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Active adults recall their physical activity differently to less active adults: test-retest reliability and validity of a physical activity survey

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Active adults recall their physical activity differently to less active adults: test-retest

reliability and validity of a physical activity survey

Abstract

Issue Addressed: This paper determined the test-retest reliability and criterion validity of a modified version of the Active Australia Survey (AAS) and whether these properties varied across participants' activity levels.

Methods: Participants (n=63) responded to repeat administrations of the AAS and wore an accelerometer for seven days. Analyses used Spearman's Rho (r_s) or weighted kappa (κ) and Bland-Altman methods. Variation in mean difference and 95% limits of agreement (LOA) across average levels of activity were tested by linear regression.

Results: Reliability correlations (r_s [95% CI]) for minutes/week ranged from 0.40 (0.16, 0.59) to 0.80 (0.68, 0.87). For days/week, the agreement (κ [95% CI]) between administrations ranged from 0.43 (0.34, 0.73) to 0.83 (0.61, 0.93). There was a small mean difference between administrations (-8.46 moderate-vigorous minutes/week); 95% LOA widened as participants' average activity levels increased. Validity correlations (r_s [95% CI]) for minutes/week ranged from 0.50 (0.28, 0.66) to 0.61 (0.43, 0.75). For days/week, the agreement (κ [95% CI]) ranged from 0.35 (0.10, 0.50) to 0.61 (0.29, 0.87). Mean difference between the AAS and accelerometer and 95% LOA both varied with participants' activity levels.

Conclusions: The reliability and validity of the modified AAS were better than previously published versions, but varied according to participants' activity levels.

So what? In this study, participants who engaged in more activity had more measurement error than less active participants. This proportionality will have important implications for cross-sectional and

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intervention studies. This phenomenon needs to be examined for other self-reported physical activity

measures.

Keywords: measurement, exercise, accelerometer, questionnaires, surveillance

Introduction

The benefits of regular physical activity are well-known.[1] Most developed countries regularly monitor population physical activity levels and fund initiatives to increase participation.[2-4] The quality of this monitoring relies on accurate methods of measuring physical activity in large populations. Although the disadvantages of self-report measurement are well known,[5] and the use of accelerometry for population surveillance is becoming increasingly feasible,[6-8] self-report measurement still represents an efficient way to collect data on physical activity in population health research.

The Active Australia Survey (AAS)[9] was designed as a telephone-administered instrument for population surveillance of physical activity in Australian adults,[10-12] but has also been used to evaluate interventions.[13-15] The AAS assesses frequency (sessions) and duration (minutes) of past week physical activity. The test-retest reliability of the AAS has been established in Australian[12, 16, 17] and United States (US) adults,[18] and has been validated against accelerometers among: Australian men and women;[16, 19] Australian women;[12] and, US women.[18] The concurrent validity of the AAS has been assessed against the Australian National Health Survey (NHS), International Physical Activity Questionnaire (IPAQ) and the US Behavioral Risk Factors Surveillance System (BRFSS).[20] These evaluations revealed that the AAS has modest reliability and validity, similar to other physical activity surveillance tools (e.g. IPAQ).

Aside from modest reliability and validity results, other limitations of the body of evidence regarding the validity and reliability of the AAS include the untested assumption of whether or not measurement properties are constant across activity levels, and the mismatch in the definition of frequency between the tool and physical activity guidelines (which refer to days/week, not sessions). The only existing study to assess variation across average values found that the concurrent validity of the AAS (against NHS, IPAQ and BRFSS) worsened with increasing levels of activity.[20] There is need for consistency in definitions of physical activity frequency between guidelines and assessment tools. Mismatch between the definitions of physical activity frequency in guidelines and tools, over-reporting and limitations of accelerometry may all contribute to the recent findings that population rates of

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guideline compliance are dramatically higher in the US[7] and England[8] when assessed by self-report than by accelerometry.

Accordingly, we modified the AAS to assess the "number of days" activity was undertaken instead of "sessions of activity". This study aimed to determine the test-retest reliability and criterion validity of the adapted version the AAS. In view of previous findings,[20] we also examined whether reliability and/or validity varied according to participants' levels of physical activity. Test-retest reliability was established through repeat administrations of the AAS. Criterion validity was established by comparing AAS data to data from an accelerometer. While the accelerometer does not provide a gold-standard measure, it provides a useful criterion as it has good reliability and validity[21] and, importantly, it is not subject to the same sources of error as self-report.

Methods

The study was advertised within an Australian university via email to staff and students. The email outlined the eligibility criteria (30-70 years, able to read English, no experience in administering the AAS). Interested participants, were emailed an information sheet, and then telephoned to confirm eligibility and gain verbal informed consent. This study was approved by The University of Queensland Human Research Ethics committee, Brisbane (#2009001169).

Participants were each posted an Actigraph GT1M accelerometer, a daily log (to record accelerometer removals, water, cycling and strength activities) and a reply-paid envelope (Day 1). Two days later, participants were telephoned to prompt them to wear their accelerometer and to complete a demographic survey (Day 3). The AAS was administered via telephone and participants were prompted to mail back their accelerometer and daily log after seven days of accelerometer data collection (Day 10). The second administration of the AAS occurred 3-5 days after the first (Day 13-15), with both AAS administrations assessing the previous seven days of activity.

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Trained staff administered the AAS using a standard script (Supplementary File 1). The adapted

version of the AAS required participants to recall the number of days/week and minutes/week that they

engaged in: walking (in at least 10-minute bouts); vigorous gardening; vigorous activity; and, other

moderate activity over the past week. The days reported in each category in the adapted AAS are not

mutually exclusive and therefore the sum of days/week across categories may equal more than seven. As

per the AAS protocol,[9] the minutes/week data were truncated at 840 minutes (necessary for an item in

three participants at Time 1 and two participants at Time 2). Total moderate-vigorous activity was

calculated for minutes/week and days/week data based on the sum of walking, moderate and vigorous

activities (vigorous activity was not weighted in order to compare it to accelerometer-recorded

minutes/week).

The accelerometers were set to collect data in one minute epochs. Participants were asked to wear

the accelerometer around their waist for seven consecutive days, and to only remove it when sleeping or

in contact with water. Participants also recorded the timing and duration of activities that the

accelerometer may not correctly detect (i.e., water-based activities, cycling and strength training).

Accelerometer data were downloaded using the Actigraph software and processed using an adapted SAS

program from the National Cancer Institute.[22] Data included all monitored time except bouts of an hour or

longer of zero counts, with allowance for up to two counts that were <50 counts/minute. As per common

practice, days were considered valid if there were at least 10 hours of wear. Participants were included in

the analysis if they had at least five valid wear days. As five days of monitoring is sufficient to reflect

habitual activity,[21] weekly values were taken as 7 times the average value for valid days for participants

with less than seven days of valid accelerometer data (n=13). Additionally, to be included in the analysis

participants needed to have recorded no water, cycling or strength activities in their wear log. This was

done to exclude participants who could have reported activity in the AAS that was not detectable by the

accelerometer. The data were analysed using established cut-points for moderate ($\geq$1952 cpm) and

vigorous ($\geq$5725 cpm) activity.[23] Minutes/week were based on the number of one minute epochs

accumulated in ten minute bouts within a given intensity range (allowing for a maximum of two epochs outside of the cut-point range). Days/week data identified the number of days that had at least one ten minute bout of activity within the specified intensity range (allowing for a maximum of two epochs outside of the cut-point range).

Analyses were conducted in SPSS version 17.0 (SPSS, Inc. Chicago IL) and STATA version 11 (StataCorp LP, College Station, TX, USA) with significance set at $p<0.05$. AAS and accelerometer data were skewed, thus medians (25-75th percentiles) were used to describe the distributions of the data and tests assuming normal distributions (i.e., intra-class correlations) were not used. Test-retest reliability was assessed for all AAS categories separately (walking, moderate and vigorous), and for the moderate-vigorous activity total, for minutes/week and days/week data. Criterion validity was assessed for moderate (moderate + walking), vigorous, and total moderate-vigorous categories, for minutes/week and days/week data. For the continuous minutes/week data, Spearman's correlation coefficients (r_s) with 95% confidence intervals (based on Fisher's transformation) were calculated to examine the relationship between the two AAS administrations (test-retest reliability) and between the AAS data (at Time 1) and accelerometer data (criterion validity). Difference was calculated for minutes/week data between AAS administrations (Time 2 – Time 1) and between AAS and accelerometer data (AAS Time 1- accelerometer), and both difference variables were normally distributed. Bland-Altman plots were created to assess agreement between AAS Time 1 and 2 and between AAS Time 1 and accelerometer data for minutes/week data.[24] Linear regression was used to assess whether the mean difference and/or variability in difference varied across average values for each plot.[25] If average values were associated with mean difference and/or variability in mean difference, data were log-transformed. If this did not resolve the problem, then the mean difference and 95% limits of agreement were reported based on the linear regression analyses.[25] For the categorical days/week data, kappa statistics (κ) with exponential weighting for disagreement (95% confidence intervals), were calculated to assess absolute agreement between repeat AAS administrations and between AAS Time 1 and accelerometer data.

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Participants were classified as meeting the physical activity guidelines based on AAS data if they reported five or more days/week and a total of at least 150 minutes/week of moderate-vigorous activity. Guideline compliance based on accelerometer data was classified as at least 150 minutes of moderate-vigorous activity (accumulated in at least 10-minute bouts) and five or more days of monitoring with at least one ten minute bout of moderate-vigorous activity. Weighted kappa statistics (95% confidence intervals) were calculated to assess agreement between classification of guideline compliance between the AAS and accelerometer data.

Results

One hundred and sixteen participants provided verbal consent, and 103 completed the study protocol. All 103 participants had five or more valid days of accelerometer data and 63 of those did not record water, strength or cycling activities in their log. The participants included in the analysis (n=63) had a mean (± standard deviation) age of 49.5 years (± 12.5), a mean body mass index (BMI) of 26.1 (± 5.6) kg/m^2, and the majority (60.3%) had university level education (Table 1). There were no significant differences between participants who were (n=63) and were not (n=40) included in the study sample for any demographic characteristic or physical activity (data not shown).

Insert Table 1 here

The median amount of moderate-vigorous minutes/week reported in the AAS was the same at Time 1 and 2 (180 minutes/week; Table 2). The correlation between minutes/week data reported at Time 1 and 2 was lowest for moderate activity ($r_{s} = 0.40$); and highest for total moderate-vigorous activity ($r_{s} = 0.80$; Table 2). The absolute agreement between days/week reported at Time 1 and 2 was weakest for moderate activity ($\kappa = 0.43$); and strongest for vigorous activity ($\kappa = 0.83$; Table 2). The Bland-Altman plot for agreement between AAS Time 1 and 2 for total moderate-vigorous minutes/week is shown in Figure 1

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(Panel A). The mean difference between AAS administrations was constant across average levels of

activity (-8.46 minutes/week). The variability in mean difference between AAS administrations was

significantly associated with the average amount of activity (β=0.22, SE 0.06, p<0.001, intercept=45.17).

Log-transformation did not resolve the heteroscedasticity; thus, the limits of agreement were estimated as

(-8.46 +/- (110.96 + 0.54 x average of AAS administrations)).

Insert Table 2 here

Insert Figure 1 here

The median amount of moderate-vigorous accelerometer-recorded activity was 75 minutes/week

(Table 2). The correlations (r_s) between the AAS and accelerometer data ranged from 0.50 (moderate) to

0.61 (moderate-vigorous total) for minutes/week (Table 2). The absolute agreement (κ) between AAS and

accelerometer days/week data ranged from 0.35 (moderate) to 0.61 (vigorous; Table 2). The Bland-

Altman plot of agreement between AAS and accelerometer moderate-vigorous minutes/week is shown in

Figure 1 (Panel B). Linear regression showed a significant positive association between the mean

difference in AAS and accelerometer data and the average of these two measures (β=0.50, SE 0.11,

p<0.001; intercept=22.60). Thus, the mean difference was estimated based on the regression equation

(22.60 + 0.50 x average of AAS and accelerometer data). The variance also increased significantly with

the average of the two measures (β=0.41, SE 0.06, p<0.001; intercept=28.47). Log-transformation did not

resolve the problems, thus, the limits of agreement were estimated as the mean difference +/- (69.94 +

1.01 x average of AAS and accelerometer data).

Based on data from the AAS at Time 1, 30 (48%) participants met the physical activity guidelines,

whereas data from the accelerometers suggest that only 17 (27%) participants met the guidelines. Sixteen

participants (25%) were classified as meeting the guidelines by both the AAS and accelerometer data, 32

(51%) were consistently classified as not meeting the guidelines, 14 (22%) met the guidelines based on

AAS but not accelerometer data, and 1 (2%) participant met the guidelines according to accelerometer data

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but not AAS data. The agreement between guideline compliance categories based on the AAS and

accelerometer data was good (κ=0.51, 95% CI 0.32, 0.71).

Discussion

The version of the AAS used in this study had better test-retest reliability and criterion validity than

previous versions[12, 16-19] and compared to other brief self-report instruments (e.g. IPAQ, BRFSS).[26, 27] This

study also showed that the AAS had poorer test-retest reliability and more error compared to an

accelerometer as the amount of physical activity increased. This suggests that studies using the AAS may

have more random measurement error and more bias relative to an accelerometer in more active

participants than in less active participants.

The test-retest reliability for moderate-vigorous minutes/week in our adapted AAS was stronger

than what has been shown previously for other versions, in which the intraclass correlations for test-retest

reliability ranged from 0.32 (95% CI 0.09, 0.52) for moderate-vigorous minutes/day,[18] to 0.64 (95% CI

0.57, 0.70) for moderate-vigorous minutes/week.[17] The absolute agreement for test-retest reliability of

days/week data in this study was also stronger than previous studies that examined the relative agreement

between repeat AAS administrations for sessions/week data (r_s=0.58).[12] For both minutes/week and

days/week, our version of the AAS showed stronger validity compared to an accelerometer than in

previous studies, which have shown correlations ranging from 0.29 (95% CI 0.16, 0.41) for moderate-

vigorous minutes/day,[19] to 0.52 (95% CI not reported) for moderate-vigorous minutes/week,[12] and 0.48

(95% CI not reported) for sessions/week.[12]

A number of issues may contribute to the observed differences in reliability and validity results

between studies, including the: version of the AAS (our version, the original version or other

modifications, such as inclusion of specific domains for transport and leisure walking[19] and sitting

questions[18]); study populations; statistics reported; and, mode of administration (interviewer-

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administration[19] or self-completion[12, 18]). The reliability results might also be affected by the time period between repeat administrations, which for previous studies was 14 days,[12] 7 days,[18] and 1 day.[17] The validity results may also be affected by varying protocols for treating accelerometer data and the weight status of the samples, as weight has previously been shown to impact on AAS validity estimates.[16]

Most previous studies have treated reliability and validity as constant across participants' activity levels, but our examination revealed this assumption to be incorrect. Our results showed that the performance of the AAS was proportional to the amount of physical activity that occurs, which is consistent with previous findings that the concurrent validity of the AAS with other self-reported tools worsens with increasing activity levels.[20] There are a number of plausible reasons why reliability and validity might vary across physical activity levels. Reporting of behaviour may be better when there is less activity to recall; further, variation in actual behaviour (not just recalling the behaviour) may be greater among more active, compared with less active, participants. In terms of validity, the accelerometer is not a gold-standard criterion, and its performance as a criterion might depend on people's physical activity level. The approach of using a threshold (even one with adequate sensitivity and specificity) means that each minute identified as moderate-vigorous physical activity is identified with some error, and consequently, the total amount of error increases proportionally as the underlying amount of activity increases. Further, higher levels of physical activity may be indicative of a wider range of types of physical activities performed, and the accelerometer is known to capture some types of activities better than others.[21] Finally, the different variability of accelerometer and self-report measures may have led to artefactual bias.[28]

There are a number of limitations in this study. Previous research has shown that completing a log may improve subsequent recall of vigorous activity[19] and/or walking activity[12] in the AAS. Thus, participants may have experienced a learning effect when completing the AAS at Time 2, which may have potentially biased reliability estimates, but would not have affected the validity estimates. Our AAS modifications did not include a question about days on which either moderate or vigorous activity

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occurred, which means a total moderate-vigorous days/week cannot be calculated by summing moderate

and vigorous days (similar to IPAQ). Future AAS versions should consider this to obtain congruence with

Australian physical activity guidelines. <mark>Finally, generalisability of the findings may be limited as this</mark>

<mark>study, like most validity studies, used a small convenience sample recruited through a university setting.</mark>

A strength of this study was that our treatment of the accelerometer data ensured that it was as

useful as possible as a criterion measure for AAS-reported moderate-vigorous activity. We excluded

participants who reported doing activity that may not be detected by the accelerometer and processed the

data to only recognise bouts of at least 10-minutes, in order to replicate how participants were instructed

to recall their activity (in the case of the walking category), and likely how they are able to remember

their activity (in the case of the other categories). The seven day recall period of the AAS completely

overlapped with the accelerometer wear period. Previous validations of the AAS have used overlapping

assessment periods, however only one previous study processed accelerometer data based on 10-minute

bouts,[12] and none excluded participants who reported activities not detected by the accelerometer.

Conclusion

This study has found an adapted version of the AAS, had better test-retest reliability and criterion

validity compared with previous versions of the AAS, but that these properties varied with participants'

activity levels. Future reliability and validity studies should not assume performance to be constant across

activity levels, but rather test whether this is the case.[24, 28] A greater amount of measurement error at

higher levels of activity may affect epidemiological studies of physical activity and health outcomes

because there may be more attenuation due to misclassification in more active, compared with less active

populations. Intervention studies may also be affected by a widening in measurement error and bias as

participants' activity levels increase. The impact of these issues is not clear and needs to be empirically

examined, by including both objective and self-report measures in future epidemiological and

intervention studies.

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Tables

Table 1: Demographic characteristics of convenience sample used to evaluate test-retest reliability and criterion

validity of the adapted Active Australia Survey (AAS) (n=63)

	mean ± SD
Age, yrs	49.5 ± 12.5
Height, cm	169.6 ± 9.3
Weight, kg	75.9 ± 19.0
Body mass index, kg/m^2	26.1 ± 5.6
	n (%)
Gender, male	23 (36.5)
Ethnicity, Caucasian	63 (100.0)
Marital status, married or living together	50 (79.4)
Highest level of education, university or college	38 (60.3)
Employment, full-time paid work	45 (71.4)
Weekly household income, AUD <$1000/wk	11 (17.5)

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Table 2: Test-retest reliability and criterion validity against accelerometer data of the adapted Active Australia Survey (AAS) in a convenience sample of Australian adults (n=63)

	Test-retest Reliability Outcomes			Criterion Validity Outcomes		
	Time 1 AAS median (25-75th %ile)	Time 2 AAS median (25-75th %ile)	r_s (95%CI)	AAS Time 1 median (25-75th %ile)	Accelerometer median (25-75th %ile)	r_s (95%CI)
Minutes per week						
walking	135 (45-225)	120 (60-240)	0.76 (0.63, 0.85)	-	-	-
moderate	0 (0-0)	0 (0-0)	0.40 (0.16, 0.59)	140 (50-280) [†]	56 (10-118) [†]	0.50 (0.28, 0.66)
vigorous	0 (0-40)	0 (0-60)	0.64 (0.47, 0.77)	0 (0-40)	0 (0-0)	0.60 (0.41, 0.74)
moderate-vigorous total	180 (90-330)	180 (95-350)	0.80 (0.68,0.87)	180 (90-330)	75 (21-209)	0.61 (0.43, 0.75)
	Time 1 AAS median (25-75th %ile)	Time 2 AAS median (25-75th %ile)	κ (95%CI)	AAS Time 1 median (25-75th %ile)	Accelerometer median (25-75th %ile)	κ (95%CI)
Days per week						
walking	4 (2-6)	4 (2-6)	0.64 (0.45, 0.81)	-	-	-
moderate	0 (0-0)	0 (0-0)	0.43 (0.34, 0.73)	4 (3-7) [†]	2 (1-4) [†]	0.35 (0.10, 0.50)

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vigorous	0 (0-1)	0 (0-1)	0.83 (0.61, 0.93)	0 (0-1)	0 (0-0)	0.61 (0.29, 0.87)
moderate-vigorous total	5 (3-7)	6 (3-7)	0.63 (0.36, 0.76)	5 (3-7)	3 (1-5)	0.45 (0.34, 0.66)

[†] moderate total for criterion validity includes both walking and moderate items from AAS at Time 1

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Figure 1: Bland-Altman plots of agreement between moderate-vigorous minutes/week (MVPA) reported in the adapted Active Australia Survey (AAS) at Time 1 and 2 (Panel A) and between Time 1 and accelerometer data (Panel B) (n=63)
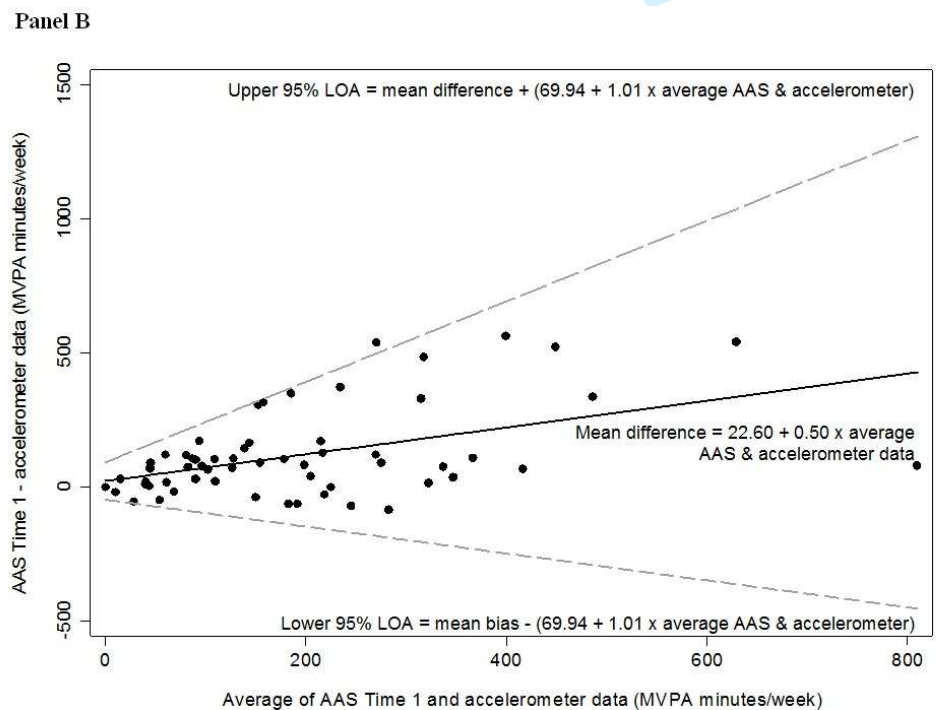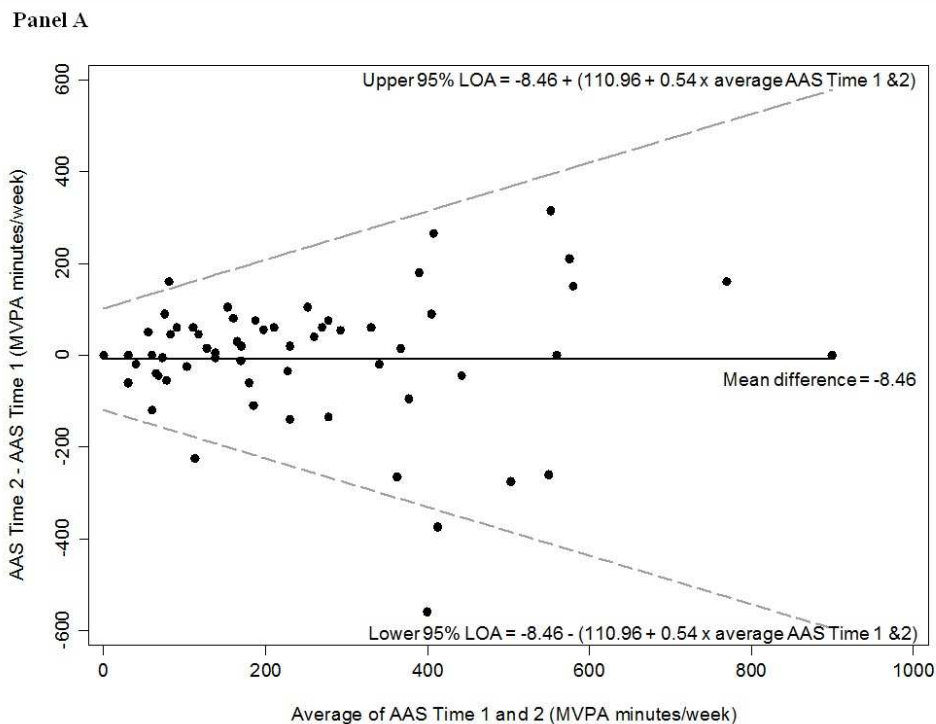
Supplementary File 1: Adapted Active Australia Survey Interview Script

I would like to ask you some brief questions about the activity you did **IN THE LAST WEEK.**

1.a   In the last week, how many days have you **walked continuously,** for at least 10 minutes, for recreation, exercise or to get to or from places? (Only count the days you walked for at least 10 minutes without stopping.)

_____ DAYS   *[If answer is 0, then skip to 2.a]*

1.b   What do you estimate was the **total time** that you spent walking in this way in the last week?

_____ MINUTES

2.a   In the last week, how many days did you do any **vigorous gardening or heavy work** around the yard which made you breathe harder or puff and pant? (e.g. things like heavy digging, pushing a lawn mower)

_____ DAYS   *[If answer is 0, then skip to 3.a]*

2.b   What do you estimate was the **total time** that you spent doing vigorous gardening or heavy work around the yard in the last week?

_____ MINUTES

The next questions EXCLUDE household chores, gardening or yard work:

3.a   In the last week, **how many days** did you do any **vigorous physical activity** which made you breathe harder or puff and pant? (e.g. jogging, cycling, aerobics, competitive tennis).

_____ DAYS   *[If answer is 0, then skip to 4.a]*

[Interviewer clarification: The types of activities which might be reported here, in addition to the above examples, include team games such as football, hockey, basketball, netball, squash, cross-country skiing, cross-country hiking (i.e. rough or steep terrain), weight lifting, boxing, rock climbing, gymnastics, using a rowing machine, certain martial arts, high-impact and step aerobics. It is important to remember that the activity must make the participant breathe much harder and have a large effect on heart rate AND make them unable to talk while doing the activity.]

3.b   What do you estimate was the **total time** that you spent doing this vigorous physical activity in the last week?

_____ MINUTES

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4.a   In the last week, how many days did you do any other more **moderate physical activities** that you have not already mentioned? (e.g. swimming, social tennis, golf, etc) (Not walking; covered earlier)

_____ DAYS   *[If answer is 0, then skip to 5.a]*

[Interviewer clarification: The types of activities which might be expected, in addition to the above examples, include dancing, badminton, table tennis, horseback riding, canoeing, kayaking, volleyball, cricket, baseball or softball, downhill skiing, cross-training, surfing and windsurfing. The activity must make the participant breathe harder and increase the heart rate but still allow them to talk, but not sing, while doing the activity]

4.b   What do you estimate was the **total time** that you spent doing these activities in the last week?

_____ MINUTES

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