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Assessing Sitting Across Contexts: Development of the Multi-Context Sitting Time Questionnaire

Geoffrey P. Whitfield,
The University of Texas School of Public Health

Kelley K. Pettee Gabriel, and
The University of Texas School of Public Health

Harold W. Kohl III
The University of Texas School of Public Health, The University of Texas at Austin

Abstract

Purpose—To describe the development and preliminary evaluation of the Multi-context Sitting Time Questionnaire (MSTQ).

Method—During development of the MSTQ, contexts and domains of sitting behavior were utilized as recall cues to improve to accuracy of sitting assessment. The terms "workday" and "non-workday" were used to disambiguate occupational and discretionary sitting. An expert panel evaluated content validity. Among 25 participants, test-retest reliability of the MSTQ items was assessed with intra-class correlation coefficients (ICCs). Convergent validity was assessed versus relative and absolute accelerometer-estimated sedentary time and activity log using Pearson (r) or Spearman (ρ) correlation coefficients where appropriate.

Results—Pilot testing revealed web-based MSTQ administration to be rapid, scalable, and inexpensive. Most items in the MSTQ demonstrated acceptable reliability (ICCs > .70). Compared to accelerometer-estimated sedentary time relative to total wear time, the MSTQ exhibited a low correlation on workdays (r = .34) and a moderately high correlation on non-workdays (r = .61).

Conclusions—The systematic development of the MSTQ resulted in several improvements over previous tools and may serve as a model for purpose-driven questionnaire design. Additional validation is needed to conclusively determine the utility of the MSTQ.

Keywords

Sedentary; Validation; Endurance Athletes; Epidemiology; Accelerometers

Interest into the health effects of sedentary behavior has recently increased. Sitting time has shown direct associations with undiagnosed diabetes mellitus, impaired glucose tolerance, obesity, systolic blood pressure, dyslipidemia, and all-cause mortality (Dunstan et al., 2004; Healy et al., 2008; Hu, Li, Colditz, Willett, & Manson, 2003; Katzmarzyk, Church, Craig, & Bouchard, 2009; Owen, Healy, Matthews, & Dunstan, 2010; Proper, Singh, van Mechelen, & Chinapaw, 2011). This body of research exists despite inconsistent terminology (e.g., sitting vs. sedentary vs. physical inactivity) and inconsistent assessment of this complex behavior. Regarding terminology, the present report follows Owen et al. (2010) who define

Correspondence should be addressed to Geoffrey P Whitfield, The University of Texas School of Public Health, Austin Regional Campus, 1616 Guadalupe St, Suite 6.300, Austin, TX 78701. Geoffrey.P.Whitfield@uth.tmc.edu.

"sedentary behaviors" as those that only involve sitting, and uses "sedentary" and "sitting" interchangeably.

Regarding assessment, self-reported sedentary behavior tools have often consisted of a single item estimating total daily sitting (Katzmarzyk et al., 2009), or time spent in a single sedentary behavior as an indicator of overall sitting (Dunstan et al., 2004; Healy et al., 2008). Sitting time in a single context and domain (e.g., the context of television [TV] watching and domain of leisure time) is an incomplete proxy for total sitting. Highlighting this problem, Clark et al. (2011) demonstrated weak, non-significant correlations between reported TV viewing and accelerometer-estimated sedentary time in a nationally-representative sample of US adults. Arguably, soliciting sitting in several contexts and domains would more accurately estimate total sitting, and could eventually allow illumination of differential health effects across sitting contexts. Presently the pool of available multi-context sitting assessment tools (Marshall, Miller, Burton, & Brown, 2010; Rosenberg et al., 2010; Salmon, Owen, Crawford, Bauman, & Sallis, 2003) needs expansion and refinement. The purpose of this research note is to describe the development of the Multi-context Sitting Time Questionnaire (MSTQ) and provide preliminary evaluation of test-retest reliability and convergent validity in a unique sample.

Method

MSTQ development

Initial development was guided by limitations in questionnaires noted above. First, contexts of sitting across the occupational, leisure-time, and transportation domains were used as cues for recall to enhance accurate reporting of total sitting time. Estimates of context- or domain-specific sitting time were considered a secondary benefit. The domestic domain was deemed to overlap with leisure-time sitting and was not included. Contexts were chosen to capture the majority of daily sitting time. In the occupational domain, contexts included working, reading, and studying to allow for clear reporting among professionals and students. In the leisure-time domain, the contexts included TV and movie watching; non-work computer and video game use; and talking, texting, and socializing. In the transportation domain included seated transportation other than bicycling. Total daily sitting time was estimated by summing across the contexts above. Further, the terms "work day" and "non-work day" were chosen to disambiguate "week day" and "weekend day" for those respondents working non-traditional schedules. Finally, respondents could select days of the week that were usual workdays.

For initial refinement, a panel of two experienced researchers and two doctoral students in physical activity epidemiology evaluated the content validity of the MSTQ. Instructions to treat the contexts as mutually exclusive were recommended to reduce over-reporting, as were items asking if responses reflected usual behavior or if mobility was reduced during the recall period. The MSTQ was kept short and converted to electronic format (www.questionpro.com) to allow for rapid assessment (five minute administration in pre-tests of kinesiology students). Demographic items were adapted from the Behavioral Risk Factor Surveillance System (http://apps.nccd.cdc.gov/BRFSSQuest/index.asp). The MSTQ is presented as an Appendix.

Participants

A convenience sample of 25 recreational runners was recruited in Austin, Texas, USA in January, 2011. The mean (standard deviation) age was 34.5 (7.7) years, 56% were female, and 44% reported any graduate school. Runners were chosen to increase the odds of ample sitting exposure. Endurance athletes tend to be educated and affluent (Van Middelkoop, Kolkman, Van Ochten, Bierma-Zeinstra, & Koes, 2008) and therefore likely employed in less physically-demanding occupations than those with less education (Proper, Cerin, Brown, & Owen, 2007).

Instruments

MSTQ Scoring—All time values were converted to minutes. For workdays and non-workdays, sitting time across contexts was summed to estimate total sitting time. Waking minutes were calculated as 1440 – (reported sleep time in minutes). Proportion of waking time spent sitting was calculated as total reported sitting divided by waking minutes.

Comparison Measures—Participants completed the Bouchard activity log, a previously validated activity assessment (Bouchard et al., 1983), during accelerometer wear. Briefly, in 15-minute blocks, participants recorded a code matching their predominant activity level. Total daily sitting was calculated as the number of blocks containing the sitting code multiplied by 15.

Participants were issued an accelerometer (ActiGraph GT1M, Pensacola, FL) on an elastic belt to wear on their right hip on a workday and non-workday. Movement was recorded in 60-second epochs, and the data were screened for wear time using the methods of Troiano et al. (2008). At least 10 hours of wear per day were required for analyses. Epochs with <100 counts were classified as sedentary (absolute sedentary time), a value found valid by Matthews et al. (2008). To account for differences in wear time among participants, estimated sedentary time was also expressed relative to wear time, calculated as sedentary minutes / wear minutes.

Protocol

After signing an informed consent, each participant twice completed the on-line MSTQ at their leisure, separated by one week. This interval was used because habitual sedentary levels were deemed unlikely to change in one week. During the intervening week, participants wore an accelerometer and completed an activity log on a workday and non-workday (chosen by the participant as reflective of habitual activity). The protocol was approved by the institutional review board of the University of Texas Health Science Center, Houston, Texas, USA.

Data Analysis

Univariate analyses and distributional tests were conducted on all variables. Workday and non-workday differences in the MSTQ were tested with paired *t*-tests or Wilcoxon sign-rank tests as appropriate; Cohen's *d* was calculated. Test-retest reliability was assessed with intra-class correlation coefficients (ICC), calculated with a two-way, mixed effects model, with between-measure variance excluded from the denominator. Conservative, single-measure ICCs were reported. Interpretation of reliability followed Baumgartner, Jackson, Mahar, and Rowe (2003): <.70, unacceptable; .70–.79, below-average acceptable; .80–.89, average acceptable; .90–1.0, above-average acceptable. As Baumgartner et al., note, no single scale adequately classifies reliability across various types of tests, and this general scale may be conservative when applied to behavior recall versus physical performance assessments (2003).

Differences in estimated sitting time between the MSTQ and other measures were tested with paired t-tests or Wilcoxon sign-rank tests, where appropriate. Convergent validity between the MSTQ and other measures was estimated with Pearson or Spearman rank order correlation coefficients, where appropriate. Statistical significance was set at $\alpha = .05$.

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Statistical Package for the Social Sciences (SPSS, IBM Corporation, Somers, NY) was used to calculate ICCs and STATA 11 (College Station, TX) was used for all other analyses.

Results

Table 1 presents mean and median reported values from the first MSTQ administration. Mean total sitting time was higher on workdays than non-workdays (659 versus 568 min, respectively, $t(24) = 2.21$, $p = .04$, $d = .40$) while reported sleeping was lower on workdays than non-workdays (430 versus 499 min, respectively, $t(24) = -6.30$, $p < .001$, $d = 1.51$).

Test-retest reliability

Four participants were excluded from reliability analyses (2 reported total sitting >1440 min, 2 reported change in behavior or injury status). Among the remaining 21, the mean test interval was 7.2 days (range: 3.0–13.9). Total sitting on workdays and non-workdays exhibited below-average acceptable reliability of .76 and .72, respectively (Table 1). Most sitting contexts exhibited similar reliability, with exceptions for workday sitting during computer/video game use (non-work) and talking/texting/socializing (.39 and .27, respectively).

Convergent validity

Valid accelerometry was collected for 21 and 16 participants on workdays and non-workdays, respectively. There were no significant differences in descriptive characteristics between those with complete versus missing accelerometry (data not shown). For workdays and non-workdays, 22 and 21 participants completed the activity log, respectively. Among estimates of sedentary time, only absolute sedentary time was skewed and required non-parametric statistical methods. Comparisons of total sitting estimates are presented in Table 2, panel A. The activity log was consistently the lowest estimate, followed by the accelerometer, then MSTQ. Differences between the MSTQ and Activity log reached statistical significance. The proportion of waking time reported as sitting in the MSTQ and the proportion of accelerometer wear minutes with counts <100 (relative sedentary time) were similar (Table 2, panel B).

Table 3 presents results of correlation analyses. The MSTQ exhibited higher correlation coefficients versus relative sedentary time than absolute sedentary time. The association between non-workday MSTQ and relative accelerometry was of moderately high strength (Pearson's r=.61, p=.01). Correlations tended to be higher for non-workdays than workdays.

Discussion

The objective of this research was to develop the MSTQ, a questionnaire to assess usual sitting behavior on workdays and non-workdays across several sitting contexts and domains, and provide preliminary estimates of reliability and validity. A systematic approach was followed for MSTQ development. First, weaknesses of current assessment tools were identified, followed by collaborative development of methods addressing those limitations. Next, content validity was assessed and suggested improvements were incorporated. Finally, preliminary validation was conducted in a small convenience sample. This systematic approach resulted in a tool that was easily adapted to electronic format and quick to administer, two characteristics that argue for good scalability in future, larger applications. The research utility of the MSTQ cannot be determined by the present results, but after a single development cycle, preliminary small-sample reliability and validity estimates suggest similar performance to other self-reported activity measures (van Poppel, Chinapaw,

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Mokkink, van Mechelen, & Terwee, 2010). The present results can be used for focused revision to further improve performance.

Using a conservative reliability estimate, the MSTQ demonstrated below-average acceptable reliability for estimates of total sitting (ICCs of .76 on workdays and .72 on non-workdays). Among contexts, only workday "talking / texting / socializing" and "computer / video game use (non-work)" exhibited low ICCs of .27 and .39, respectively. This may reflect high true variability on workdays for these activities, which would warrant additional measurement periods to improve accuracy. Alternatively, reporting of work-related activities in these contexts may require clearer instructions for mutual exclusivity in future MSTQ versions.

The MSTQ joins a small group of multi-context sitting questionnaires (Marshall et al., 2010; Rosenberg et al., 2010; Salmon et al., 2003). These three studies reported test-retest reliability for total- and context-specific sitting of similar magnitude to the present results. Two studies used accelerometers as a reference measure (Marshall et al., 2010; Rosenberg et al., 2010), and neither exhibited acceptable convergent validity. Of note, both used "weekday" and "weekend day" in questionnaire assessments and neither utilized relative sedentary time. Longer wear captures more daily sedentary behavior, resulting in higher absolute sedentary time versus a participant with identical sedentary exposure but less wear time. Expressing sedentary time relative to wear time attenuates this difference, yielding a more stable estimate of sedentary behavior (Pettee Gabriel et al., 2012). Relying on absolute values may be especially problematic when the self-report period is a full week (Rosenberg et al., 2010) and less than a week of accelerometer wear is recorded: absolute sedentary time for a participant with three days of valid wear would not likely correlate strongly with a week of self-reported sitting.

Strengths of the present study include systematic development of a rapid, self-administered, on-line sitting questionnaire that spans three domains and several contexts. This potentially fills a gap in sedentary assessment with simple administration, scalability, low cost, and improved detail versus crude proxy measures and tools with ambiguous wording. Further, this study extends sedentary research to a sample of recreational endurance athletes. With over nine hours of daily sitting and weekly training averaging 7.8 hours, these results support Owen et al.'s (2010) conceptualization of an "active couch potato".

Limitations of the present study include the small, homogeneous sample, which precludes broad generalization. Additional validation is needed to obtain better estimates of reliability and validity. Also, we were unable to assess validity within contexts, as neither accelerometers nor the activity log captured such. Finally, uniaxial accelerometers only provide a proxy of sedentary time as they are unable to distinguish between quiet sitting and standing. Accordingly, analyses of strict agreement such as Bland-Altman plots were not utilized. The above limitations can be countered in a larger validation study utilizing multiple days of a body position monitor as a criterion measure (e.g., ActivPal) with an accompanying context-specific activity log or diary.

In conclusion, this research suggests a development strategy that may assist other researchers in devising activity questionnaires. Additional validation is needed, but the MSTQ may provide rapid, low-cost sedentary behavior assessment for future studies of many sizes.

What Does This Paper Add?

Sedentary behavior is a complex construct that occurs in different domains and contexts. Single-item measures may underestimate total sitting, and options are limited for self-reported assessment of multiple sedentary behaviors across occupational and leisure domains. The Multi-context Sitting Time Questionnaire (MSTQ) may fill this gap by soliciting usual sitting across several contexts and domains to estimate total sitting. The systematic development of the MSTQ resulted in several improvements over previous tools and may serve as a model for purpose-driven questionnaire design. Though additional validation is needed, the MSTQ is brief and scalable through on-line platforms, suggesting usefulness in a range of studies.

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APPENDIX

MULTICONTEXT SITTING TIME QUESTIONNIARE (MSTQ)

What is your current employment status? Please select the answer that requires the most time. For example, if you work full time and attend school part-time, select "employed for wages"

1. Employed for wages
2. Self-employed
3. Out of work for more than 1 year
4. Out of work for less than 1 year
5. A homemaker
6. A student
7. Retired
8. Unable to work

How many hours per week do you typically work? ________

In a typical week, what are your primary work days? (select all that apply)

1. Monday
2. Tuesday
3. Wednesday
4. Thursday
5. Friday
6. Saturday
7. Sunday

The next two questions will ask about the time you spend sleeping and sitting. First, we will ask about a WORK DAY, then a NON-WORK DAY.

Think about a usual week. In the lines below, please indicate the number of hours and minutes per WORK DAY you spend doing each of the activities listed. Please do not record time twice in different categories: for example, if you were reading while watching TV, only report that time under one category.

	Hours	Minutes
Sleeping (per night)		
Sitting while working, reading, or studying		
Sitting while watching TV or movies		
Sitting while using a computer or video game (non-work)		
Sitting during transportation (not including bicycles)		
Sitting while talking, texting, or other socializing		

The next question asks about the time you spend sleeping and sitting on a NON-WORK DAY

Think about a usual week. In the lines below, please indicate the number of hours and minutes per NON-WORK DAY you spend doing each of the activities listed. Please do not record time twice in different categories: for example, if you were reading while watching TV, only report that time under one category.

	Hours	Minutes
Sleeping (per night)		
Sitting while working, reading, or studying		
Sitting while watching TV or movies		
Sitting while using a computer or video game (non-work)		
Sitting during transportation (not including bicycles)		
Sitting while talking, texting, or other socializing		

Do your answers in the sleeping/sitting time questions reflect your normal activity levels? (Yes/No)
At any time during the past 2 weeks, was your ability to move reduced due to injury or illness? (Yes/No)

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Table 1

Descriptive statistics from the first administration of the MSTQ and test-retest reliability for MSTQ items

Question	Mean (SD)	Median (IQR)	ICC (95% CI)
Training time (hours/week)	7.1 (4.4)	6 (3.5, 9)	0.99 (0.97, 0.99)
Working time (hours/week)	41.7 (10.8)	40 (40, 50)	0.94 (0.85, 0.97)
Workday (minutes)			
Sleep	430.2 (45.6)*	420 (420, 480)	0.76 (0.49, 0.89)
Sitting	659.2 (221.2)*	660 (480, 840)	0.76 (0.50, 0.89)
Working/reading/studying	352.2 (188.0)	300 (240, 480)†	0.83 (0.62, 0.93)
TV/movies	109.2 (80.3)*	120 (60, 120)	0.93 (0.84, 0.97)
Computer/video games	59.2 (69.7)	30 (20, 60) †	0.39 (0.00, 0.70)
Inactive transportation	85.8 (120.8)	60 (30, 60)	0.97 (0.93, 0.99)
Talking/texting/socializing	52.8 (38.8)	60 (30, 60) †	0.27 (0.00, 0.62)
Non-workday (minutes)			
Sleep	499.2 (44.9)	480 (480, 540)	0.84 (0.66, 0.93)
Sitting	568.2 (228.9)	570 (390, 720)	0.72 (0.42, 0.87)
Working/reading/studying	114.0 (106.8)	120 (30, 120)	0.65 (0.31, 0.84)
TV/movies	180 (110.9)	180 (120, 240)	0.85 (0.67, 0.94)
Computer/video games	95.6 (86.1)	60 (30, 120)	0.84 (0.64, 0.93)
Inactive transportation	75 (37.0)	60 (60, 90)	0.70 (0.40, 0.87)
Talking/texting/socializing	103.6 (79.2)	90 (45, 120)	0.62 (0.27, 0.83)

Note. ICC = Intra-class correlation coefficient; SD = standard deviation; IQR = inter-quartile range; CI = Confidence Interval

*statistically significant difference from comparable non-workday value, $p < .05$, paired *t*-test

†statistically significant difference from comparable non-workday value, $p < .05$, Wilcoxon sign-rank test

Table 2

Panel A: means with standard deviations and medians with inter-quartile ranges for total minutes of sedentary, all measures. Panel B: proportion of MSTQ-reported waking time spent sitting and proportion of accelerometer wear-time <100 counts (relative sedentary time).

A	MSTQ (minutes sitting)	Activity Log (minutes sitting)	Accelerometer (minutes <100 counts)	B	MSTQ % (% of waking time sitting)	Relative accelerometer (% weartime <100 counts)
Workday						
n	25	22	21		25	21
Mean (SD)	659.2 (221.2)	450.0* (183.4)	550.9 (89.1)		65.2% (21.4)	63.3% (8.2)
Median (IQR)	660 (480, 840)	420 (315, 600)	518 (491, 586)		64.7% (46.9, 82.9)	62.1% (56.9, 68.9)
Non-workday						
n	25	21	16		25	16
Mean (SD)	568.2 (228.9)	414.3* (161.6)	478.6 (80.1)		60.6% (24.9)	63.8% (9.0)
Median (IQR)	570 (390, 720)	420 (315, 510)	486.5 (421.5, 521)		61.8% (40.6, 75.0)	65.4% (56.7, 69.1)

Note. SD = standard deviation, IQR = inter-quartile range

* For the same type of day, significantly different from MSTQ at $p<0.05$, paired t-test

Table 3

Convergent validity of the MSTQ versus three measures assessed by Pearson or Spearman correlation coefficients with p-values

	Activity log	Accelerometer	Accelerometer adjusted
Workday			
MSTQ	0.35 p=0.11	0.16* p=0.48	0.34 p=0.13
Non-workday			
MSTQ	0.39 p=0.08	0.44* p=0.09	0.61 p=0.01

Note.

* Indicates Spearman correlation coefficient, all others are Pearson correlation coefficients