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Reliability and Validity of an Internet-based Questionnaire Measuring Lifetime Physical Activity

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Lifetime exposure to physical activity is an important construct for evaluating associations between physical activity and disease outcomes, given the long induction periods in many chronic diseases. The authors' objective in this study was to evaluate the measurement properties of the Lifetime Physical Activity Questionnaire (L-PAQ), a novel Internet-based, self-administered instrument measuring lifetime physical activity, among Canadian men and women in 2005–2006. Reliability was examined using a test-retest study. Validity was examined in a 2-part study consisting of 1) comparisons with previously validated instruments measuring similar constructs, the Lifetime Total Physical Activity Questionnaire (LT-PAQ) and the Chasan-Taber Physical Activity Questionnaire (CT-PAQ), and 2) a priori hypothesis tests of constructs measured by the L-PAQ. The L-PAQ demonstrated good reliability, with intraclass correlation coefficients ranging from 0.67 (household activity) to 0.89 (sports/recreation). Comparison between the L-PAQ and the LT-PAQ resulted in Spearman correlation coefficients ranging from 0.41 (total activity) to 0.71 (household activity); comparison between the L-PAQ and the CT-PAQ yielded coefficients of 0.58 (sports/recreation), 0.56 (household activity), and 0.50 (total activity). L-PAQ validity was further supported by observed relations between the L-PAQ and sociodemographic variables, consistent with a priori hypotheses. Overall, the L-PAQ is a useful instrument for assessing multiple domains of lifetime physical activity with acceptable reliability and validity.

epidemiologic methods; exercise; human activities; motor activity; questionnaires; reproducibility of results; validation studies

Abbreviations: CI, confidence interval; CT-PAQ, Chasan-Taber Physical Activity Questionnaire; ICC, intraclass correlation coefficient; L-PAQ, Lifetime Physical Activity Questionnaire; LT-PAQ, Lifetime Total Physical Activity Questionnaire; MET, metabolic equivalent; PAJH, Physical Activity and Joint Health.

Questionnaires are often the only feasible method of assessing habitual physical activity in large populations (1) because they are easy to administer, relatively inexpensive, and noninvasive (2). These features become relevant when measuring lifetime exposure to physical activity, a particularly important construct in evaluating associations between physical activity and disease outcomes, given the long induction or latency periods in many chronic diseases (3, 4). However, measurement of lifetime physical activity is challenging. Objective measures such as accelerometers and doubly labeled water would be most accurate, but these methods involve unreasonable subject burden and cost (5). The questionnaire has been the preferred instrument for measuring lifetime physical activity in epidemiologic studies and will probably continue to play an important role in measurement of this construct (6). Thus, there is need for continued development of instruments that allow for comprehensive measurement of lifetime physical activity, with demonstrated reliability and validity. At the same time, there is also a need for instruments that are efficient to administer and that minimize subject burden.

As part of the Physical Activity and Joint Health (PAJH) Study, a population-based Canadian cohort study on the relation between lifetime physical activity and osteoarthritis,

we developed the Lifetime Physical Activity Questionnaire (L-PAQ), an Internet-based, self-administered instrument. We evaluated the measurement properties of the L-PAQ by assessing 1) reliability in a test-retest study and 2) validity in a 2-part study comparing the L-PAQ with previously described instruments and testing of a priori hypotheses on constructs measured by the L-PAQ.

MATERIALS AND METHODS

Subjects

Validation studies of the L-PAQ were conducted among PAJH Study subjects in Vancouver, Canada, in 2005–2006 (Figure 1). The source population for the PAJH Study was the Canadian Association of Retired Persons, Canada's largest advocacy group for persons aged 50 years or more. Members were recruited via 2 methods: 1) an invitation e-mail sent to 28,000 members with Internet access who had agreed to receive such e-mail and 2) study information sent through an online newsletter to 100,000 members. Through these methods, subjects across Canada were recruited over the Internet and completed the baseline PAJH survey, and hence constituted the PAJH cohort as well as provided data for L-PAQ validation studies. A subcohort of subjects who resided in the metropolitan Vancouver area of British Columbia was recruited for the face-to-face aspects of the validation studies, conducted at the Arthritis Research Centre of Canada. The University of British Columbia Behavioural Research Ethics Board granted ethical approval, and each subject provided informed consent.

Data collection

As part of baseline data collection for the PAJH Study, subjects completed the L-PAQ via the Internet and answered additional questions on general health, knee and hip health, comorbid conditions, and sociodemographic characteristics. A study Web site was developed that allowed subjects to log in with a user name and password, enter and save their responses, and return later to continue or complete the questionnaire. The computer survey technology employed ''skip logic'' to reduce subject burden; for example, negative responses to specific questions prompted the questionnaire to skip through subsequent questions that were logically irrelevant to the respondent. Overall, completion of the survey usually took 1–1.5 hours.

Measurement of lifetime physical activity

The construct measured by the L-PAQ was physical activity performed over the course of the subject's lifetime across 3 domains: sports/recreation, occupational activity, and household activity. For all domains, only time spent in physical activity was queried about; information on sedentary behaviors was not captured.

In the sports/recreation section, subjects were provided a list of 64 leisure activities and the opportunity to enter any additional activities that were not on the list. Respondents who had performed an activity at least 100 times in their lifetime were prompted to provide information on duration (number of years they had performed the activity), frequency (how often they had performed the activity, measured in days per week), and average length of each activity session (measured in minutes or hours). For each activity, respondents were additionally asked to report the amount of time spent per hour (0, 1–<5, 5–<15, 15–<30, 30–<45, or 45–60 minutes) performing each of the following bodily movements: sitting, standing, walking, running/jogging, squatting or knee-bending without lifting, and squatting or knee-bending with lifting or force.

The occupational activity section used an open format in which respondents indicated all jobs they had held over their lifetime. For each occupation, respondents were asked to specify job title or type, duration (years), average number of hours per week worked, and whether the job was full-time, part-time, or seasonal. Respondents were also asked to report the amount of time spent in an 8-hour period (none, ≤1, 2–4, 5–7, or 8 hours) performing each of the following bodily movements: sitting, standing, standing while holding or moving objects weighing more than 50 pounds (>23 kg), walking, walking while carrying objects weighing more than 50 pounds, moving or pushing objects weighing more than 75 pounds (>34 kg), using heavy tools, squatting continuously, and kneeling continuously.

In the household activity section, respondents were asked about 4 general areas of activity performed at home: 1) caring for children, 2) caring for elderly or disabled persons, 3) gardening, and 4) housework. For each area of household activity, respondents were asked to specify

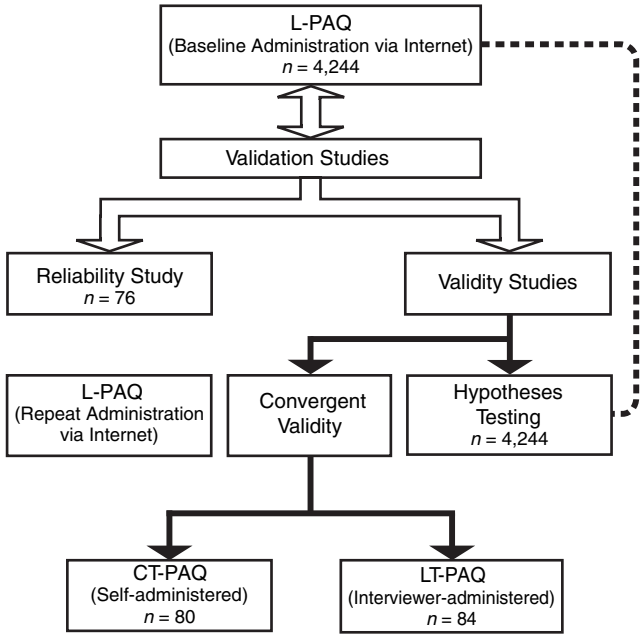

Figure 1. Study design for validation of the Lifetime Physical Activity Questionnaire (L-PAQ) within the Physical Activity and Joint Health Study, Canada, 2005–2006. CT-PAQ, Chasan-Taber Physical Activity Questionnaire; LT-PAQ, Lifetime Total Physical Activity Questionnaire.

duration (number of years) and frequency (number of hours per week). Respondents were also asked to report the amount of time spent in an 8-hour period performing each of the bodily movements listed above for occupational activity, with the exception of use of heavy tools.

For the 3 L-PAQ domains, lifetime participation in each specific activity was calculated by taking the product of duration (years), frequency (days/week), and length of each activity session (hours) (i.e., total lifetime hours = duration × frequency × length of activity session). Physical activity was then expressed as lifetime average weekly participation, calculated by dividing total lifetime hours by respondent age and the constant value, 52 (i.e., lifetime average hours/week = total lifetime hours/age/52). We also expressed the data in terms of energy expenditure by multiplying L-PAQ outcome measures by the average intensity of each activity (expressed as the metabolic cost of that activity in metabolic equivalents (METs)) to obtain average weekly energy expenditure over the subject's lifetime (lifetime average MET-hours/week). One MET represents the metabolic rate of a resting individual and is set at 3.5 mL of oxygen consumed per kilogram of body mass per minute (7). For sports and household activities, representative MET codes for specific activities were assigned using the Compendium of Physical Activities (7, 8). MET values for occupational activities were calculated using reported durations of bodily movements during a working day.

Validation studies

An overview of the L-PAQ validation studies within the PAJH Study is shown in Figure 1. To determine reliability, we conducted a test-retest study by providing subjects in the validation subcohort access to the retest version of the L-PAQ, which consisted of questions identical to those in the baseline version of the L-PAQ administered for the PAJH Study. The average length of time between questionnaire administrations was 8 months.

In the first part of the validation studies, we examined convergent validity by comparing the L-PAQ with 2 previously described and validated questionnaires measuring similar constructs: the Lifetime Total Physical Activity Questionnaire (LT-PAQ), an interviewer-administered questionnaire developed by Friedenreich et al. (9), and the Chasan-Taber Physical Activity Questionnaire (CT-PAQ), a self-administered questionnaire developed by Chasan-Taber et al. (4). Similar to the L-PAQ, the LT-PAQ was designed to assess the lifetime amount and level of physical activity across recreational, occupational, and household domains. Friedenreich et al. reported high reliability of the LT-PAQ, with Pearson correlation coefficients ranging from 0.72 (sports) to 0.87 (occupation) (9). The CT-PAQ assesses the duration, frequency, and intensity of lifetime physical activity across sports and household activities and was shown to be highly reliable, with intraclass correlation coefficients (ICCs) of 0.82, 0.87, and 0.78 for total activity, sports, and household activity, respectively (4). Administration of the LT-PAQ for our validation studies involved face-to-face interviews with subjects in the subcohort. Prior to each LT-PAQ interview, subjects completed a life events calendar, a memory aid for improving recall (9). A single investigator conducted all LT-PAQ interviews. At the end of the LT-PAQ interviews, consenting subjects completed the CT-PAQ.

The second part of the validity studies involved testing of hypotheses based on responses to the baseline administration of the L-PAQ in the PAJH cohort. We tested the following hypotheses based on previously reported relations between physical activity and sociodemographic variables: 1) males have higher participation in sports/recreational activity than females (10); 2) males have higher participation in occupational activity than females (10); 3) females have higher participation in household activity than males (10); and 4) subjects with lower levels of education have lower participation in sports/recreational activity than those with higher levels of education (11–13).

Analyses

Lifetime physical activity scores were calculated for the L-PAQ for each domain of physical activity and for total physical activity. Following initial calculations, we applied decisions in the scoring process to correct data errors prior to validity and reliability analyses. Specifically, several subjects mistakenly overreported the number of hours per week (>168 hours/week) spent performing physical activity, most commonly involving the child-care item in the household domain. When this occurred, we applied a ceiling of 126 hours/week. This was chosen as a conservative estimate based on several justifications. First, it allowed for minimal self-care and sleep. Second, during the face-to-face interviews, subjects reported up to 18 hours/day for 7 days/week (126 hours/week) of physically active child care, with reports remaining consistent despite use of probing interview techniques. Finally, social science literature was reviewed for reports or descriptions of time spent by women in domestic activity (14, 15). On the basis of these factors, we rationalized that 126 hours/week would be an appropriate ceiling to apply. Notably, the problem of overreporting of hours/week did not occur in any of the other physical activity domains.

Scores for the LT-PAQ (9) and the CT-PAQ (4) were calculated according to previously described algorithms for the respective questionnaires. For calculation of CT-PAQ scores, we excluded walking, since Chasan-Taber et al. reported lack of reliability for this item (4). To assess reliability, we calculated ICCs and 95% confidence intervals based on 2-way fixed-effects analysis-of-variance models (16) for the correlation between the baseline L-PAQ and the retest L-PAQ. We used nonparametric statistics to assess validity, since scores for all 3 questionnaires had nonnormal distributions; we used Spearman correlation coefficients to determine the correlations between the L-PAQ and the LT-PAQ, as well as between the L-PAQ and the CT-PAQ, across similar domains and total physical activity. For hypothesis tests, we also used nonparametric tests (the Wilcoxon and Kruskall-Wallis tests) to evaluate relations between sociodemographic factors and L-PAQ activity scores. For all hypothesis tests, the significance level was set at $P = 0.05$, and all tests were 2-sided. All analyses were conducted using SPSS, version 12 (SPSS, Inc., Chicago, Illinois).

Table 1. Baseline Characteristics of Participants in Validation Studies of the Lifetime Physical Activity Questionnaire, Physical Activity and Joint Health Study, Canada, 2005–2006

Characteristic	All PAJH Study Subjects (n = 4,244)		Validation Subcohort[a] (n = 88)	
	Mean (SD)	%	Mean (SD)	%
Age, years	61.5 (7.6)		64.0 (7.6)	
Height, inches[b]	67.4 (5.0)		67.9 (3.6)	
Body weight, pounds[b]	177.3 (39.5)		173.8 (33.1)	
Male gender		37		49
Marital status				
Married/common-law		58.0		59.9
Widowed/separated/divorced		33.0		26.9
Single		4.7		9.1
Missing data		4.3		4.1
Ethnic origin				
White		93.6		91.0
Other		6.3		9.0
Level of education				
College/university/postgraduate study		47.7		51.1
Elementary/high school		33.8		29.5
Technical or trade school		17.4		18.2
Missing data		1.1		1.2
Total annual household income, Can$				
≤19,999		8.5		5.7
20,000–39,999		24.8		34.3
40,000–59,999		24.4		25.7
60,000–79,999		18.1		15.7
80,000–99,999		10.6		7.1
≥100,000		11.8		11.4
Missing data		1.8		0.1

Abbreviations: PAJH, Physical Activity and Joint Health; SD, standard deviation.
[a] Subjects in the subcohort are included in the data for all PAJH Study subjects.
[b] 1 inch = 2.54 cm; 1 pound = 0.45 kg.

RESULTS

A total of 4,269 persons across Canada completed the baseline PAJH survey. Of these, 4,244 had complete L-PAQ data and were included in the validation studies. The baseline characteristics of the validation study subjects are shown in Table 1. Data for validation study subjects are shown as all PAJH Study subjects ($n = 4,244$) and subjects in the subcohort ($n = 88$). Overall, subjects in the validation studies had a mean age of 61.5 years and were predominantly Caucasian. When we compared the subcohort with the rest of the PAJH subjects ($n = 4,156$), subcohort subjects were older and had a more equal gender distribution, but they did not differ in terms of physical characteristics or demographic variables, including marital status, ethnic origin, highest level of education, and total household income.

Table 2 shows lifetime physical activity scores for all PAJH Study subjects for each activity domain and for total activity. Mean and median lifetime average hours/week of total activity for all subjects were 46.5 and 41.1, respectively.

Reliability

The retest version of the L-PAQ was completed by 76 subjects (39 men and 37 women) in the validation subcohort. The highest reliability coefficients were obtained for sports/recreation activity, with ICCs of 0.89 for lifetime average hours/week and 0.88 for lifetime average MET-hours/week (Table 3). The lowest reliability coefficients were obtained for household activity, with ICCs of 0.67 for both lifetime average hours/week and lifetime average MET-hours/week. Additional analyses of gender-specific reliability for total physical activity yielded ICCs of 0.85 (95% confidence interval (CI): 0.71, 0.92) and 0.51 (95% CI: 0.15, 0.75) in men and women, respectively, for lifetime average hours/week and 0.92 (95% CI: 0.85, 0.96) and 0.62 (95% CI: 0.26, 0.80), respectively, for lifetime average MET-hours/week.

Table 2. Mean and Median Lifetime Average Hours per Week and Lifetime Average Metabolic Equivalent Hours per Week Spent by Cohort Study Subjects in Various Physical Activity Domains (n = 4,244), Physical Activity and Joint Health Study, Canada, 2005–2006

Physical Activity Domain	Mean (SD)	Median
Lifetime average hours/week		
Sports/recreation	3.1 (5.2)	1.6
Occupation	21.3 (11.4)	22.0
Household	21.9 (23.1)	14.0
Total physical activity	46.5 (25.2)	41.1
Lifetime average MET-hours/week[a]		
Sports/recreation	18.3 (31.9)	8.8
Occupation	60.1 (78.5)	38.1
Household	66.6 (69.1)	44.1
Total physical activity	146.6 (111.6)	118.3

Abbreviations: MET, metabolic equivalent; SD, standard deviation.
[a] One MET represents the metabolic rate of a resting individual and is set at 3.5 mL of oxygen consumed per kilogram of body mass per minute (7).

Validity

Face-to-face LT-PAQ interviews were completed with 84 subjects (42 men and 42 women) in the subcohort. In the comparison of the L-PAQ and the LT-PAQ, the highest correlations were obtained for household activity (0.71 for both lifetime average hours/week and lifetime average MET-hours/week), and the lowest correlations were obtained for total physical activity (0.41 and 0.37 for lifetime average hours/week and lifetime average MET-hours/week, respectively) (Table 4). In additional analyses according to gender, correlation coefficients for total activity were higher for men (lifetime average hours/week, 0.50; lifetime average MET-hours/week, 0.55) than for women (lifetime average hours/week, 0.40; lifetime average MET-hours/week, 0.37).

The CT-PAQ was completed by 80 subjects (39 men and 41 women) in the subcohort. When the L-PAQ was compared with the CT-PAQ, the highest correlations were obtained for sports/recreation, and this was consistent for both lifetime average hours/week and lifetime average MET-hours/week (0.58 and 0.61, respectively). Intermediate correlations were seen for household activity (Table 4). Finally, correlations for total physical activity were higher for men (lifetime average hours/week, 0.51; lifetime average MET-hours/week, 0.52) than for women (lifetime average hours/week, 0.43; lifetime average MET-hours/week, 0.43).

In the second part of the validity studies, we confirmed a priori hypotheses regarding sociodemographic factors and lifetime physical activity (Table 5). First, we confirmed that males had greater lifetime sports/recreational and occupational activity than females and that females had greater lifetime household activity than males. We found an increasing trend in amount (lifetime average hours/week) and intensity (lifetime average MET-hours/week) of sports/recreational activity with increasing level of education. Finally, we found a negative relation between higher levels of education and intensity of occupational activity among males. Specifically, men with an elementary school education had the highest intensity of occupational activity (130.4 lifetime average MET-hours/week), and men with college/university and postgraduate levels of education had the lowest intensity of occupational activity, with lifetime average MET-hours/week of 60.1 and 53.0, respectively.

DISCUSSION

In this reliability and validity study of the L-PAQ, an Internet-based instrument measuring 3 domains of lifetime physical activity, reliability was acceptable overall and

Table 3. Intraclass Correlation Coefficients for the Reliability of the Lifetime Physical Activity Questionnaire, Physical Activity and Joint Health Study, Canada, 2005–2006

Physical Activity Domain	Baseline L-PAQ (n = 76)		Retest L-PAQ (n = 76)		Intraclass Correlation Coefficient	95% Confidence Interval
	Mean (SD)	Median	Mean (SD)	Median		
Lifetime average hours/week						
Sports/recreation	2.7 (3.6)	1.5	2.4 (3.0)	1.1	0.89	0.84, 0.94
Occupation	23.2 (12.4)	22.6	21.1 (8.7)	21.8	0.84	0.75, 0.89
Household	19.2 (22.6)	10.3	17.0 (16.8)	9.0	0.67	0.49, 0.79
Total physical activity	45.2 (25.5)	39.8	40.5 (17.7)	38.2	0.73	0.57, 0.83
Lifetime average MET-hours/week[a]						
Sports/recreation	15.2 (19.2)	8.6	13.9 (18.0)	7.3	0.88	0.81, 0.92
Occupation	56.2 (114.4)	35.4	48.1 (54.6)	36.2	0.77	0.64, 0.86
Household	59.1 (70.7)	33.9	51.0 (49.5)	28.2	0.67	0.48, 0.79
Total physical activity	130.6 (143.4)	89.7	113.0 (81.2)	92.1	0.72	0.56, 0.82

Abbreviations: L-PAQ, Lifetime Physical Activity Questionnaire; MET, metabolic equivalent; SD, standard deviation.
[a] One MET represents the metabolic rate of a resting individual and is set at 3.5 mL of oxygen consumed per kilogram of body mass per minute (7).

Table 4. Spearman Correlation Coefficients for the Convergent Validity of the Lifetime Physical Activity Questionnaire With the Lifetime Total Physical Activity Questionnaire and the Chasan-Taber Physical Activity Questionnaire, Physical Activity and Joint Health Study, Canada, 2005–2006

Physical Activity Domain	L-PAQ (n = 84)		LT-PAQ (n = 84)		Spearman Correlation Coefficient
	Mean (SD)	Median	Mean (SD)	Median	
Lifetime average hours/week					
Sports/recreation	2.7 (3.5)	1.5	4.2 (3.7)	3.2	0.52
Occupation	22.5 (12.3)	22.3	23.0 (7.7)	23.1	0.55
Household	19.3 (22.4)	10.3	12.9 (9.0)	10.7	0.71
Total physical activity	44.5 (24.5)	39.7	40.1 (9.3)	40.4	0.41
Lifetime average MET-hours/week[a]					
Sports/recreation	14.8 (18.6)	8.6	21.1 (24.2)	14.6	0.60
Occupation	53.3 (109.9)	34.6	52.7 (27.1)	49.1	0.50
Household	59.8 (70.4)	33.0	38.5 (27.4)	31.2	0.71
Total physical activity	127.8 (138.1)	89.5	112.3 (40.5)	108.3	0.37
	L-PAQ (n = 80)		CT-PAQ (n = 80)		
	Mean (SD)	Median	Mean (SD)	Median	
Lifetime average hours/week					
Sports/recreation	3.4 (4.2)	1.9	3.2 (3.6)	2.1	0.58
Household	20.5 (27.3)	10.2	11.8 (15.0)	5.9	0.56
Total physical activity	23.9 (27.5)	12.4	15.0 (15.7)	9.3	0.50
Lifetime average MET-hours/week					
Sports/recreation	13.5 (16.5)	8.5	18.8 (21.5)	11.9	0.61
Household	63.4 (85.1)	31.4	34.9 (44.2)	18.3	0.57
Total physical activity	76.9 (85.3)	49.4	53.7 (50.1)	38.7	0.49

Abbreviations: CT-PAQ, Chasan-Taber Physical Activity Questionnaire; L-PAQ, Lifetime Physical Activity Questionnaire; LT-PAQ, Lifetime Total Physical Activity Questionnaire; MET, metabolic equivalent; SD, standard deviation.

[a] One MET represents the metabolic rate of a resting individual and is set at 3.5 mL of oxygen consumed per kilogram of body mass per minute (7).

tended to be higher for sports/recreational and occupational activity than for household activity. Based on comparisons with 2 previously validated instruments, the L-PAQ showed good convergent validity for household activity and moderate convergent validity for sports/recreational and occupational activity. The construct validity of the L-PAQ was supported by confirmation of hypotheses on the relation between sociodemographic factors and lifetime physical activity.

L-PAQ reliability, measured using ICCs which ranged from 0.65 to 0.89, was comparable to the previously reported reliability of similar lifetime physical activity questionnaires, including the CT-PAQ (4) and the LT-PAQ (9). For example, the highest reliability coefficients were seen for sports/recreation, consistent with reliability studies of the CT-PAQ (4). In their report of CT-PAQ reliability, Chasan-Taber et al. reasoned that sports and recreational activities may be more memorable and more easily recalled, given that they may require greater planning or effort to engage in (4). We also found good reliability coefficients for occupational activity. For most people, working life is constant and comprises a significant span of time; this may facilitate recall of occupational activities (9).

The average time span between administrations of the L-PAQ was 8 months (range, 2–8)—a longer interval than in previous retest studies of other questionnaires measuring lifetime physical activity, which ranged from 1 week to 8 weeks (3, 4, 9). The extended washout period in the L-PAQ reliability study would have minimized bias by reducing any tendency of respondents to recall previous responses, though one concern with this length of interval is any potential change in the construct being measured (17). However, since the measurement of interest covered the subject's lifetime, it unlikely that there was a significant change that would have influenced lifetime activity patterns over an 8-month period.

Evaluating the validity of questionnaires measuring lifetime physical activity exposure has been recognized as a challenge by previous researchers (4, 6, 9). Since a gold standard for measuring lifetime physical activity is not available to compare with the L-PAQ, the approach taken was to apply principles of construct validation, a process that usually involves a series of studies which strengthen the nomologic network of interlocking beliefs about the construct measured by the instrument (18).

Table 5. Hypotheses Tests of Sociodemographic Factors and Lifetime Physical Activity Constructs Measured by Means of the Lifetime Physical Activity Questionnaire, Physical Activity and Joint Health Study, Canada, 2005–2006

Hypothesis	Lifetime Average Median Hours/Week			Lifetime Average Median MET-Hours/Week[a]		
	Sports/Recreation	Occupation	Household	Sports/Recreation	Occupation	Household
Lifetime sports/recreation, occupation, and household activity and gender						
Gender						
Male ($n = 1,571$)	2.8	25.5	5.9	15.8	48.3	19.3
Female ($n = 2,673$)	1.0	19.2	22.7	5.8	32.1	69.4
P value (Wilcoxon test)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Lifetime sports/recreation activity and educational level						
Level of education						
Elementary ($n = 197$)	0.7			3.4		
High school ($n = 1,230$)	1.3			6.9		
Trade/technical school ($n = 742$)	1.6			8.7		
College/university ($n = 1,468$)	1.7			9.6		
Postgraduate studies ($n = 559$)	2.3			13.2		
P value (Kruskall-Wallis test)	<0.001			<0.001		
Intensity of lifetime occupational activity and educational level in males						
Level of education						
Elementary ($n = 85$)					130.4	
High school ($n = 403$)					81.7	
Trade/technical school ($n = 325$)					98.5	
College/university ($n = 454$)					60.1	
Postgraduate studies ($n = 291$)					53.0	
P value (Kruskall-Wallis test)					<0.001	

Abbreviation: MET, metabolic equivalent.

[a] One MET represents the metabolic rate of a resting individual and is set at 3.5 mL of oxygen consumed per kilogram of body mass per minute (7).

In an instrument with demonstrated reliability, it is accepted that correlations among measures of the same construct should fall into the middle range of 0.40–0.80 (17). Results of this validity study comparing the L-PAQ with questionnaires measuring similar constructs provide support for the validity of the instrument. We found moderate correlations between the L-PAQ and the LT-PAQ and between the L-PAQ and the CT-PAQ, with correlation coefficients ranging from 0.49 to 0.71. Previous validation studies of lifetime physical activity instruments in comparison with subjective measures have yielded similar results. For example, the Historical Physical Activity Questionnaire was correlated with 4 administrations of a past-year physical activity questionnaire over a 17-year period, and Pearson correlation coefficients ranged from 0.39 to 0.62 (3).

Of particular interest was the convergent validity of the L-PAQ with the LT-PAQ, since both questionnaires measure lifetime physical activity across 3 similar domains. The questionnaires correlated well for household activity. It is possible that consistent measurement of this domain across questionnaires may have been facilitated by both the nature of household activities, which are usually done routinely over long periods of time, and the similar definitions of household activity (child care, elderly care, housework, and gardening) used in both questionnaires. Moderate correlations were observed for sports/recreation and occupational activity. Notably, while median lifetime average hours/week of household and occupational activity were comparable in both questionnaires, measurement of lifetime sports/recreational activity was lower in the L-PAQ than in the LT-PAQ (i.e., 1.5 lifetime average hours/week in the L-PAQ vs. 3.2 lifetime average hours/week in the LT-PAQ). Questionnaire design may have been a factor in these results. Specifically, the L-PAQ quantifies duration of sports/recreation participation by asking respondents to indicate their overall duration of participation (by providing the ages at which they started and stopped participation), limiting the ability of respondents to report intermittent sports participation. Capture of such information was possible with the interviewer-administered format of the LT-PAQ.

Results of hypothesis tests provide further evidence for the construct validity of the L-PAQ. We confirmed hypotheses that women accrue more physical activity exposure from household activity and less from sports/recreational

and occupational activity than males. Gender-related differences in lifetime physical activity patterns are supported in the literature; specifically, women have higher levels of household activity than men, and household activity is the major contributor to weekly energy expenditure for women (10, 19). In addition, we found that males with lower educational levels had greater physical activity from work (and less from sports/recreation), while those with the highest education had less physical activity from work and more from sports/recreation. This was a hypothesized finding and contributes to the construct validity of the L-PAQ. Previous investigators found a similar relation using *current* levels of occupational activity (11). We extended these data to lifetime physical activity levels.

Interpretation of data using self-report physical activity measures requires caution and is limited to characterizing large groups of people rather than individuals because of large within-person variability and problems with recall (1, 20–22). Despite these limitations, it has been repeatedly shown that physical activity questionnaires are both practical and valid when used appropriately for large-scale epidemiologic studies (1, 22–26). Previous authors have demonstrated the reliability of recall of physical activity, including Slattery and Jacobs (27), who reported that people can recall past activity levels when asked about their physical activity 3–4 years previously; Blair et al. (28), who similarly reported reliability of long-term recall of physical activity up to 10 years previously; and Falkner et al. (29), who reported acceptable levels of reliability of recall of physical activity in the distant past (30 years). In a review focused on the limitations of physical activity questionnaires, Shephard (1) concluded that while detailed interpretation and attempts to estimate precise dosage are inadvisable, use of data to monitor change in population activity and provide categorical estimates is valuable. If the questionnaire is adequately designed for a particular population and has acceptable reliability and validity, the instrument should be able to rank-order adults by category of activity level and by sociodemographic group, thus providing a *relative* distribution of historical physical activity (3).

Several strengths of the L-PAQ and the validation studies deserve comment. Adapted from previously reported instruments (2, 9, 10), the L-PAQ captured detailed information on 3 primary domains of physical activity and specifically utilized an extensive, open-ended list of sports/recreational activities, plus an open-ended format for occupation that permitted respondents to report the specific activities in which they regularly engaged. The Internet-based administration of the questionnaire permitted use of skip logic, which allowed subjects to follow individualized paths through the survey, skipping irrelevant questions. This maximized efficiency, minimized respondent burden, eliminated missing data, and allowed subject control of time management during data collection. Prior to this validation study, we undertook extensive pretesting and pilot-testing of the questionnaire to ensure that respondents could easily navigate the Internet-based user interface, understand questionnaire items, retrieve information appropriately, and make appropriate estimations. Our large primary data set from the parent cohort study and our validity subcohort both revealed a wide distribution of age, weight, lifetime physical activity, and sociodemographic variables. Additionally, conducting L-PAQ reliability and validity studies using subjects from the PAJH cohort study ensured applicability and relevance of the measure to the target study population.

Limitations of the L-PAQ and the validation studies also deserve discussion. The L-PAQ does not capture data on activity in different life periods, and assessment of physical activity was based on the total sum of activity over the respondent's lifetime. While it offered many of the aforementioned advantages, administration of a questionnaire over the Internet also has limitations—including the fact that subjects who are reached by this method of recruitment are probably those who have Internet access and are familiar with computers, and thus represent persons with higher socioeconomic status and educational levels (30, 31). Moreover, recruitment for the PAJH Study via the Internet may be vulnerable to a recognized problem with Internet surveys: Response rates are difficult to calculate, since only information on respondents is known, and it is unknown how many persons may have actually accessed the survey but declined participation (32). Nonetheless, the approximated response rate of 3.3% (the number of PAJH respondents divided by the number of Canadian Association of Retired Persons members recruited) for the PAJH Study is typical of lower response rates for Internet surveys (33). We were not able to analyze the criterion validity of the L-PAQ because we lacked an objective comparator measure of lifetime physical activity. However, such a study would be cumbersome, expensive, and possibly unrealistic because it would involve outfitting subjects with an objective measure of choice, such as an activity monitor, and prospectively following them over an extended time frame. Given potential costs and subject burden, such a study was not feasible in this setting, especially since recruitment for the PAJH cohort was conducted nationwide using the Internet. Finally, a small number of subjects overestimated the amount of time spent in household activities, particularly child care. It is possible that these respondents misinterpreted the items on child care to mean *anytime* they were caring for children, irrespective of whether they were physically active or not. To address this, we carefully inspected the raw data and employed a data cleaning procedure that set a ceiling for time spent in household activity. Application of this conservative ceiling was based on experiences during the face-to-face interviews and review of social science literature.

In conclusion, the L-PAQ is a useful instrument for assessing multiple domains of physical activity over a long time period with acceptable reliability and validity. It is comparable to other physical activity instruments that are used in large epidemiologic studies.

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