Reproducibility and Validity of an Epidemiologic Questionnaire to Assess Past Year Physical Activity in Adolescents

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The reproducibility and validity of a past year physical activity questionnaire was determined in a sample of 100 adolescents aged 15–18 years, randomly selected from a population-based cohort. Subjects completed four 7-day recalls of activity approximately 3 months apart. The average of the four 7-day recalls of activity was utilized as the “gold standard” against which the past year questionnaire was compared to evaluate validity. The questionnaire was also validated against objective measures, such as physical fitness and body mass index. Interscholastic team rosters were utilized to directly validate the reporting of specific activities. One-month and one-year test-retest reproducibility of the questionnaire were determined. For different measures of activity, the Spearman correlations between the questionnaire and the average of the 7-day recalls ranged from 0.55 to 0.67 in males and 0.73 to 0.83 in females, all significant at p < 0.01. In general, although there was no association between the past year activity questionnaire results and objective measures, there was a significant, albeit weak association between the physical activity questionnaire and time to complete a 1-mile (1.61-km) run (r = -0.47) in females. Subjects reported participating in specific interscholastic sports with an accuracy of 100%, 86%, and 95% for the fall, winter, and spring sports, respectively. Test-retest reproducibility was higher over one month (r = 0.79) than over one year (r = 0.66). These data provide evidence that the questionnaire yields a reasonable estimate of past year or “habitual” physical activity in adolescents. Am J Epidemiol 1995;142:191–201.

adolescence; epidemiologic methods; exercise, physical; questionnaires

Physical activity and fitness have been identified as a national priority area for promoting the health of the US population (1). Physical activity has been shown to be inversely associated with a variety of chronic diseases in adults, including coronary artery disease (2). Cross-sectional studies have shown that many of the known risk factors for these chronic diseases are present in children and adolescents (3, 4). However, the association between childhood physical activity and risk factors for adult chronic disease is inconclusive (5).

In order to investigate the association between physical activity and health-related outcomes, it is necessary to use an instrument to measure adolescent activity that is both accurate and practical for use in epidemiologic research. Many different techniques have been utilized to assess physical activity in children and adolescents (5). Due to their convenience and low cost, questionnaires are the most widely used method for the assessment of physical activity in epidemiologic research. However, there are few data regarding the accuracy of questionnaires to assess physical activity in adolescents (6), and moreover, to our knowledge, there have been no population-based examinations of the accuracy of physical activity questionnaires.

There is currently no “gold standard” by which physical activity questionnaires, used in population-based research, can be validated. The traditional approach to validate activity questionnaires has involved comparing the questionnaires to objective measures of physical activity, such as activity monitors or aerobic fitness. However, these techniques have their own
limitations. Cost, reactivity, and instrument failure are concerns when activity monitors are used (7), and, in general, the association between physical activity and aerobic fitness is weak (8–10). In fact, these objective techniques may measure different dimensions of physical activity, thus limiting their utility to validate questionnaires.

The lack of a “gold standard” to validate questionnaires is not restricted to physical activity research. Nutritional researchers have experienced a similar problem when evaluating the validity of food frequency questionnaires. For the past decade, nutritional researchers have been utilizing a methodology that does not attempt to compare long-term (past year) food frequency questionnaires with objective measures, but rather compares a questionnaire with another subjective method judged to be superior (11).

The purpose of this report was to apply the method of questionnaire validation utilized in nutritional research to a past year physical activity questionnaire. Through this approach, we examine the reliability and validity of the current physical activity questionnaire as well as to provide a model by which future physical activity questionnaires could be validated in a standardized way.

MATERIALS AND METHODS

Subjects

The Adolescent Injury Control Study, which began in September 1989, was a 4-year prospective study of the incidence and risk factors for physician-treated injuries in a population-based cohort of adolescents. The target population was the 1,400 students that attended the two junior high schools (grades 7–9) in a metropolitan school district near Pittsburgh, Pennsylvania. A cohort of 1,245 students (89 percent of the population) was recruited to participate in the study. The study group consisted of students 12–16 years of age and was comprised of similar numbers of males (n = 641) and females (n = 604). The racial composition of the study group was white (73 percent), African American (24 percent), and Hispanic or Asian (3 percent). Informed consent was obtained from all students and parents prior to entry into the study. All students who actively participated in the study completed a past year physical activity questionnaire on an annual basis.

A sample of 110 students was randomly selected from the active cohort of 1,100 students, representing 10 percent of the students who participated at the start of the third year of the Adolescent Injury Control Study. The random sample was computer generated and based on a table of random numbers.

Past year activity questionnaire

The development and administration of the past year questionnaire utilized in this study has previously been described (12). This questionnaire, a copy of which is included in the Appendix, was adapted from the Minnesota Leisure Time Activity Survey (13) and is currently being used to assess physical activity levels in several epidemiologic studies (14–17). Briefly, students were asked to indicate all leisure-time activities they had participated in at least 10 times during the past year. For the activities about which the student responded “yes,” detailed information was collected regarding the frequency and duration of participation in this activity over the past year. The past year questionnaire yields an estimate of the average number of hours per week spent in each activity. The hours from all activities were summed to derive an overall leisure-time physical activity estimate (hrs/wk) averaged over the past year. The hours/week estimate for each activity was also multiplied by the metabolic cost of that activity (expressed as METs and obtained from existing tables (18–20)), in order to weight each activity by a crude estimate of its relative intensity. The MET-hrs/wk estimates for each activity were then summed in order to obtain a composite estimate over the past year. In addition, an estimate of hours/week spent in vigorous activity (VIG-hrs/wk) over the past year was calculated by summing the hrs/wk of only those activities with a metabolic equivalent of >6 METs.

Students also responded to four multiple choice questions that assessed “hard and light exercise” over the past 2 weeks, daily television viewing, and competitive athletic participation. These questions were adapted from the Youth Risk Behavior Survey developed by the Centers for Disease Control (21).

The questionnaire was self-administered on an annual basis in the Adolescent Injury Control Study. An additional past year questionnaire was administered approximately one month prior to the final data collection in order to evaluate short-term reproducibility (figure 1).

Criterion measure

A past week physical activity questionnaire was administered four times throughout the school year at approximately 3-month intervals (figure 1). The past week recall was identical to the past year questionnaire; however, the time periods were modified to reflect only the preceding 7 days. In addition, the students were asked to indicate if any of the activities they reported for the past 7 days were done for a school-sponsored athletic team. The average of the four summary estimates of physical activity obtained
from the weekly recalls of activity was utilized as the criterion measure.

Other measures

The student’s height and weight were measured by the research staff and reported in kilograms and centimeters. Body mass index was calculated from height and weight according to the Quetelet method (22), kg/m².

As part of the Adolescent Injury Control Study protocol, all students completed a battery of fitness tests supervised by the research staff, including a one-mile (1.61-km) walk/run (aerobic fitness), sit-and-reach test (flexibility), and pull ups (strength). The protocol for fitness testing was similar to that of the National Children and Youth Fitness Study, which allowed a direct comparison to national data (23). In addition to the strength test used in the national study, grip strength was incorporated into the fitness battery of the current study.

For direct validation of reported to actual participation in competitive activities, rosters were obtained from the athletic department of the school district that participated in the current study. From each sport roster, all students who participated in the current study were identified. The list of athletes was then compared with the students’ reporting of participation in competitive activities during the past year.

Statistical analysis

All analyses were performed utilizing the SPSS-X statistical package (24). Nonparametric statistical tests were employed due to the fact that the distributions of activity estimates were positively skewed. Summary estimates of physical activity were calculated for all questionnaires and the median value of hrs/wk, MET-hrs/wk, and VIG-hrs/wk were determined for all past year and past week physical activity questionnaires.

To evaluate the validity of the past year questionnaire, Spearman rank order correlations were utilized to compare the estimates of physical activity obtained from the past year questionnaire to the estimates of physical activity obtained from the average of the four weekly recalls of activity as well as physical fitness measures and body mass index.

Spearman rank order correlations were also utilized to evaluate the reproducibility of the estimates of physical activity obtained from the past year questionnaires.

RESULTS

Of the random sample of 110 students, 6 (5 percent) declined to participate and 4 (3.6 percent) withdrew from the study prior to final data collection. The remaining 100 students (91 percent of the random sample) completed the entire study (table 1). The sample included 47 male and 53 female adolescents aged 15–18 years. The ethnic composition of the sample was 83 percent white and 17 percent nonwhite.

<table>
<thead>
<tr>
<th>TABLE 1. Socio demographic variables, median hours/week of physical activity, and mean values of body mass index and physical fitness measures, by sex, in a sample of 100 adolescents randomly selected from a population-based cohort in a metropolitan school district near Pittsburgh, Pennsylvania, 1992–1993</th>
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<tbody>
<tr>
<td>Variable</td>
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<tr>
<td>Race (% white)</td>
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<td>Age (years)</td>
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<td>Physical activity (median hours/week)</td>
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<td>Past week #1</td>
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<td>Past week (average)</td>
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<td>Past year</td>
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<tr>
<td>Body mass index (kg/m²)</td>
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<td>1-mile (1.6-km) run (minutes)</td>
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<tr>
<td>Sit-and-reach (inches)*</td>
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<tr>
<td>Pull ups (no.)</td>
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<tr>
<td>Grip strength (kg)</td>
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</table>

* 1 inch = 2.54 cm.
The median values of the estimates of physical activity and mean values of body mass index and physical fitness variables are presented in Table 1.

The median hrs/wk of physical activity reported on the four past week recalls varied considerably during the school year (Figure 2), with the highest activity during the fall. In addition, the estimate of physical activity obtained from the past year questionnaire was very similar to the average of the four past week recalls of activity.

Reproducibility. The reproducibility coefficients (Spearman rank order) of the estimates of past year physical activity scores measured at one-year and one-month intervals are presented in Table 2. Overall, the reproducibility coefficients for the entire sample were quite high, indicating excellent long-term and short-term reproducibility. As would be expected, the one-month reproducibility coefficient ($r = 0.79$) for hrs/wk was higher than the one-year coefficient ($r = 0.66$). The reproducibility coefficients for MET-hrs/wk, which crudely adjusts for intensity of activity, and VIG-hrs/wk, which includes only those activities with a MET value of $>$6, were somewhat higher for both one-year and one-month reproducibility.

A concern when individuals complete repeated questionnaires is that a "learning effect" will take place. Therefore, in order to evaluate if the one-year reproducibility coefficients were artificially high or low due to repeated assessment of physical activity, the one-year reproducibility was examined in students who were not selected to participate in the current reliability study. Approximately 700 students actively participating in the Adolescent Injury Control Study did not participate in the current investigation; however, these students had completed a past year physical activity questionnaire in 1992 and 1993. The one-year reproducibility coefficient for the estimate of leisure-time physical activity (hrs/wk) for the current random sample ($r = 0.66$) and those students who did not participate in the current study ($r = 0.60$) were very similar, which suggests little learning effect.

Validity. To determine both a conservative and optimistic estimate of the validity of the questionnaire (11), the average of the four past week questionnaires was compared with both the past year questionnaire.
FIGURE 2. Median hours/week of physical activity reported on the four weekly questionnaires, the average of the four past week questionnaires (Avg), and the median hours/week reported on the past year questionnaire.

TABLE 4. Spearman rank order correlations comparing body mass index and physical fitness measures with past year physical activity questionnaire in a sample of 100 adolescents randomly selected from a population-based cohort in a metropolitan school district near Pittsburgh, Pennsylvania, 1992–1993.

<table>
<thead>
<tr>
<th></th>
<th>Body mass index</th>
<th>1-mile run</th>
<th>Sit-and-reach</th>
<th>Pull ups</th>
<th>Grip strength</th>
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<tbody>
<tr>
<td><strong>Males</strong></td>
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<tr>
<td>Hrs/wk†</td>
<td>−0.04</td>
<td>−0.18</td>
<td>0.15</td>
<td>0.17</td>
<td>0.04</td>
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<tr>
<td>MET-hrs/wk‡</td>
<td>−0.06</td>
<td>−0.20</td>
<td>0.15</td>
<td>0.16</td>
<td>0.04</td>
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<tr>
<td>VIG-hrs/wk§</td>
<td>−0.13</td>
<td>−0.13</td>
<td>0.04</td>
<td>−0.01</td>
<td>−0.02</td>
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<tr>
<td><strong>Females</strong></td>
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<tr>
<td>Hrs/wk</td>
<td>−0.09</td>
<td>−0.43*</td>
<td>0.15</td>
<td>−0.06</td>
<td>0.05</td>
</tr>
<tr>
<td>MET-hrs/wk</td>
<td>−0.13</td>
<td>−0.47*</td>
<td>0.14</td>
<td>−0.06</td>
<td>0.14</td>
</tr>
<tr>
<td>VIG-hrs/wk</td>
<td>−0.08</td>
<td>−0.45*</td>
<td>0.02</td>
<td>−0.06</td>
<td>0.25</td>
</tr>
</tbody>
</table>

* p < 0.01.
† Hrs/wk, estimate of overall leisure physical activity in hours/week.
‡ MET-hrs/wk, weighting of hrs/wk by the relative intensity of each activity, calculated by multiplying the hrs/wk of the activity by the metabolic cost of that activity as expressed in METs and obtained from published tables (18–20).
§ VIG-hrs/wk, hrs/wk spent in vigorous activity, calculated by summing the hrs/wk of activities with a metabolic equivalent of >6 METs.

The method most commonly utilized to validate a physical activity questionnaire is to compare it to an objective measure thought to be related to physical activity, such as body mass index or fitness. The premise is that children who are more active are less likely to be overweight and more likely to be physically fit. Therefore, the past year questionnaire was completed prior to and after the study period (table 3). For the entire sample, the correlation coefficients between the past year questionnaire and the average of the four past week questionnaires were consistently higher with the 1993 questionnaire (r = 0.76–0.84) compared with the 1992 questionnaire (r = 0.63–0.76).
compare with these objective measures (table 4). No significant association was found between reported activity and body mass index. There was also no significant association between activity and any of the physical fitness measures with the exception of aerobic fitness, assessed by the 1-mile (1.61-km) walk/run, in females.

The past year physical activity questionnaire asked the students to list all "competitive" activities in which they had participated during the past year. We had an opportunity to directly validate these reports by comparing the students' responses with the interscholastic eligibility rosters for each specific sport. Results indicated that of the 27 students listed on the fall sports rosters, 100 percent reported participating in those competitive activities on the past year questionnaire. Similar results were seen with the winter and spring sports with 12 out of 14 students (86 percent) and 19 out of 20 students (95 percent), respectively, reporting participation in those competitive activities on the past year questionnaire. Conversely, of the students not listed on the team rosters, only 3 of 70, 1 of 85, and 4 of 76 reported participating in fall, winter, and spring sports, respectively.

DISCUSSION

There have been very limited efforts to validate habitual physical activity surveys in adolescents. Moreover, there is no standard method to assess the accuracy of physical activity questionnaires. This report set out to determine the reproducibility and validity of such a questionnaire for use in adolescents. Additionally, a focus of this study was to employ the methodology utilized in nutritional research to provide a model by which activity questionnaires can be validated. By establishing a standard methodology to validate activity questionnaires, comparisons can be made regarding the accuracy of questionnaires currently utilized to assess habitual physical activity in adolescents as well as in other populations.

The physical activity questionnaire under investigation was found to be highly reproducible by comparing the estimates of physical activity obtained at one-year and one-month intervals. Surprisingly, there are no published data, to our knowledge, with which a direct comparison can be made regarding the year-to-year reproducibility of past year physical activity questionnaires utilized in adolescent populations. The majority of available data regarding the reproducibility of physical activity recall in children has involved short-term (≤7 days) recall questionnaires. The short-term reproducibility of the current questionnaire was comparable to that obtained from other studies in adolescents (25, 26). In addition, the short-term reproducibility of the past year questionnaire utilized in the current study was comparable to that found in studies of adults where a similar physical activity questionnaire was utilized (14, 27) as well as other activity questionnaires commonly utilized in adult populations (28–30).

It is important to point out that due to the representativeness of the school district and the random selection of students for the validity study, our subjects represent very typical teenagers. If validity could be shown to be strong in this sample of teenagers, the questionnaire likely provides a reasonable measure of activity for adolescents.

The choice of a reference measurement in a validation study is critical in that it should, as precisely as possible, reflect a "true" assessment of the parameter under investigation. Doubly labeled water is acknowledged as the most accurate method of determining total energy expenditure and thus validating activity questionnaires. However, the cost of this method makes it prohibitive in population-based research. The current study employed a past week recall of physical activity as the primary reference method due to minimal dependence on memory. In addition, the 7-day recall of physical activity has been shown to provide an accurate assessment of past week activity in both adolescents (26) and adults (30). The reference measurement (average of four past week questionnaires) was compared with the estimates of physical activity derived from the past year questionnaires completed prior to and after the completion of the four weekly questionnaires. According to Willett (11), this provides both a conservative and optimistic estimate of the validity of the past year questionnaires.

The estimates of physical activity obtained from the past year questionnaire completed at the completion of the current study were found to be significantly correlated with the reference method (average of four past week questionnaires). These results provide evidence that the past year questionnaire was, in fact, reflective of habitual physical activity levels of adolescents. This method to validate questionnaires has been used frequently in nutritional research (11). However, to our knowledge, it has only been previously utilized once to validate a physical activity questionnaire. The validity of a physical activity questionnaire has been examined in a sample of adult women participating in the Nurses' Health Study II (Wolf AM, et al., unpublished data). Although this study was conducted in a sample of adult women, the correlations were very similar to that found in the current sample of adolescents.

An effort was also made to evaluate the accuracy of the past year questionnaire by more traditional meth-
Questionnaire to Assess Physical Activity in Adolescents

ACKNOWLEDGMENTS

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REFERENCES


25. Janz KF, Golden JC, Hansen JR, et al. Heart rate monitoring: methods utilized by physical activity researchers. Indirect methods of validation were performed by comparing the estimates of physical activity derived from the questionnaire to objective measures such as body mass index and physical fitness. Although the associations between the objective measures and reported physical activity were in the expected direction, many of the correlations between the questionnaire and fitness measures were weak. However, the correlations are as high as, if not higher than, have been previously reported between habitual physical activity and physical fitness (8–10) or indicators of obesity (9, 31) in children and adolescents.

As a final indicator of the ability of adolescents to accurately report physical activity, the reporting of specific activities was examined. The students’ report of participation in interscholastic sports was compared to a true “gold standard,” i.e., team rosters provided by the athletic department of the school district that participated in the Adolescent Injury Control Study. Results indicated that the students were highly accurate in reporting participation in competitive activities.

The present study has employed a methodology, previously utilized to assess the accuracy of food frequency questionnaires (11), to validate a physical activity questionnaire. The questionnaire can be easily administered to large numbers of individuals with minimal cost and burden to the subjects. It is comprehensive in that both leisure-time and occupational activity can be assessed. For the purposes of the Adolescent Injury Control Study, only leisure-time activity was assessed. However, if the level of total activity is of interest, the occupational activity component should be added. In addition, the questionnaire is nonreactive and can be easily modified to reflect the leisure-time activities of different populations. Foremost, as indicated by the current study, the questionnaire provides a reasonable estimate of the “habitual” physical activity level of adolescents.
APPENDIX

PHYSICAL ACTIVITY AND EXERCISE

<table>
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<th>NAME</th>
<th>____________________________</th>
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1. How many of the past 14 days have you done at least 20 minutes of exercise **hard** enough to make you breath heavily and make your heart beat fast? (Hard exercise includes, for example, playing basketball, jogging, fast dancing or bicycling; include time in physical education class)

   1. None            4. 6 to 8 days
   2. 1 to 2 days     5. 9 or more days
   3. 3 to 5 days     

2. How many of the past 14 days have you done at least 20 minutes of **light** exercise that **was not** hard enough to make you breath heavily and make you heart beat fast? (Light exercise includes, for example, playing baseball, walking or slow bicycling; include time in physical education class)

   1. None            4. 6 to 8 days
   2. 1 to 2 days     5. 9 or more days
   3. 3 to 5 days     

3. During a normal week, how many hours **a day** do you watch television and videos, or play computer or video games before and after school?

   1. None            4. 4 to 5 hours
   2. 1 hour or less  5. 6 or more hours
   3. 2 to 3 hours    

4. During the past 12 months, how many team or individual sports or activities did you participate in on a **competitive** level, such as varsity or junior varsity sports, intramurals, YMCA or other out-of-school programs.

   1. None            4. 3 activities
   2. 1 activity      5. 4 or more activities
   3. 2 activities    

   What activities did you compete in? 1. ____________
   2. ____________
   3. ____________
   4. ____________
   5. ____________
   6. ____________
   7. ____________

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PAST YEAR LEISURE-TIME PHYSICAL ACTIVITY

Check all activities that you did at least ten times in the PAST YEAR. Do not include time spent in school physical education classes. Make sure you include all sport teams that you participated in during the last year.

- Aerobics
- Band/Drill Team
- Baseball
- Basketball
- Bicycling
- Bowling
- Cheerleading
- Dance Class
- Football
- Garden/Yard Work
- Gymnastics
- Hiking
- Ice Skating
- Roller Skating
- Running for Exercise
- Skateboarding
- Snow Skiing
- Soccer
- Softball
- Street Hockey
- Swimming (Laps)
- Tennis
- Volleyball
- Water Skiing
- Weight Training
- Wrestling (Competitive)
- Others

List each activity that you checked above in the "Activity" box below, check the months you did each activity and then estimate the amount of time spent in each activity.

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<thead>
<tr>
<th>Activity</th>
<th>January</th>
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<tr>
<th>Months per Year</th>
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LEISURE-TIME PHYSICAL ACTIVITY CALCULATIONS

1. For each activity:

$$\text{(\# months/year)} \times (4.3 \text{ weeks/month}) \times (\# \text{ days/week}) \times (\# \text{ minutes/day})$$

$$\frac{(60 \text{ minutes/hour}) \times (52 \text{ weeks/year})}{(60 \text{ minutes/hour}) \times (52 \text{ weeks/year})} = \text{hours/week of activity}$$

2. Sum the hours/week for each activity to determine the total physical activity estimate for the past year.

3. To express the results in MET-hours/week, multiply the hours/week for each activity (derived in step 1) by the activity's MET equivalent (obtained from existing charts).

Example: Basketball (MET equivalent = 9)

$$\frac{(4 \text{ months/year}) \times (4.3 \text{ weeks/month}) \times (4 \text{ days/week}) \times (60 \text{ minutes/day})}{(60 \text{ minutes/hour}) \times (52 \text{ weeks/year})} = 1.3 \text{ hours/week}$$

$$(9 \text{ METS}) \times (1.3 \text{ hours/week}) = 11.9 \text{ MET-hours/week, or 11.9 kcal/kg}^{-1}/\text{wk}^{-1}$$