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The Stanford Leisure-Time Activity Categorical Item (L-Cat): A single categorical item sensitive to physical activity changes in overweight/obese women

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Abstract

Background—Physical activity is essential for chronic disease prevention, yet <40% of overweight/obese adults meet national activity recommendations. For time-efficient counseling, clinicians need a brief easy-to-use tool that reliably and validly assesses a full range of activity levels, and most importantly, is sensitive to clinically meaningful changes in activity. The Stanford Leisure-Time Activity Categorical Item (L-Cat) is a single item comprised of six descriptive categories ranging from inactive to very active. This novel methodological approach assesses national activity recommendations as well as multiple clinically relevant categories below and above recommendations, and incorporates critical methodological principles that enhance psychometrics (reliability, validity, sensitivity to change).

Methods—We evaluated the L-Cat's psychometrics among 267 overweight/obese women asked to meet national activity recommendations in a randomized behavioral weight-loss trial.

Results—The L-Cat had excellent test-retest reliability ($\kappa=0.64$, $P<.001$) and adequate concurrent criterion validity; each L-Cat category at 6 months was associated with 1059 more daily pedometer steps (95% CI 712–1407, $\beta=0.38$, $P<.001$) and 1.9% greater initial weight loss at 6 months (95% CI –2.4 to –1.3, $\beta=-0.38$, $P<.001$). Of interest, L-Cat categories differentiated from each other in a dose-response gradient for steps and weight loss ($P_s<.05$) with excellent face validity. The L-Cat was sensitive to change in response to the trial's activity component. Women increased one L-Cat category at 6 months ($M=1.0\pm1.4$, $P<.001$); 55.8% met recommendations at 6 months whereas 20.6% did at baseline ($P<.001$). Even among women not meeting recommendations at both baseline and 6 months ($n=106$), women who moved 1 L-Cat categories at 6 months lost more weight than those who did not ($M=-4.6\%$, 95% CI –6.7 to –2.5, $P<.001$).

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CONFLICT OF INTEREST

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Conclusions—Given strong psychometrics, the L-Cat has timely potential for clinical use such as tracking activity changes via electronic medical records especially among overweight/obese populations unable or unlikely to reach national recommendations.

Keywords

obesity; physical activity; assessment; psychometrics; sensitivity to change

Physical activity is essential for chronic disease prevention,¹ yet <40% of overweight/obese adults meet the 2007 American College of Sports Medicine (ACSM) and American Heart Association (AHA)'s recommendations to accrue at least moderate-intensity activity for 30 minutes five days each week.^{2–4} For time-efficient counseling, clinicians need a brief assessment tool for physical activity that reliably and accurately assesses a full range of activity levels, and most importantly, is sensitive to clinically meaningful activity changes.

Existing brief assessment tools have significant methodological limitations. A tool recently integrated into the electronic medical records of a nationwide health care system asks individuals to estimate days per week of activity and average minutes per session.⁵ Yet, this tool has no reported reliability or validity psychometrics; lack of a time frame in the question stem undermines reliability;⁶ and individuals are typically extremely inaccurate at estimating past behavioral frequency relying instead on simple cognitive heuristics (e.g., rule-based estimation).⁷ Two widely-used epidemiological tools ask for separate time estimates of moderate- and vigorous-intensity activities which are then collapsed into three categories.⁸ Yet, these require trained personnel to administer; reliability and validity are only poor to adequate for the two lower categories;⁸ and neither tool has been evaluated for sensitivity to change, unlikely to be high with only three categories. Other brief assessments rely on binary thresholds (met recommendations or not) limiting sensitivity to change below recommendations.⁹ This is problematic given the dose response for activity (dose) and health benefits (response) may be steeper for less active individuals, i.e., they receive greater health benefits for a given increase in activity than more active individuals.¹⁰

Here, we evaluated the psychometrics of a new tool—the Stanford **Leisure-Time Activity Categorical Item (L-Cat)**—a single item comprised of six descriptive categories ranging from inactive to very active. The L-Cat's novel descriptive categorical approach assesses both national activity recommendations and multiple clinically relevant categories below and above recommendations. It also incorporates critical methodological principles known to enhance psychometrics:⁶ each category (response option) has a corresponding description (response label) increasing reliability; category descriptions use easy-to-understand language about activity patterns enhancing face validity; category descriptions include concrete activity examples increasing criterion validity and reducing over-reporting; and categories assess a full range of activity levels optimizing potential for sensitivity to change.

This study evaluated the L-Cat's psychometrics among 267 overweight/obese women in a randomized behavioral weight-loss trial. Assessing clinically relevant improvements in activity among overweight/obese adults is critical and timely. Less than 40% of these adults meet the 2007 recommendations, but they comprise 69% of primary care patients who often have complicated co-morbid conditions and higher health costs.^{1, 11, 12}

METHODS

Participants and procedures

Data are from a randomized behavioral weight-loss trial collected February 2008-May 2011 and fully described elsewhere (e.g., the CONSORT flow diagram).¹³ Women ($N=267$) who completed an online screening questionnaire, were 21 years, had a BMI 27–40 kg/m², free of chronic health conditions, and participate in physical activity were randomized to one of two 6-month weight-loss interventions. Each week, women met in group sessions and set behavioral goals (daily personalized calorie targets to produce weight loss of ½-1 lb per week and daily pedometer step goals to accrue at least moderate-intensity activity for 30 minutes five days per week primarily via brisk walking). Women completed online questionnaires and clinic visits at the research center at baseline and 6 months. Retention was excellent (95% returned for the 6-month visit).¹³ The trial was approved by the Stanford University Institutional Review Board. Participants provided written informed consent.

Measures

Demographics—These were collected at screening and baseline.¹³

Stanford Leisure-Time Activity Categorical Item (L-Cat)—The L-Cat is self-administered and comprised of six activity categories. Each category consists of 1–2 sentences describing common activity patterns differing in frequency, intensity, duration, and types of activities, thus encompassing content validity.⁹ Respondents pick the category best describing their activity during the past month. The L-Cat was collected at baseline and 6 months. It was also collected at screening (2–6 weeks before baseline) for the second half of the sample ($n=131$).

The L-Cat was informed by a tool from the 1970s which had promising criterion validity among less-educated older adults (only 23% were college educated).¹⁴ To maximize the L-Cat's clinical relevance, we added a moderate-intensity activity category that explicitly referenced the 2007 recommendations, clearly distinguished between inactive and light-intensity categories given differential health benefits, and shortened the time frame to one month.

The six L-Cat categories broadly correspond to both recently proposed and established consensus definitions distinguishing among intensity levels based on metabolic equivalents (METs).^{1, 15} The L-Cat includes one inactive category (~1.0–1.5 METs), one light-intensity (~1.6–2.9 METs), two moderate-intensity (~3.0–5.9 METs), and two vigorous-intensity categories (~ 6.0 METs). The two moderate-intensity categories differ in frequency (3 versus 5 times/week), likewise for the two vigorous-intensity categories. The first three categories (inactive, light, moderate activity 3 times/week) assess levels below the 2007 ACSM/AHA recommendations, the middle category (moderate activity 5 times/wk for 30 minutes a time) is consistent with 2007 recommendations and the top two categories (vigorous activity 3 times/week or 5 times/week for 30 minutes a time) assess levels above recommendations (see Table 1).

Each L-Cat category includes examples of activities that correspond to the intensity level for that category based on the MET values for these activities listed in the 2011 Compendium of Physical Activities.¹⁶ For instance, the moderate-intensity categories (~3.0–5.9 METs) include examples such as ‘brisk walking’ consistent with Compendium activities such as ‘walking for transportation’ (3.5 METs). For a few activities, the MET value does not match the L-Cat category’s intensity level. MET values for Compendium activities are increasingly derived from laboratory studies using prescribed activities (e.g., vacuuming a 9-square meter section for 7 minutes).¹⁷ However, in everyday situations, some higher-intensity activities are likely to be interspersed with lower-intensity activities. For instance, the L-Cat light-intensity category includes ‘sweeping floors’ (3.8 METs), a moderate-intensity activity likely interspersed with ‘dusting’ (2.3 METs), a light-intensity activity.

Pedometer steps—During the 6-month interventions, women wore Omron dual axial pedometers (Model HJ-720ITC) daily during waking hours except when showering or swimming, and recorded steps per day and mean steps each week. To match the L-Cat’s 1-month time frame, pedometer data from the last four weeks of the 6-month interventions were used. In recent validation studies, a minimum of three days of activity monitoring sufficiently estimated habitual physical activity over three weeks.^{18, 19} Here, 79.8% (n=213/267) met the three-day minimum over the last four weeks and monitored 6.2 ± 1.2 days per week. Likewise, the minimum number of weeks to sufficiently capture individual variation in pedometer steps from week to week at an intra-class correlation (ICC) standard of 0.80 can be calculated using the Spearman-Brown prophecy formula.^{19, 20} Here, the ICC was 0.84 (i.e., inter-individual variability was the largest source of variation), the minimum number of weeks was 1, and women monitored 3.3 ± 0.9 weeks.

Weight loss—Using standardized protocols and staff blind to condition,¹³ body weight was measured on a standard beam balance scale with participants in light clothing and without shoes and height was measured using a stadiometer at baseline and 6-month clinic visits.

Statistical analyses

Psychometrics included test-retest reliability (response to same measure 2–6 weeks apart), concurrent criterion validity (relationship with previously validated measures assessed at similar time points), and sensitivity to change (response to trial’s activity component). Concurrent criterion validity was evaluated at two time points (BMI at baseline, pedometer steps and weight loss at 6 months). There were no baseline missing data; missing 6-month weights (n=13) and online questionnaires (n=16) were imputed using the baseline carried forward approach. This study used multiple linear regression and chi-square tests to examine relationships between the L-Cat and criterion variables, the Jonckheere-Terpstra non-parametric trend test to evaluate ordered differences among categories, analysis of variance to test pair-wise comparisons between categories, and t-tests to compare those meeting recommendations and those who did not.

RESULTS

Demographics

The sample (N=267) was middle-aged (48.4 ± 10.8 years), married/living with someone (68.9%, n=184), and college educated (67.0%, n=179).¹³ A third self-designated as non-White (33.7%, n=90): Latina/Hispanic (10.5%, n=28), multiethnic (2 races/ethnicities; 10.1%, n=27), Asian (9.4%, n=25), Black/African American (3.0%, n=8), and Native Hawaiian/Pacific Islander (0.7%, n=2). Most women were obese (BMI ≥ 30 64.4%, n=172; $M=32.1 \pm 3.5$ kg/m²) and had participated in a prior weight-loss program such as Weight Watchers (67.8%, n=181). As expected, women lost $-8.8\% \pm 6.3$ of their initial weight at 6 months with no intervention differences ($P=.52$).¹³

Psychometrics

Descriptive data for psychometric variables by L-Cat category are in Figures 1A–1F.

Test-retest reliability—Test-retest reliability was excellent (Spearman's $r=0.80$; $P<.001$) with substantial strength of agreement (weighted $\kappa=0.64$; 95% CI, 0.54–0.73; $P<.001$).²¹ Women did not change categories between screening and baseline ($M=0.0 \pm 0.8$; $P=.83$).

Concurrent criterion validity with BMI at baseline—The L-Cat at baseline had clinically relevant concurrent criterion validity with BMI at baseline (Figure 1A). An increase in L-Cat category was associated with a lower BMI at baseline of ~ 0.5 BMI unit ($B=-0.4$; 95% CI, -0.8 to -0.1 ; $\beta=-0.14$; $P=.02$) with a range of ~ 2 BMI from lowest to highest categories. The non-parametric trend was not significant ($P=.09$). However, women who met recommendations at baseline were ~ 1 BMI unit lower than those not meeting recommendations ($M=1.3$; 95% CI, 0.3–2.3; $P=.01$).

Concurrent criterion validity with pedometer steps at 6 months—The L-Cat at 6 months had adequate concurrent criterion validity with mean daily pedometer steps at 6 months (Figure 1B). An increase in one L-Cat category was associated with 1059 more steps (95% CI 712–1407; $\beta=0.38$; $P<.001$). The non-parametric trend was significant ($P<.001$). In a post-hoc analysis, the L-Cat at 6 months differed on mean steps at 6 months in a dose-response gradient among almost all pair-wise comparisons of L-Cat categories ($P_s<.05$). The inactive category was not included in this analysis due to small sample size (n=2). Of clinical relevance, women who reported light activity 1–2 times/wk had fewer steps than all other more active categories ($P_s<.02$); women who reported moderate activity ≥ 5 times/wk had more steps than women who reported moderate activity 3 times/wk and fewer steps than women reported vigorous activity ≥ 5 times/wk ($P_s<.003$); and women who reported vigorous activity ≥ 5 times/wk had more steps than women in all other categories ($P_s<.003$). The expected exceptions were for women who reported vigorous activity 3 times/wk who had no more pedometer steps than women who reported 3 times/wk of moderate activity ($P=.58$) or than women who reported ≥ 5 times/wk of moderate activity ($P=.07$). Women who met recommendations at 6 months had ~ 2400 more steps than those not meeting recommendations ($M=2371$; 95% CI 1549–3193; $P<.001$).

Concurrent criterion validity with weight loss at 6 months—The L-Cat at 6 months had adequate concurrent criterion validity with percent of initial weight lost at 6 months (Figure 1C). An increase of one L-Cat category at 6 months was associated with an increase in the percent of initial weight lost at 6 months of -1.9% (95% CI -2.4 to -1.3 ; $\beta = -0.38$; $P < .001$). The non-parametric trend was significant ($P < .001$). In a post-hoc analysis, the L-Cat at 6 months differed on percent of initial weight lost at 6 months in a dose response gradient among many pair-wise comparisons of L-Cat categories ($P_s < .05$). Of clinical relevance, women in the two least active categories lost little weight and did not differ from one another ($P = .41$). Women who reported moderate activity 3 times/wk, moderate activity 5 times/wk, or vigorous activity 3 times/wk did not differ from one another ($P_s > .08$) but lost much more weight than the two least active categories ($P_s < .02$). Women who reported vigorous 5 times/wk lost more weight than all other categories ($P_s < .05$) except for women who did vigorous 3 times/wk ($P = .09$). Adjusting for BMI at baseline did not affect pair-wise comparisons ($P = .92$). Women who met recommendations at 6 months lost more weight at 6 months than those who did not meet recommendations ($M = -4.0\%$; 95% CI -5.5 to -2.6 ; $P < .001$).

Concurrent criterion validity with established clinical standards—Percentages of women who achieved 5% and 10% loss of initial weight at 6 months differed by L-Cat category at 6 months ($P_s < .001$) (Figure 1D). The non-parametric trend was significant for 5% and 10%, respectively ($P_s < .001$). Women who met recommendations at 6 months were more likely to lose 5% than those not meeting them (83.2% vs 58.5%; $P < .001$), likewise for 10% loss (55.7% vs. 28.8%; $P < .001$).

Sensitivity to change at 6 months—The L-Cat was sensitive to change in response to the trial's activity component. Women increased one category from baseline to 6 months ($M = 1.0 \pm 1.4$; $P < .001$). Over half (55.8%) met recommendations at 6 months whereas only 20.6% did at baseline ($P < .001$) (Figure 1E). Among at-risk women who did not meet recommendations at both baseline and 6 months ($n = 106$), those who increased 1 L-Cat categories from baseline to 6 months lost more weight than those who stayed the same or decreased categories ($M = -4.6\%$, 95% CI -6.7 to -2.5 ; $P < .001$) (Figure 1F).

DISCUSSION

The L-Cat—a single item comprised of six descriptive categories ranging from inactive to very active—had strong psychometrics among overweight/obese women in a randomized weight-loss trial. The L-Cat had excellent test-retest reliability, excellent face validity given the number of daily pedometer steps reported for each category, and adequate concurrent criterion validity given each category increment at 6 months was associated with ~1000 more steps and ~2% greater weight loss at 6 months. Of particular interest, the L-Cat categories differentiated from each other in a dose-response gradient for both steps and weight loss, and it was sensitive to change in response to the trial's activity component, which is rarely evaluated.

The L-Cat has compelling clinical implications. First, it could be included in electronic medical records consistent with the recent ACSM and American Medical Association's

‘Exercise is Medicine’ initiative and other innovative efforts promoting regular assessment of physical activity as a ‘vital sign’.^{5, 22–24} Second, the L-Cat could assess activity improvements among vulnerable clinical populations who are unable or unlikely to reach national recommendations. Third, the L-Cat may be valuable for activity counseling given the clear behavioral targets at each activity level. All patients could benefit, consistent with the ‘health at every size’ paradigm.^{2, 25} Counter to stereotype, some overweight/obese patients are already active and most normal-weight patients need to be more active—percentages meeting 2007 recommendations differ by <8% across weight categories.⁴

Given the L-Cat’s promising psychometrics, we recommend minor edits: refine the question stem to include any time not spent working at a job, add descriptive words to clarify activity intensity, replace a few out-of-date activities with culturally relevant ones, and simplify some wording (see Table 1). Future research can examine the L-Cat’s psychometrics in laboratory and field settings for activities other than brisk walking (e.g., elliptical training), determine whether the shape of the gradient across activity categories differs by health outcomes (especially moderate activity 5 times/wk and vigorous activity 3 times/wk), and evaluate data collection via digital devices.

The overweight/obese sample of women was similar to many primary care populations.¹¹ Future psychometric research should include men, ethnic minorities, and low-literate populations. In summary, the L-Cat—comprised of six descriptive categories ranging from inactive to very active assessing multiple clinically relevant patterns—had strong psychometrics, including sensitivity to change, underscoring timely potential for clinical use.

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Figure 1A. Mean BMI at baseline by L-Cat at baseline (n=267).

Women who met recommendations at baseline had a lower BMI at baseline than women who did not meet recommendations ($P=.01$).

Figure 1B. Mean daily pedometer steps at 6 months by L-Cat at 6 months (n=213).

(P for trend<.001). All pairwise comparisons (P s<.05) except Vig 3X/wk vs. Mod 3X/wk and Vig 3X/wk vs. Mod ≥5X/wk (Inactive category not included in pairwise analysis given $n<5$). Women who met recommendations at 6 months had more steps at 6 months than those not meeting recommendations ($P<.001$).

Figure 1C. Mean % of initial weight lost at 6 months by L-Cat at 6 months (n=267).

(P for trend<.001). Most pairwise comparisons (P s<.05). Mod 3X/wk, Mod ≥5X/wk, and Vig 3X/wk did not differ (P s>.08), but all categories lost more than Inactive or Light 1-2X/wk (P s<.02). Women who met recommendations at 6 months lost more weight than those not meeting them ($P<.001$).

Figure 1D. Percentage who lost 5% and 10% initial weight at 6 months by L-Cat at 6 months (n=267).

(P s for trend<.001). Women who met recommendations at 6 months were more likely to lose 5% and 10% of initial weight than those who did not meet recommendations (P s<.001).

Figure 1E. Percentage of participants at baseline and 6 months by L-Cat (n=267).

Women were more likely to meet recommendations at 6 months than at baseline ($P<.001$).

Figure 1F. Mean % of initial weight lost at 6 months by L-Cat change from baseline to 6 months (n=106).

Among women who did not meet recommendations at both baseline and 6 months (n=106), women who increased ≥1 L-Cat categories lost more weight at 6 months than those who stayed the same or decreased categories ($P<.001$).

Figure 1.
Parts A-F. Key psychometric variables by L-Cat categories

Table 1

Stanford Leisure-Time Activity Categorical Item (L-Cat)

Original Version	Recommended Version (L-Cat 2.2)
<p>During the past month, which statement best describes the kinds of physical activity you usually performed during your FREE TIME (i.e., recreational or leisure time)?</p> <ol style="list-style-type: none"> 1. I did not engage in much physical activity. I mostly did things like watching television, reading, playing cards, or playing computer games. Only occasionally, <u>no more than once or twice a month</u>, did I do anything more active such as getting outdoors for a walk or playing tennis. 2. <u>Once or twice a week</u>, I engaged in <u>light activities</u> such as getting outdoors on the weekends for a walk. Or I did some light chores around the house such as sweeping floors or vacuuming. 3. <u>About three times a week</u>, I did some <u>moderate activity</u> such as brisk walking, swimming, or riding a bike <u>for about 15–20 minutes each time</u>. Or about once a week, I did some moderately difficult chores such as raking, washing windows, or mowing the lawn for about 45–60 minutes. Or about once a week, I played sports such as doubles tennis or basketball for about 45–60 minutes. 4. <u>Almost daily, that is five or more times a week</u>, I did some <u>moderate activity</u> such as brisk walking, swimming, or riding a bike <u>for 30 minutes or more each time</u>. Or about once a week, I did some moderately difficult chores or played team sports for 2 hours or more. 5. <u>About three times a week</u>, I engaged in a regular program of physical fitness involving some kind of heavy or <u>vigorous physical activity</u> such as running or riding hard on a bicycle <u>for 30 minutes or more each time</u>. Or I did chores such as heavy gardening or played active sports such as handball or singles tennis for 60 minutes or more each time. 6. <u>Almost daily, that is five or more times a week</u>, I engaged in a regular program of physical fitness involving some kind of heavy or vigorous physical activity for 30 minutes or more each time. 	<p>During the past month, which statement best describes the kinds of physical activity you usually did? Do not include the time you spent working at a job. Please read all six statements before selecting <u>one</u>.</p> <ol style="list-style-type: none"> 1. I did not do much physical activity. I mostly did things like watching television, reading, playing cards, or playing computer games. Only occasionally, <u>no more than once or twice a month</u>, did I do anything more active such as going for a walk or playing tennis. 2. <u>Once or twice a week</u>, I did <u>light activities</u> such as getting outdoors on the weekends for an easy walk or stroll. Or once or twice a week, I did chores around the house such as sweeping floors or vacuuming. 3. <u>About three times a week</u>, I did <u>moderate activities</u> such as brisk walking, swimming, or riding a bike <u>for about 15–20 minutes each time</u>. Or about once a week, I did moderately difficult chores such as raking or mowing the lawn for about 45–60 minutes. Or about once a week, I played sports such as softball, basketball, or soccer for about 45–60 minutes. 4. <u>Almost daily, that is five or more times a week</u>, I did <u>moderate activities</u> such as brisk walking, swimming, or riding a bike <u>for 30 minutes or more each time</u>. Or about once a week, I did moderately difficult chores or played sports for 2 hours or more. 5. <u>About three times a week</u>, I did <u>vigorous activities</u> such as running or riding hard on a bike <u>for 30 minutes or more each time</u>. 6. <u>Almost daily, that is five or more times a week</u>, I did <u>vigorous activities</u> such as running or riding hard on a bike <u>for 30 minutes or more each time</u>.