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# Pedometer Estimated Step Rates and Energy Expenditure

Jennifer Lee Oliver

*University of Tennessee - Knoxville*

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# UNIVERSITY HONORS PROGRAM

## SENIOR PROJECT - APPROVAL

Name: Jenny Oliver

College: Education, Health & Human Sciences Department: Health & Exercise Science

Faculty Mentor: Dr. Bassett

PROJECT TITLE: Pedometer Estimated Step Rates & Energy Expenditure

I have reviewed this completed senior honors thesis with this student and certify that it is a project commensurate with honors level undergraduate research in this field.

Signed: David R. Bassett, Jr. Faculty Mentor

Date: 5/03/04

Comments (Optional):

Jenny Oliver  
April 27, 2004  
Senior Honors Project

## **Pedometer Estimated Step Rates and Energy Expenditure**

### **Background:**

In 1995, the Centers for Disease Control and Prevention (CDC) and the American College of Sports Medicine (ACSM) issued the recommendation that adults need to participate in at least 30 minutes of moderate intensity physical activity, preferably all days of the week in order to achieve health benefits<sup>[1]</sup>. In an effort to help adults achieve the recommendation for physical activity, a pedometer, used for measurement and motivational purposes, has been widely promoted<sup>[2]</sup>. A pedometer records the number of up and down movements of the hip that occur during ambulatory (walking) movement<sup>[3]</sup>. For individuals who rely on a pedometer to measure activity level, it is recommended that 10,000 steps per day be taken in order to achieve health benefits.

### **Purpose:**

If pedometers are to be used to monitor physical activity level, as well as motivate physical activity participants, researchers recognize a need for the CDC and ACSM public health recommendations to be translated into terms of pedometer steps<sup>[4]</sup>. The purpose of this study is to observe various physical activities and determine how many steps are accumulated with a pedometer over a 30-minute time period. Additionally, energy expenditure was examined to determine if there is a correlation between number of steps taken and the energy cost of various activities.

### **Methods:**

287 male and female students participating in the University of Tennessee physical education classes were recruited for participation in this study. The physical characteristics of the participants are shown in Table 1. Fifteen different classes were monitored for this study: badminton, bowling, exercise with music (step aerobics), figure skating, golf (putting and driving range), jogging, racquetball, soccer, social dance (foxtrot), softball, tai chi, tennis, walking, weight training and yoga,. Participants who volunteered wore a pedometer on the waistband of their pants (on the midline of the thigh) for 30 minutes while participating in their class-specific activity. Energy expenditure of the activities was expressed in multiples of METs. A MET (metabolic equivalent) is defined as the resting rate of energy expenditure of an average person ( $3.5 \text{ mL}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$ ).

**Table 1. Physical characteristics of study participants**

	<b>Males</b>	<b>Females</b>
Age (years)	21.45 ± 3.50	20.65 ± 1.99
Height (in.)	71.12 ± 2.72	65.29 ± 2.60
Weight (lbs.)	182.62 ± 48.02	137.54 ± 22.29
BMI	25.31 ± 5.60	22.66 ± 3.21

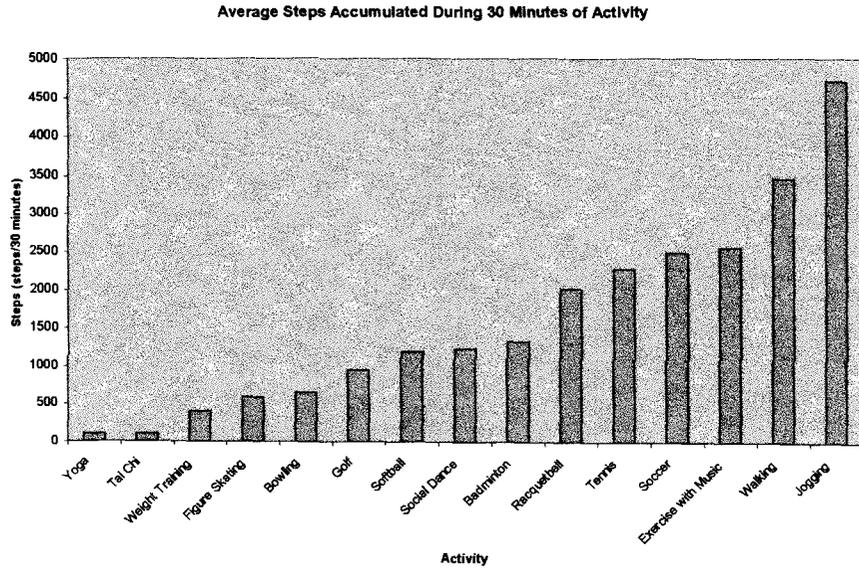
**Results:**

**Table 2. Physical Activity Energy Level Classification Chart**

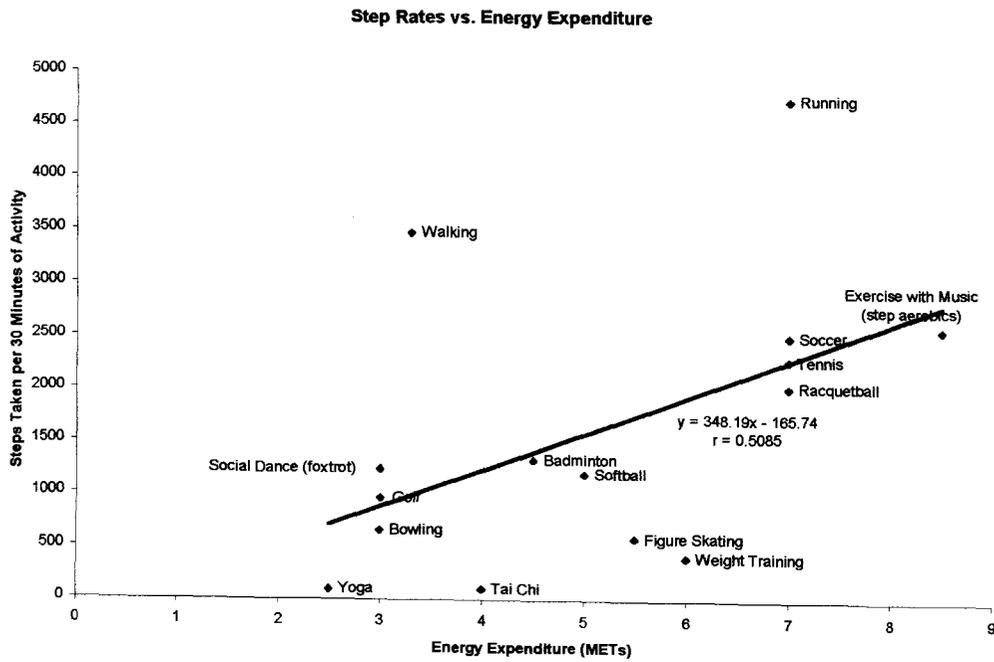
	<b>MET Level*</b>	<b>Activity</b>	<b>Steps</b>
<b>Low</b>	2.5	Yoga	95.6
	3	Bowling	651.45
<b>Moderate</b>	3	Golf	956
	3	Social Dance (foxtrot)	1232.7
	3.3	Walking	3466.5
	4	Tai Chi	99.5
	4.5	Badminton	1325.8
	5	Softball	1192.1
	5.5	Figure Skating	583.7
	6	Weight Training	402.2
<b>High</b>	7	Racquetball	2018.4
	7	Tennis	2276.2
	7	Soccer	2492.7
	7	Jogging	4724.7
	8.5	Exercise with Music (step aerobics)	2563.5

*\*(source: Compendium of Physical Activities: an update of activity codes and MET intensities)<sup>[12]</sup>*

**Figure 1. Number of steps accumulated by the pedometer during 30 minutes of activity.**



**Figure 2. Correlation of step rates and energy expenditure**



## Conclusions:

Pedometers are most accurate when measuring ambulatory (walking) movement. When trunk movement is not in the vertical plain, step estimates become inaccurate. In this study, the pedometer had difficulties accurately measuring the step rate for golf. An average of 956 steps taken while practicing golf-swing form on a driving range was recorded. This is highly improbable, as there was little variation from the stance of participants. Little ambulatory movement occurred, leading to the observation that perhaps the rotation of the hips during the golf swing was sensed by the pedometer and recorded as a step.

Pedometer estimated step rates moderately correlated with estimated energy expenditure ( $r=0.51$ ) for the activities observed. This is consistent with other studies measuring the correlation between steps and energy expenditure, where  $r$  values ranged from 0.46-0.88 (mean of reported correlations:  $r=0.68$ )<sup>[5,6,7]</sup>.

The use of the pedometer's step counts to estimate energy expenditure was not effective for three activities: weight training, figure skating and tai chi. In weight training, activity focuses on movement of arms and legs against set resistances. Weight training does not focus on ambulatory movement. Weight training is an activity with moderate energy expenditure, but step rates are uncharacteristically low for that level of energy expenditure. In figure skating, step rates were also uncharacteristically low because stride length is increased. An individual travels much further in one stride, thus delaying the time before the next step is taken, which ultimately resulted in less steps taken over any given time interval. In tai chi, much of the movement contributing in energy expenditure was with the arms, which is unrecordable by a pedometer. The steps taken may not have been detected by the pedometer. One study show that slow, shuffling gates, similar to those taken during tai chi, were not easily detected by a pedometer<sup>[11]</sup>.

Moderate intensity activities (3-6 METs) demonstrated a step frequency of 500-2000 steps/30 minutes. This estimate is lower than the 3100 steps taken during a 30 minute walk (standard moderate activity)<sup>[10]</sup>. This is important to note because this study's results suggest that moderate intensity activity levels can be met at a lower step frequency. Activities of high intensity (> 6 METs) demonstrated a step frequency of 2000-5000 steps/30 minutes. These results were "smoothed" for practicality purposes. Low intensity activities (< 3 METs) were underrepresented in this experiment and further study is needed to determine an accurate step frequency range.

Studies show that on average, people take 6000-7000 steps per day without participating in leisure time physical activity.<sup>[8,9]</sup> By participating in 30 minutes or more of moderate and/or vigorous leisure time activity, an individual can achieve 7000-12000 steps per day. This is effective in helping individuals achieve the health recommendation of taking 10,000 steps per day.

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