonary indirect breath-by-breath calorimetry system (MetaMax 3B, Cortex Biophysik, Leipzig, Germany). The MetaMax was fixed on to a chest harness worn by the participant. A flexible facemask (Cortex Adult Face Mask, Cortex Biophysik) covered the participant's mouth and nose. Before each test, gas and volume calibration took place with a 3-litre syringe, according to the manufacturer's guidelines. The oxygen analyser was calibrated with known gas mixtures of 18% O_2 and 5% CO_2. The room air calibration was automatically run before each test to update the CO_2 analyser baseline and the O_2 analyser gain so that they coincided with atmospheric values. Data were averaged using a moving average over seven breaths. VO_{2peak} was defined as the highest VO_2 attained during an MT over 30 s.[12] Respiratory exchange ratio (RER) and MET were calculated by Metasoft 2.1 software (Cortex Biophysik). Heart rate was recorded through the MetaMax via a Polar X-Trainer Plus (Polar Electro OY, Kempele, Finland) measurement system. Maximum heart rate was defined as the highest heart rate measured during the test. The relative oxygen consumption was calculated by dividing VO_{2peak} (MT) by the VO_2 measured during the field test. The same method was used to calculate %HR, %RER, %MET and %Lct (lactate).[6] Blood samples were drawn from the ear lobe before the start of the test and at the point of exhaustion. Lactate concentrations were determined enzymatically (EKF; BIOSEN 5030, Magdeburg, Germany). Participants were also requested to state their rate of perceived exertion (RPE) according to Borg's scale[13] of 6–20 before and at the end of the test.

Field test

During the first visit, all 80 participants of the intervention study were informed about the possibility of being tested in the field. None of them knew if or when this was going to happen. A maximum of 3 days before the field test, all 18 participants were called to make an appointment. During the field test, they were asked to cycle to or from their workplace, using the same route, intensity and road bicycle as during their daily trips to and from work. All participants lived in a rural area, in Oost-Vlaanderen, a region of Belgium with a flat terrain. None of the tests was conducted in the city.

Table 1 Descriptive characteristics of the study participants at baseline

Variable	Total (n = 18)	Men (n = 10)	Women (n = 8)
Body weight (kg)	76.6 (13.7, 59.6–109.4)	79.1 (8.0, 64.6–91.1)	73.4 (18.8, 59.6–109.4)
Height (cm)	171 (8, 154–181)	175 (5, 167–181)*	165 8, 154–176)
Age (years)	41.7 (6.8, 33–54)	42.1 (8.2, 33–54)	41.3 (5.2, 34–49)
Body mass index (kg/m^2)	26.2 (4.8, 19.7–41.7)	25.8 (2.7, 19.7–28.8)	26.8 (6.8, 21.0–41.7)
Body fat (%)	28.0 (9.2, 10.6–49.3)	22.3 (5.9, 10.6–30.4)*	35.1 (7.6, 27.5–49.3)
Fat mass (kg)	21.9 (10.7, 6.9–53.9)	18.0 (6.1, 6.9–27.7)	26.8 (13.5, 17.0–53.9)
Free fat mass (kg)	54.4 (8.8, 40.8–68.5)	61.0 (3.5, 57.6–68.5)*	46.2 (5.8, 40.8–55.5)

Values are mean (SD, range).
Significant difference from women: *$p<0.01$.

During the field test, the same calorimetry system was used as the one used during the MT. Volume and gas calibrations were conducted in the same way as described earlier. Before each individual test, ambient air was measured according to the manufacturer's instructions. Data were averaged from the start to the end of the trip. Blood samples were drawn from the ear lobe, before and at the end of the trip, and stored in a cooled box until analysis. RPE was noted before and at the end of the trip. The energy expenditure and MET values were calculated by the software using the measurement of VO_2. The product of the absolute energy expenditure and the weekly frequency of cycling reported by the participants were used to calculate the weekly energy expenditure.

Statistical analysis

Data were analysed using SPSS, V. 12.0. The one-sample Kolmogorov–Smirnov goodness-of-fit-test was used to test whether the outcome variables had a normal distribution. Results showed that the distribution was normal. The values were averaged among the participants to obtain group mean (standard deviation(SD)) values. Paired-sample t tests were run to see whether there was a significant difference between the MT and the field test scores. Independent-sample t tests were run to see whether there was a significant difference between values for men and women. For the RPE, a Mann–Whitney U test for non-parametric data was used to test for differences between men and women, and a Wilcoxon's signed ranks test for non-parametric data was used to test for differences between the MT and the field test scores. The level of significance was set at $p<0.01$ to help protect against potential type I errors. Pearson's correlation (r) was used to calculate the associations between the parametric variables.

RESULTS

The mean (SD) one-way distance was 8.3 (4.6) km (table 2). The mean (SD) duration and speed during the field test was 24.1 (10.7) min and 20.1 (4.5) km/h, respectively. The duration and speed of the daily trips from and to work, as recorded in the diaries, was 27.1 (11.8) min and 17.8 (3.9) km/h, respectively. During the field test, the participants cycled significantly ($p<0.01$) faster than during the daily cycling. The average difference in cycling speed between the field test results and the results from the daily diaries was 13%.

Table 3 shows the mean (SD) values for absolute and relative maximal power (W_{max} and W_{max}/kg, respectively), time to exhaustion, heart rate, absolute and relative oxygen uptake capacity (VO_2 and VO_2/kg, respectively), RER, MET, RPE, and Lct for the MT, MT2 and field test. The results show a significant increase in the W_{max} ($p<0.05$), W_{max}/kg ($p<0.01$) and time to exhaustion ($p<0.05$) between MT and MT2 for the total group. Only in men did the W (/kg) and time to exhaustion change significantly ($p<0.05$) between MT and MT2. All participants rated their fatigue as ''somewhat hard'' on the Borg RPE scale. Men had significantly higher W (/kg), VO_2 (/kg), MET and Lct values than women during the MT, MT2 and field test. Men and women indicated that they were equally fatigued at the end of the field test. As for the total group, the values measured during the field test were significantly lower than those measured during the MT for men and women separately.

Table 4 shows the mean (SD) of the percentage difference between MT and field test and between MT2 and field test for heart rate, VO_2, VO_2/kg, RER, MET and Lct. During the field test, men and women exercised at a mean intensity of >75% of the maximum values during the MT. Men and women cycled at the same percentage of their maximum exercise capacity. The lactate concentration measured at the end of the field test was 40% of that measured at the end of the MT and MT2. We found no significant difference between the percentages at the MT and MT2.

Table 5 shows the mean (SD) for measures and estimates of energy expenditure. During the field test, men consumed significantly more kcal/h ($p<0.01$) and kcal/kg/h ($p<0.05$) than women. The energy expenditure per week during the field test was on average 1539 (892) kcal/week, with no significant difference between values for men and women.

DISCUSSION

Our results indicate that the mean intensity of the field test was >75% of the maximum aerobic capacity, with all the values >50% of the maximum capacity. The mean MET was 6.8 and the mean energy expenditure was 1539 kcal/week. Participants rated their fatigue as ''somewhat hard''. Our study is unique because it is the first time the intensity of commuter cycling has been directly measured.

In an attempt to examine the external validity of our results, the mean time, speed and distance travelled were compared with those in other studies. The mean time spen on a one-way trip was 24 min, with no significant difference between time spent by men and women. This commuter time corresponds to the findings of Oja *et al*.[4] The time spent on a two-way trip exceeds the minimum of 30 min of physical activity recommended by the CDC and the ACSM.[1] The mean one-way distance and cycling speed in our study is in accordance with that reported by Oja *et al*[4] and Hendriksen *et al*.[3] In our study, men seemed to cycle faster ($p = 0.043$) than women. The higher commuter cycling speed of men is in accordance with that reported by Hendriksen *et al*,[3] where men and women cycled at an average speed of 19.7 and 17.9 km/h, respectively.

Walking and cycling to work enables a considerable proportion of the working population to perform regular physical activity.[2] To be considered fitness enhancing, the physical activity should be performed at an intensity of >55–65% of the maximum heart

Table 2 Cycling characteristics of participants according to their daily diaries and the field test

Variable	Total	Men	Women
One-way trips (km)	8.3 (4.6, 2.1–19.4)	9.5 (4.9, 3.9–19.4)	6.9 (4.0, 2.1–14.8)
Time (min)			
Field test	24.1 (10.7, 7.4–43.6)*	25.1 (9.6, 12.0–37.4)†	22.9 (12.4, 7.4–43.6)†
Daily diary	27.1 (11.8, 7.8–50.2)	28.3 (11.8, 12.9–50.2)	25.6 (12.5, 7.8–45.7)
Cycling speed (km/h)			
Field test	20.1 (4.5, 13.4–33.0)*	22.0 (4.7, 17.2–33.0)†‡	17.8 (3.0, 13.4–20.9)†
Daily diary	17.8 (3.9, 13.0–31.1)	19.5 (4.0, 15.7–31.1)	15.6 (1.9, 13.0–19.3)

Values are mean (SD, range).
*Significant difference from daily diary; $p<0.01$.
†Significant difference from daily diary; $p<0.05$.
‡Significant difference from women; $p<0.05$.

Table 3 Physiological variables measured during maximal tests and field test for the total group, men and women

	MT			MT2			FT		
Variable	Total	Men	Women	Total	Men	Women	Total	Men	Women
W_{max} (W)	193 (57)††	237 (30)††*	137 (16)	205 (60)	249 (32)*	150 (36)	/	/	/
W_{max}/kg (W/kg)	2.6 (0.7)†	3.0 (0.5)††*	2.0 (0.5)	2.8 (0.8)	3.2 (0.6)*	2.2 (0.7)	/	/	/
Time (s)	674 (137)††	748 (119)††*	583 (98)	737 (180)	797 (127)	662 (216)	/	/	/
HR (beats/min)	179 (18)	176 (22)	183 (11)	175 (19)	175 (20)	174 (18)	141 (20)‡	140 (21)‡	140 (21)‡
VO_2 (l/min)	2.29 (0.56)	2.73 (0.25)*	1.73 (0.21)	2.30 (0.57)	2.72 (0.25)*	1.79 (0.40)	1.80 (0.47)‡	2.10 (0.36)‡*	1.42 (0.26)‡
VO_2/kg (ml/kg/min)	30 (7)	35 (4)*	25 (5)	31 (7)	35 (4)*	26 (8)	24 (7)‡	27 (6)‡**	20 (5)‡
RER	1.17 (0.08)	1.19 (0.07)	1.15 (0.08)	1.19 (0.09)	1.23 (0.09)	1.15 (0.08)	0.97 (0.09)‡	1.01 (0.09)‡	0.92 (0.08)‡
MET	8.9 (2.1)	10.1 (1.7)*	7.4 (1.7)	8.9 (2.1)	10.1 (1.0)	7.4 (2.1)	6.8 (1.9)‡	7.7 (1.7)‡**	5.7 (1.3)‡
RPE	16 (2)	16 (3)	17 (2)	16 (2)	16 (2)	17 (1)	13 (2)‡	13 (2)‡‡	13 (2)‡‡
Lct (mmol/l)	9.54 (2.23)	10.65 (1.77)**	8.17 (2.04)	9.45 (2.47)	10.67 (2.24)*	7.92 (1.89)	4.00 (2.24)‡	4.55 (2.68)‡	3.31 (1.39)‡

FT, field test; HR, heart rate; Lct, lactate; MET, metabolic equivalent; MT, maximal exercise test; MT2, second maximal exercise test; RER, respiratory exchange ratio; RPE, rate of perceived exertion; VO_2, oxygen consumption.
Values are mean (SD).
Maximal power (W_{max}, W_{max}/kg), time to exhaustion (time), HR, ergospirometry (VO_2, VO_2/kg, RER, and MET), RPE, and lactate (Lct) during maximal test (MT and MT2) and FT. RPE and Lct were taken at the end of the FT.
Significant difference from women, in MT, MT2 and field test: *$p<0.01$; **$p<0.05$.
Significant difference from MT2: †$p<0.01$; ††$p<0.05$.
Significant difference from MT and MT2: ‡$p<0.01$; ‡‡$p<0.05$.

rate.[8] In the present study, the mean heart rate during the field test was 79% of the maximal value for the group as a whole. Men and women had a mean heart rate of 80% and 77%, respectively, which was not significantly different. Hendriksen *et al*[3] measured heart rate as a predictor of exercise intensity. The intensity, expressed as a percentage of the maximum heart rate, was significantly ($p<0.01$) higher for the female participants (75% and 68%, respectively).[3] In the study of Kukkonen-Harjula *et al*[14] the mean heart rate during commuter cycling corresponded to 70% of the maximum heart rate. The mean absolute heart rate in our study was 141 beats/min and was similar to the heart rate measured by Oja *et al*.[4] In our study VO_2 was continuously measured and corresponded to 79% of the VO_{2peak} and a mean MET value of 6.8 for the group as a whole. This is more than the 57% and 57–65% of the VO_{2max} found by Kukkonen-Harjula *et al*[14] and Oja *et al*,[4] respectively, where in both studies the mean cardiorespiratory strain was calculated according to the individual heart rate–oxygen consumption regression in the laboratory test. According to the results of our study and the studies of Hendriksen *et al*,[3] Kukkonen-Harjula *et al*[14] and Oja *et al*,[4] we can state that cycling at a self-chosen intensity is performed at an intensity that is high enough to meet the ACSM recommendations[8] for the improvement of fitness and the CDC and ACSM recommendations for the improvement of health.[1]

Comparing men and women showed that men cycled over a longer distance, spent more time and cycled faster during the field test. Men had higher absolute values during the MT and during the field test, except for heart rate, which was higher for women. We can conclude that men cycled at an intensity higher than that by women, but when looking at the relative intensities, there seemed to be no significant difference between the cycling intensities of men and women.

To decrease all-cause mortality, a minimum of 1050 kcal/week should be expended.[7 9 10] It was estimated that the participants expended about 220 kcal or 3.0 kcal/kg during an every day one-way trip and 1539 kcal or 20.6 kcal/kg in total during a typical week. To compare different participants over the same time interval, we recalculated the absolute energy expenditure (kcal) to a relative energy expenditure (kcal/h). The mean relative energy expenditure in our study was 540 kcal/h or 7.2 kcal/kg/h, with men consuming significantly ($p<0.01$) more energy per unit of time than women. Comparing these results with the CDC and ACSM recommendations, 540 kcal/h corresponds to "hard/vigorous" activity. We found no correlations between age or body weight and energy expenditure. The correlation (r) between kcal/h and kcal/kg/h and the cycling speed was 0.6 ($p = 0.012$) and 0.7 ($p = 0.002$), respectively.

Our results might suggest that the mean energy expenditure rate during cycling is adequate for a reduction in all-cause mortality. However, the large variation in the weekly energy expenditure suggests that many participants may not have engaged in enough exercise to obtain the health benefits associated with regular exercise. This is emphasised by the fact that, although the great majority (83%) of them reached a commuting time of >30 min a day and cycled more than five one-way trips to or from work, only 61% reached the above-mentioned volume and expended >1050 kcal/week. Further, the large SD values in the whole group can be explained mainly by a

Table 4 Physiological values measured during field test relative to the maximal values measured during maximal tests

	FT/MT (%)			FT/MT2 (%)		
Variable	Total	Men	Women	Total	Men	Women
HR (beats/min)	78.7 (10.9)	80.0 (9.8)	77.2 (12.7)	80.6 (9.3)	80.6 (8.3)	80.6 (11.0)
VO_2 (l/min)	79.3 (12.6)	77.2 (13.0)	82.0 (12.4)	78.2 (14.7)	77.8 (14.8)	78.7 (15.7)
VO_2 (ml/kg/min)	79.2 (12.8)	77.4 (13.0)	81.3 (13.0)	77.0 (14.8)	77.3 (17.0)	76.6 (12.8)
RER	82.8 (7.5)	84.5 (6.6)	80.7 (8.5)	81.4 (7.1)	81.6 (4.2)	81.2 (10.0)
MET	77.4 (13.5)	77.1 (13.9)	77.7 (13.9)	77.4 (14.7)	76.8 (16.8)	78.2 (12.6)
Lct	42.1 (19.8)	41.7 (19.1)	42.7 (21.9)	43.2 (20.4)	44.0 (24.0)	42.0 (16.3)

FT, field test; HR, heart rate; Lct, lactate; MET, metabolic equivalents; MT, maximal exercise test; MT2, second maximal exercise test; RER, respiratory exchange ratio; VO_2, oxygen consumption.
Values are mean (SD).
HR, ergospirometry (VO_2, VO_2/kg, RER, and MET), rating of perceived exertion (RPE), and Lct.
For RPE and Lct the % MT−FT was calculated between the maximum values of MT, MT2 and the values taken at the end of FT.

Table 5 Energy expenditure for the total group and for men and women separately during the field test

Variable	Total	Men	Women
kcal	220 (115)	261 (107)	169 (110)
kcal/kg	3.0 (1.7)	3.4 (1.5)	2.5 (1.8)
kcal/h	540 (139)	630 (110)*	428 (75)
kcal/kg/h	7.2 (1.9)	8.1 (1.8)**	6.0 (1.4)
kcal/week	1539 (892)	1811 (916)	1200 (785)
kcal/kg/week	20.6 (12.6)	23.3 (12.5)	17.3 (12.7)

Values are mean (SD).
Significant difference from women: * $p<0.01$; ** $p<0.05$.

gender difference. Although seven women reached the minimal volume for health benefits, only 57% expended 1050 kcal/week. This is in contrast with men. All men reached the minimal volume and expended >1050 kcal/week. These results might suggest that the advice on minimal energy expenditure[7 9 10] to reach health benefits should be different for men and women.

A problem with the present and similar investigations is the potential measurement error associated with being observed. For example, did the participants cycle at a faster pace just because they were being tested? We attempted to solve this problem by instructing them to cycle at the same intensity as during their regular commuter cycling. Despite our instructions, they cycled faster during the field test compared with the data in the diaries. The high values measured during this study can be explained partly by the higher cycling speed in comparison with their everyday cycling.

The field test was carried out 12 weeks after the MT. The rather high intensity of the field test could be partly explained by a training effect. The 12 weeks time interval between the MT and the field test was chosen to ascertain that the subjects had become regular commuter cyclists at the time of testing (field test). To investigate whether the time interval of 12 weeks had biased our results (ie an overestimation of the intensity of the field test), a second maximal test (MT2) was carried out 24 weeks after the MT. No significant differences in heart rate or VO_2 were found between the percentages at MT and MT2. Although the heart rate and VO_{2peak} did not improve, the physical fitness of the participants increased significantly, as expressed by the total time to exhaustion ($p = 0.033$) and absolute ($p = 0.017$) and relative ($p = 0.010$) maximal power between MT and MT2. Thus, we conclude that the rather high values of the field test may be caused by faster cycling during the field test, by a training effect, and possibly by the fact that the field test was conducted in a rural area.

CONCLUSION

At least 30 min of moderate-intensity (3–6 METs) activity on most days is assumed to confer health benefits.[1] For the improvement of fitness,[8] a duration of 20–60 min at a heart rate from 55/65% to 90% of the maximum heart rate is recommended.

In our study, the participants cycled from or to work at moderate to high intensity, corresponding to >75% of the maximal physiological variables. Men cycled faster and consumed considerably more energy per hour than women. With respect to the study limitations, it is concluded that cycling to work provides the possibility for regular exercise at an intensity that is high enough to meet the ACSM recommendations for the improvement of cardiovascular fitness. Thus, the intensity in our study was high enough to meet the CDC and ACSM recommendations for the improvement of health. Care must be taken not to overestimate when interpreting the results, because the participants cycled faster during the field test than during daily cycling and because of the difference in cycling intensity of men and women.

What is already known on this topic

- People cycle to work at an intensity that corresponds to 68–75% of the maximum heart rate, with mean (standard deviation) heart rates of 129 (13) and 139 (18) for men and women, respectively.

What this study adds

- It is the first time that the intensity was measured directly with a breath-by-breath device in a real-life situation in sedentary people.
- Cycling to work is done at an intensity that is high enough to meet the recommendations of the American College of Sports Medicine for the improvement of fitness and those of the Centers for Disease Control and Prevention and the American College of Sports Medicine for the improvement of health.

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