

Tools to measure physical activity in local level weight management interventions: a rapid review.

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Background

Obesity is a consequence of a chronic positive energy balance. That is when energy intake from food exceeds total daily energy expenditure (TDEE). Total daily energy expenditure (TDEE) is the sum of basal metabolic rate (BMR), the thermic effect of food (TEF) and activity thermogenesis (AT).¹ AT accounts for approximately 25-30% of TDEE and comprises two components.¹ The first is the energy expenditure due to purposeful physical activity such as sport, or active recreation such as gym-going. Even for adults who meet current public health recommendations for physical activity (at least five, thirty minute occasions of moderate intensity physical activity per week) physical activity will only constitute ~100 kcals per day (net) to TDEE. The second component of AT is non-exercise thermogenesis (NEAT) which encompasses all physical activity that is not purposeful.¹ It is the daily 'incidental' activity of moving around, standing, toe-tapping, dressing, washing etc. NEAT can vary between people of the same weight by as much as 2000 kcals per day compared to differences in exercise or purposeful physical activity of just a few hundred kcals. Therefore, NEAT is more important in weight management than exercise. Time spent sitting is inversely related to NEAT and a number of cross-sectional and some

prospective studies have suggested that daily sitting time or total screen time as a proxy measure, both at work and during leisure time, is associated with the risk of obesity.²⁻⁴

Therefore, two behaviours emerge that independently contribute to daily energy expenditure and the risk of overweight/obesity. It follows that programmes and interventions designed to manage obesity risk should measure both behaviours. In order to avoid misclassification bias, measures used should have published reliability and validity data. As the energy cost of physical activity is important in the association with obesity, validity should ideally be assessed against doubly labelled water, the gold standard measure of energy expenditure.⁵

Methods

Building on the work already undertaken by NOO, I used a recent review of methods for assessing physical activity that compared self-report measures with direct measures such as doubly labelled water.⁶ The review categorised studies according to the direct measure of physical activity used to assess validity. Therefore, it was simple to identify self-report measures of physical activity that had been validated against doubly labelled water. As already stated, criteria for selecting instruments include being able to estimate energy expenditure and validation against doubly labelled water. Additional criteria used to select instruments included:

- a) relatively easy and practical to administer in a field setting;
- b) mean difference between energy estimated by self-report and doubly labelled water <40%

- c) instrument should have been used in a trial of exercise promotion and detected a significant difference between intervention and control participants;
- d) population in the validity study generalisable to wider population.

All of the studies in the review by Prince et al (2008),⁵ that reported using double labelled water as the validity measure, were identified and assessed against the criteria above.

In general, log books, diaries and interview administered questionnaires appear to be more accurate than simple self-completion recall questionnaires. No existing physical activity measure perfectly met all of the above criteria. However, four instruments met a high percentage of them.

1. Stanford 7-day recall

The instrument was originally developed for the Five Cities Project.⁷ It is interview administered and takes approximately 15 minutes to complete. It has acceptable reliability and validity.^{8,9} It has been used in numerous intervention studies including the Activity Counseling Trial (ACT).¹⁰

2. International Physical Activity Questionnaire (IPAQ) Long version

In the validity study, the IPAQ Long form was self-completed although a research assistant was in attendance to assist the participants. Completion time was estimated at 15 minutes.¹¹ IPAQ long has previously been shown to have acceptable reliability and criterion validity (www.ipaq.ki.se). To the best of my knowledge the IPAQ questionnaire has not been used in an activity intervention trial and shown it can measure change in physical activity over time. It was not designed for this purpose

although that it is not to say that it could not if fully tested. An advantage of IPAQ long is that it includes questions on sitting activities such as reading, television viewing and sitting at a desk.

3. New Zealand Physical Activity Questionnaire (Short Form)

The NZPAQ-SF was assessed in the same study as the IPAQ and was derived from it.¹¹ It is shorter (approximately 10 minutes to complete) and uses show cards to prompt people to recall moderate and vigorous activities they have undertaken in the last 7 days. The administration method was the same as IPAQ with a research assistant available to assist participants. The instrument has been used in a primary care based randomised controlled trial in New Zealand that showed a significant difference between intervention and control groups.¹²

4. 7-day physical activity diary

This is a self completion diary that requires participants to 'tick' 15 minute blocks of activity as they occur over the course of each day, for 7 consecutive days. It includes, occupational, leisure time and sports activity. It requires no verbal instruction for completion.¹³ Although no estimate of completion time is given it is reasonable to assume that the daily completion time is minimal. The main challenge for participants is likely to be remembering to do it for 7 days. The validity is good although reliability is unclear. The measure was designed for use in epidemiological studies so its usefulness in intervention studies is unknown. A downloadable scoring scheme is available at www.dife.de (follow links for 'Presse').

A common finding of the doubly labelled water validity studies is that self-report measures typically overestimate lower intensity physical activities and underestimate

higher intensity physical activities. Although, measurement errors are deemed to be 'acceptable' for epidemiological studies, their magnitude may make it challenging, but still possible, to detect very small differences in energy expenditure observed in before and after design, intervention studies.

Measurement of sedentary time

The most common sedentary activity to be assessed in self-report measures is television (TV) viewing, although measures may also include other sitting activities such as computer use, reading etc. Some measures also distinguish between sitting at work, during leisure time and while travelling. A recent review found nine studies that assessed reliability and three that assessed validity.¹⁴ Assessing the validity of self-reported sitting measures is particularly difficult as there is no 'gold-standard' measure of sitting that can be used as a referent method. That said, existing questionnaires report similar reliability and validity standards as self-reported physical activity measures. This is typically stated as 'moderate'. The IPAQ long has a reliable and valid measure of sitting time, estimated as the total number of hours and minutes per day spent sitting for a weekday and a weekend day.¹⁵ Another measure of sedentary behaviours that has acceptable validity has been used in an Australian survey.¹⁶ It asks participants to recall a range of sedentary pursuits during leisure time including computer use and TV viewing. Measures of sedentary behaviours tend to be short and easy to complete. Their use in intervention studies is unknown.

Conclusion

It appears that there are a range of instruments that can be used to assess both energy expenditure from physical activity and sedentary behaviour, that meet the majority of the criteria set. A consideration not included in validity studies but perhaps a concern for practitioners, is the complexity of the scoring scheme. Most instruments have a scoring scheme that would require computer assistance.

Perhaps a useful activity for NOO would be to provide electronic versions of a range of questionnaires that have the scoring schemes embedded within them. It may be possible to make these available as executable files from the NOO website.

References

1. Levine JA, Vander Weg MW, Hill JO, Klesges RC. Non-exercise activity thermogenesis. The crouching tiger hidden dragon of societal weight gain. *Arterioscler Thromb Vasc Biol* 2006;26:729-736
2. Hamilton MT, Hamilton DG, Zderic TW: Role of low energy expenditure and sitting in obesity, metabolic syndrome, type 2 diabetes, and cardiovascular disease. *Diabetes* 2007, 56:2655-2667.
3. Parsons TJ, Manor O, Power C. Television viewing and obesity: a prospective study in the 1958 British birth cohort. *Eur J Clin Nutr.* 2008 Dec;62(12):1355-63
4. Hu FB, Li TY, Colditz GA, Willett WC, Manson JE: Television watching and other sedentary behaviors in relation to risk of obesity and type 2 diabetes mellitus in women. *JAMA* 2003; 289:1785-1791.
5. Lamonte MJ, Ainsworth BE. Quantifying energy expenditure and physical activity in the context of dose response. *Medicine and Science in Sports and Exercise* 2001;33(Suppl):S370-S378.
6. Prince SA, Adamo KB, Hamel ME, Hardt J, Gorber SC, Tremblay M. A comparison of direct versus self-report measures for assessing physical activity in adults: a systematic review. *Int J Behav Nutr Phys Act.* 2008 Nov 6;5:56.
7. Blair SN, Haskell WL, Ho P, Paffenbarger RS Jr, Vranizan KM, Farquhar JW et al. Assessment of physical activity by a seven day recall in a community survey and controlled experiments. *Am J Epidemiol* 1985;122:794-804.

8. Richardson MT, Ainsworth BE, Jacobs DR, Leon AS. Validation of the Stanford 7-day recall to assess habitual physical activity. *Ann Epidemiol.* 2001 Feb;11(2):145-53.
9. Mahabir S, Baer DJ, Giffen C, Clevidence BA, Campbell WS, Taylor PR, Hartman TJ. Comparison of energy expenditure estimates from 4 physical activity questionnaires with doubly labelled water estimates in postmenopausal women. *Am J Clin Nutr* 2006;84:230-236.
10. Blair SN, Applegate WB, Dunn AL, Ettinger WH, Haskell WL, King AC, Morgan TM, Shih JA, Simons-Morton DG. Activity Counseling Trial (ACT): rationale, design and methods. *Med Sci Sports Exerc* 1998;30:1097-1106.
11. Maddison R, Ni Mhurchu C, Jiang Y, Vander Hoorn S, Rodgers A, Lawes CM, Rush E. International Physical Activity Questionnaire (IPAQ) and New Zealand Physical Activity Questionnaire (NZPAQ): A doubly labelled water validation. *Int J Behav Nutr Phys Act.* 2007 Dec 3;4:62.
12. Lawton BA, Rose SB, Elley CR, Dowell AC, Fenton A, Moyes SA. Exercise on prescription for women aged 40-74 recruited through primary care: two year randomised controlled trial. *BMJ* 2008;337.doi:10.1136/bmj.a2509.
13. Koebnick C, Wagner K, Thielecke F, Moeseneder J, Hoehne A, Franke A, Meyer H, Garcia AL, Trippo U, Zunft HJ. Validation of a simplified physical activity record by doubly labeled water technique. *Int J Obes (Lond).* 2005 Mar;29(3):302-9.

14. Clark BK, Sugiyama T, Healy GN, Salmon J, Dunstan DW, Owen N. Validity and reliability of measures of television viewing time and other non-occupational sedentary behaviour of adults: a review. *Obes Rev.* 2008 Jul 8. [Epub ahead of print]
15. Rosenberg DE, Bull FC, Marshall AL, Sallis JF, Bauman AE. Assessment of sedentary behavior with the International Physical Activity Questionnaire. *J Phys Act Health.* 2008;5 Suppl 1:S30-44.
16. Salmon J, Owen N, Crawford D, Bauman A. Physical activity and sedentary behaviour: a population based study of barriers, enjoyment and preference. *Health Psychology* 2003;22:178-188.

Annex: Physical Activity – Self Reported Measures (Levels of Physical Activity and Sedentary Behaviour)

Authors: Kath Roberts, Nick Cavill, Melvyn Hillsdon. This summary was produced using a number of reviews of physical activity tools, particularly reviews by Bauman et al¹ and Dugdill and Stratton².

MEASURES VALIDATED AGAINST DOUBLY-LABELLED WATER					
Tool	Population	What it measures	Caveats/Limitations/ Validation	Administration Method/ Practical Application	Key Reference/ Copyright/Ownership/ Location
Stanford 7- Day Physical Activity Recall	Adults	Respondents are asked about the number of hours spent in sleep, moderate, hard, and very hard activities during the preceding week. Examples of the types of activities in each category are provided, and the week is separated into weekend days and weekdays. The remaining amount of time is presumed to have been spent in light activities. A formula is available for the calculation of daily energy expenditure in kilocalories, and norms are available from the Stanford Heart Disease Prevention Program.	The instrument was originally developed for the Five Cities Project. It is interview administered and takes approximately 15 minutes to complete. It has acceptable reliability and validity. Validity has also been assessed against doubly labelled water indicating that the instrument provides a reasonable estimate of daily energy expenditure. It has been used in numerous intervention studies including the Activity Counselling Trial (ACT).	Interview administered recall instrument	Blair et al, 1985 ³ Mahabir et al 2006 ⁴ Blair et al 1998 ⁵ http://stressandhealth.stanford.edu/measures/7Day.html#

<p>IPAQ (International Physical Activity Questionnaire)</p>	<p>Population level. Validated for use in 15 – 69 year olds.</p>	<p>Recall questionnaire for past 7 days.</p> <p>Short form: frequency, duration of time spent on walking/vigorous/moderate intensity/sedentary activity (sitting)</p> <p>Long form: domains unspecified: household/yard work, occupational, self-powered transport, leisure time related PA as well as sedentary activity (sitting on a weekday/weekend day); pace of walking/cycling</p>	<p>The IPAQ is a population level instrument designed for surveillance and for cross-national monitoring of PA/inactivity. It was not initially designed for evaluating intervention studies.</p> <p>There are varying reports of validity⁶. Some authors have found over reporting of physical activity⁷. Low criterion validity results were found between IPAQ and an accelerometer⁸ whereas Ekelund et al⁹ found similar criterion validity scores for the short IPAQ, suggesting that the specificity to correctly classify people achieving 30 minutes of physical activity per day was sound.</p> <p>IPAQ (long version) has been validated against doubly labelled water and provides an acceptable estimate of daily energy expenditure.</p>	<p>Telephone or self administered</p>	<p>Craig et al., 2003¹⁰</p> <p>Maddison et al., 2007¹¹.</p>
<p>New Zealand Physical Activity Questionnaire (Short Form)</p>	<p>Middle aged adults</p>	<p>A short self-completion recall (approximately 10 minutes to complete) that uses show cards to prompt people to recall moderate and vigorous activities they have been undertaken in the last 7 days.</p>	<p>Validated against doubly labelled water. The instrument has been used in a primary care based randomised controlled trial in New Zealand that showed a significant difference between intervention and control groups. In studies the self-completion has been supervised by a researcher.</p>	<p>7-day recall</p>	<p>Maddison et al 2007¹²</p> <p>Lawton et al., 2008¹³</p>

7-day physical activity diary	Adults	This is a self completion diary that requires participants to 'tick' 15 minute blocks of activity as they occur over the course of each day, for 7 consecutive days. It includes, occupational, leisure time and sports activity.	The validity is good although reliability is unclear. A validity study using double labeled water indicates that the measure is a reasonable estimate of daily energy expenditure. The measure was designed for use in epidemiological studies so its usefulness in intervention studies is unknown.	7 day diary	www.dife.de Koebnick et al., 2005 ¹⁴
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OTHER MEASURES					
Tool	Population	What it measures	Caveats/Limitations/ Validation	Administration Method/ Practical Application	Key Reference/ Copyright/Ownership/ Location
GPAQ (Global Physical Activity Questionnaire)	Population level; designed primarily for developing countries.	<p>14 items similar to IPAQ short, but with domain specific estimates possible for work/domestic related PA, active transport, leisure time PA and total sitting time recall period is 'usual week.'</p> <p>Domains – work/domestic moderate and vigorous activities; number of days, time/day</p> <ul style="list-style-type: none"> - active travel/commuting by walk/cycling; number of days, time, day - leisure time PA; number of days, time/day - sitting; time/day 	<p>The GPAQ is a population level questionnaire used by the WHO Steps program for national level cardiovascular surveillance. Used for determining population level trends and prevalence.</p> <p>Validated for use in 16 – 84 year olds¹⁵ ; designed primarily for use in developing countries.</p>	Telephone or self administered	WHO Steps program ¹⁶

<p>PAQ – C/A (Physical Activity Questionnaire for Older Children and Adolescents)</p>	<p>Validated for use with Children and Adolescents 9 – 15 years</p>	<p>7 day recall questionnaires assessing general levels of physical activity</p>	<p>A study by Kowalski, Crocker and Faulkner (1997)¹⁷ supported the validity of the tool against a motion sensor, Leisure Time Exercise Questionnaire, 7 day Physical Activity questionnaires and a step test in a group of 186 older children.</p>	<p>Self reported questionnaire</p>	
<p>Community Health Activities Models Program for Seniors (CHAMPS)</p>	<p>Older adults</p>	<p>Recall period: a typical week during the past 4 weeks. Weekly frequency, duration, intensity of PA in the domains leisure-time/recreation, housework/yard work as well as activities to socialise; option to estimate caloric.</p> <p>Two primary measures calculated: frequency per week of PA converted into minutes per week of PA and calories per week expended in all physical activities.</p>	<p>It has been validated against interviewer-collected data on physical activity as well as sensitivity to change following a moderate intensity PA programme^{18 19}.</p>	<p>Self reported questionnaire</p>	<p>http://sbs.ucsf.edu/iha/champs/</p>

Godin Leisure Time Exercise Questionnaire	Adults	7 day recall. Frequency per week of strenuous (heart beats rapidly), moderate (not exhausting) and mild (minimal effort) exercise for more than 15 minute; frequency of regular activity long enough to work up a sweat.	For use in cross-sectional intervention studies to assess exercise behaviour among population groups.	Self reported questionnaire	Godin and Shephard 1985 ²⁰
Minnesota Leisure time Physical Activity Questionnaire	Adults	Last 12 months recall. Measures frequency, duration of sports, recreational, yard and household activities.	Can be used for both large scale surveillance as well as studies in smaller settings e.g. health facility settings. A number of studies have validated the questionnaire against 48 hour physical activity records, accelerometry and doubly labelled water with strongly correlated results.	Respondents report along a list of 63 activities 'did you perform this activity?'	Richardson et al., 1994 ²¹ , Jacobs 1997 ²² ; Taylor et al., 1978 ²³ ; Fosom et al., 1986 ²⁴ .
Paffenbarger Physical Activity Questionnaire	Adults	Recall period: usual weekday/usual weekend day over the past week or past year. Measures intensity of walking/chair climbing on a usual day;	Can be used to assess global leisure time physical activities retrospective, prospective cohort or intervention studies.		Rauh et al., 1992 ²⁵ ; Ainsworth et al., 1993 ²⁶ ; Washburn et al., 1991 ²⁷ ; Albanes et al., 1990 ²⁸

		duration, intensity, type of PA on a usual wkday/wkend day as well as sitting, reclining, sleeping, participation in PA for long enough to sweat/get out of breath for at least once a week, ave frequency, duration of sport, recreation or other PA in the past year.			
Seven Day Physical Activity Recall (PAR)	Adults	Duration, intensity of leisure time/occupational PA as well as gardening, walking and sleeping during morning/afternoon/evening; option to estimate total kilocalories per day from hours spent on these activities	Appears most appropriate for use in community surveys or controlled experiments with general or clinical populations,	Self reported questionnaire	Sallis 1997 ²⁹ Dishman and Steinhardt 1988 ³⁰ ; Jacobs et al 1993 ³¹ ; Rauh et al 1992 ³² ; Taylor et al 1984 ³³
Scottish Physical Activity Questionnaire	Adults	Recall period: last 7 days Leisure time and occupational PA, stages of exercise behaviour change	To measure outcomes in PA interventions; for use with large sample sizes	Self reported questionnaire	Lowther et al., 1999 ³⁴

EPIC	45-79 year old men and women	Produces a composite measure of physical activity. Unclear whether it detects change as a result of interventions or whether the categories are appropriate for evaluation studies.	Has been validated against motion sensors and all-cause mortality and was found to be predictive of all-cause mortality ^{35 36} .	Developed as a surveillance tool for large epidemiological studies.	
Single item as used in Outdoor Health Questionnaire		Single question: in the past week on how many days have you accumulated at least 30 minutes of moderate intensity physical activity such as brisk walking, cycling, sport, exercise and active recreation? (do not include physical activity that may be part of your usual job or role activities)	Undergoing face validity and test-retest reliability by Loughborough university.		http://www.whi.org.uk/results.asp?key=2537 0 3CB9715613341 p 971 0&parentkey=2537 0 3CB9715613341 p 971 0

References (for appendix)

- 1 Bauman A E, Phongsavan P, Schoeppe S, Owen, N. Physical activity measurement- a primer for health promotion. *Global Health Promotion*, Vol. 13, No. 2, 92-103 (2006)
- 2 Dugdill L, Stratton G. (2007). *Evaluating Sport and Physical Activity Interventions*. Salford. University of Salford/Sport England.
- 3 Blair SN, Haskell WL, Ho P, Paffenbarger RS Jr, Vranizan KM, Farquhar JW, Wood PD. Assessment of habitual physical activity by a seven-day recall in a community survey and controlled experiments. *Am J Epidemiol* 1985; 122:794-804
- 4 Mahabir S, Baer DJ, Giffen C, Clevidence BA, Campbell WS, Taylor PR, Hartman TJ. Comparison of energy expenditure estimates from 4 physical activity questionnaires with doubly labelled water estimates in postmenopausal women. *Am J Clin Nutr* 2006;84:230-236.
- 5 Blair SN, Applegate WB, Dunn AL, Ettinger WH, Haskell WL, King AC, Morgan TM, Shih JA, Simons-Morton DG. Activity Counseling Trial (ACT): rationale, design and methods. *Med Sci Sports Exerc* 1998;30:1097-1106.
- 6 Dugdill L, Stratton G. (2007). *Evaluating Sport and Physical Activity Interventions*. Salford. University of Salford/Sport England.
- 7 Rzewnicki R, Vanden Auweele Y and De Bourdeaudhuij I. (2003) Addressing over-reporting on the International Physical Activity Questionnaire (IPAQ) telephone survey with a population sample. *Public Health Nutr.* 6, 299-305.
- 8 Craig, C. L., et al. (2003). "International physical activity questionnaire: 12-country reliability and validity." *Med Sci Sports Exerc* 35: 1381-95.
- 9 Ekelund U, Sepp H, Brage S, Becker W, Jakes R, Hennings M and Wareham NJ. (2006). Criterion-related validity of the last 7-day, short form of the International Physical Activity Questionnaire in Swedish adults. *Public Health Nutr.* Apr;9(2):258-65.
- 10 Craig, C. L., et al. (2003). "International physical activity questionnaire: 12-country reliability and validity." *Med Sci Sports Exerc* 35: 1381-95.

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- 11 Maddison R, Ni Mhurchu C, Jiang Y, Vander Hoorn S, Rodgers A, Lawes CM, Rush E. International Physical Activity Questionnaire (IPAQ) and New Zealand Physical Activity Questionnaire (NZPAQ): A doubly labelled water validation. *Int J Behav Nutr Phys Act.* 2007 Dec 3;4:62.
 - 12 Maddison R, Ni Mhurchu C, Jiang Y, Vander Hoorn S, Rodgers A, Lawes CM, Rush E. International Physical Activity Questionnaire (IPAQ) and New Zealand Physical Activity Questionnaire (NZPAQ): A doubly labelled water validation. *Int J Behav Nutr Phys Act.* 2007 Dec 3;4:62.
 - 13 Lawton BA, Rose SB, Elley CR, Dowell AC, Fenton A, Moyes SA. Exercise on prescription for women aged 40-74 recruited through primary care: two year randomised controlled trial. *BMJ* 2008;337.doi:10.1136/bmj.a2509.
 - 14 Koebnick C, Wagner K, Thielecke F, Moeseneder J, Hoehne A, Franke A, Meyer H, Garcia AL, Trippo U, Zunft HJ. Validation of a simplified physical activity record by doubly labeled water technique. *Int J Obes (Lond).* 2005 Mar;29(3):302-9.
 - 15 Armstrong T, Bull F. Development of the World Health Organization Global Physical Activity Questionnaire (GPAQ) (2006). *Journal of Public Health.* Volume 14, Number 2.
 - 16 www.who.int/ncd_surveillance/en/stepsinstrumentcore_exp_v1.4.pdf
 - 17 Kowalski, K C, Crocker P R E, Faulkner R A (1997). Validation of the Physical Activity Questionnaire for Older Children. *Pediatric Exercise Science.* 9(2).
 - 18 Stewart, A.L., Mills, K.M., King, A.C., Haskell, W.L., Gillis, D. and Ritter, P.L. (2001): CHAMPS Physical Activity Questionnaire for older adults: outcomes for interventions. *Medicine and Science in Sports and Exercise.* 1126-1141.
 - 19 King, A.C., Castro, C., Wilcox, S., Eyler, A.A., Sallis, J.F. and Brownson, R.C. (2000) Personal and environmental factors associated with physical inactivity among different racial-ethnic groups of U.S. middle-aged and older aged women. *Health Psychology.* 19 (4), 354-364
 - 20 Godin, G. and Shephard, R.J. (1985): A simple method to assess exercise behaviour in the community. *Canadian Journal of Applied Sport Science.* 8, 104-114.

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- 21 Richardson, M.T., Leon, A.S., Jacobs, D.R., Ainsworth, B.E. and Serfass, R. (1994): Comprehensive evaluation of the Minnesota Leisure Time Physical Activity Questionnaire. *Journal of Clinical Epidemiology*. 47 (3), 271-281
 - 22 Jacobs, D.R. (1997): Minnesota Leisure-Time Physical Activity Questionnaire. *Medicine and Science in Sports and Exercise*. Suppl 29 (6), S62-S72.
 - 23 Taylor, H.L., Jacobs, D.R., Shucker, B., Knudsen, J., Leon, A.S. and DeBacker, G. (1978): A questionnaire for the assessment of leisure-time physical activities. *Journal of Chronic Diseases*. 31, 741-755
 - 24 Folsom, A.R., Jacobs, D.R., Caspersen, C.J., Gomez-Marin, O. and Knudsen, J. (1986): Test-retest reliability of the Minnesota Leisure Time Physical Activity Questionnaire. *Journal of Chronic Diseases*. 39, 505-511.
 - 25 Rauh, M.J.D., Hovell, M.F., Hofstetter, C.R., Sallis, J.F., Gleghorn, A. (1992): Reliability and validity of self-reported physical activity in Latinos. *International Journal of Epidemiology*. 21, 966-971.
 - 26 Ainsworth, B.E., Leon, A.S., Richardson, M.T., Jacobs Jr., D.R. and Paffenbarger, R.S. (1993): Accuracy of the College Alumnus Physical Activity Questionnaire. *Journal of Clinical Epidemiology*. 46, 1403-1411
 - 27 Washburn, R.A., Smith, L.L., Goldfield, S.R. and McKinlay, J.R. (1991) Reliability and physiologic correlates of the Harvard Alumni Activity Survey in a general population. *Journal of Clinical Epidemiology*. 44, 1319-1326
 - 28 Albanes, D., Conway, J.M., Taylor, PR, Moe, P.W. and Judd, J. (1990): Validation and comparison of eight physical activity questionnaires. *Epidemiology*. 1, 65-71.
 - 29 Sallis, J.F. (1997): Seven-Day Physical Activity Recall. *Medicine and Science in Sports and Exercise*. Suppl 29 (6), S89-S103.
 - 30 Dishman, R.K. and Steinhardt, M. (1988): Reliability and concurrent validity for a 7-d recall of physical activity in college students. *Medicine and Science in Sports and Exercise*. 20, 14-25
 - 31 Jacobs, D.R., Ainsworth, B.E., Hartman, T.J., Leon, A.S. (1993): A simultaneous evaluation of ten commonly used physical activity questionnaires. *Medicine and Science in Sports and Exercise*. 25, 81-91
 - 32 Rauh, M.J.D., Hovell, M.F., Hofstetter, C.R., Sallis, J.F., Gleghorn, A. (1992): Reliability and validity of self-reported

physical activity in Latinos. *International Journal of Epidemiology*. 21, 966-971.

- 33 Taylor, C.B., Coffey, T., Berra, K., Iaffaldano, R., Casey, K. and Haskell, W.L. (1984): Sevenday activity and self report compared to a direct measure of physical activity. *American Journal of Epidemiology*. 127, 933-941.
- 34 Lowther, M., Mutrie, N., Loughlan, C. and McFarlane, C. (1999): Development of a Scottish physical activity questionnaire: a tool for use in physical activity interventions. *British Journal of Sports Medicine*. 33, 244-249.
- 35 Wareham NJ, Jakes RW, Rennie KL, Schuit J, Mitchell J, Hennings S, Day NE. Validity and repeatability of a simple index derived from the short physical activity questionnaire used in the European Prospective Investigation into Cancer and Nutrition (EPIC) study. *Public Health Nutr*. 2003 Jun;6(4):407-13.
- 36 Khaw KT, Jakes R, Bingham S, Welch A, Luben R, Day N, Wareham N. Work and leisure time physical activity assessed using a simple, pragmatic, validated questionnaire and incident cardiovascular disease and all-cause mortality in men and women: The European Prospective Int J Epidemiol. 2006 Aug;35(4):1034-43. Epub 2006 May 18. Investigation into Cancer in Norfolk prospective population study.