Two short questionnaires on leisure-time physical activity compared with serum lipids, anthropometric measurements and aerobic power in a suburban population from Oslo, Norway

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Abstract

The aim was to indirectly validate two short postal questionnaires measuring leisure-time physical activity (LPA) by comparing the answers with serum lipids and anthropometric measurements.

Methods: All inhabitants aged 31-67 years in two suburban, multicultural areas of Oslo, Norway were invited to “Romsås in Motion”, a community intervention survey, in 2000. Of those, 2950 participants (48%) met and were re-invited in 2003. LPA was measured by two short instruments used since the 1970s (referred to as the Gothenburg instrument) and since 1994 in Cohort of Norway (CONOR). Each instrument was compared with relevant measurements at baseline including LPA according to an adapted version of the long International Physical Activity Questionnaire (IPAQ-L). In addition, changes during 2000-2003 in reported LPA were compared with changes in body weight, waist-to-hip ratio, lipids and other measurements.

Results: LPA measured by the Gothenburg instrument correlated weakly, but consistently with relevant biological and anthropometrical measurements and with IPAQ-L. The correlation coefficients were -0.1 to -0.2 with triglycerides, total-to-high density lipoprotein (HDL)-cholesterol ratio and waist-to-hip ratio, around 0.1 with HDL-cholesterol and 0.3 with maximal aerobic power. For the CONOR instrument a similar pattern was found in both sexes for the hard LPA and in women for light LPA. LPA measured by each short instrument was in line with LPA measured with IPAQ-L.

Conclusions: In a multi-linguistic, suburban population in Oslo, Norway, LPA measurements by each of two short questionnaires were weakly, but consistently correlated with relevant biological and anthropometric measurements and with IPAQ-L.

Key words: Physical activity, Questionnaire, Validation, VO_{2max}, Serum lipids, Waist-to-hip ratio

Background

The recruitment of participants to health surveys depends, among other factors, on the volume of the survey questionnaire – the shorter being the most attractive [1]. This highlights the need for brief instruments for measuring health related behaviours such as physical activity (PA) in large epidemiological studies. A short instrument developed in Gothenburg, Sweden in the 1960s to measure leisure-time PA (LPA) [2, 3] has for decades been used in Norwegian health surveys. This instrument is here referred to as the Gothenburg instrument. A rather similar four-category form on LPA was used in the WHO MONICA project [4]. Since 1994 an additional brief instrument has been used in Norwegian surveys to capture small volumes of LPA more precisely, either as a supplement or alternatively to the Gothenburg instrument. This latter form has been used in the Cohort of Norway (CONOR) with 181,891 participants [5] and is here referred to as the CONOR instrument.

Before being widely used, the Gothenburg instrument was validated by interview and compared with maximal oxygen uptake (VO_{2max}) and working capacity in men [2, 3]. It was found to correlate positively with aerobic capacity in both sexes [6]. In cohort studies it has been negatively associated with coronary heart disease (CHD) and its risk factors [7-9], breast cancer [10], fractures in weight-bearing skeleton [11] and diabetes [12]. A study of this instrument's relationship with serum cholesterol, blood pressure and BMI during 1974-1999 indicated that its construct validity had remained stable over the

25 years it had been in use [13]. The study population included in these analyses did, however not include the two largest cities in Norway.

Demographic changes with urbanization and immigration from non-western countries have taken place, and the prevalence of overweight has increased [14]. Thus, the knowledge concerning the Gothenburg instrument in a relatively mono-cultural and non-obese Norwegian population may not be valid in other settings. Consequently, since this instrument has been used in large cohorts and might be included in future surveys, it is important to update the validity information.

For the CONOR instrument, a validation study performed in a random sample of men aged 20-39 years found moderate agreement for hard LPA with accelerometer (Spearman's rho=0.31) and VO_{2max} (rho=0.46) [15]. In the case of light LPA no significant correlation was found. The CONOR instrument has not been validated with objective measures in women, and has so far not been compared with biological and anthropometric measurements. The CONOR participants will be followed prospectively for various health outcomes.

On this background, the main aim of this study was to indirectly validate LPA measurements by the Gothenburg and the CONOR instruments by assessing the relationship with serum lipids, anthropometric measurements, cardio-respiratory fitness and self-reports according to detailed questions on LPA in the long International Physical Activity Questionnaire (IPAQ-L).

Materials and methods

The "Romsås in Motion" Study

The “Romsås in Motion” Study is a population-based three-year pseudo-experimental community intervention programme including Romsås, a low-income, multi-ethnic population in Oslo, and a similar population in a neighbouring district, Furuset [16, 17]. We used the Gothenburg and the CONOR instruments along with biological and anthropometric measurements and the first version of the long IPAQ-L [18], the latter recently indirectly validated [19]. All 6,140 inhabitants aged 31-67 years, 24 % born in non-western countries, were invited. Baseline tests were conducted between March and May 2000. The participants gave a written consent for the use of their results in research. The Regional Ethics Committee and Norwegian Data Inspectorate approved the study protocol. A total of 2,950 subjects (22% non-westerners) met (47.8% of invited).

Figure 1 shows the flow of participants through the study. Based on demographic and socio-economic variables, the participants appeared to be fairly representative of the invited population [16]. Baseline participants still living in the Oslo area, were invited for the follow-up tests in 2003 (N=2,644). Of those 1,766 (67%) met for the second examination and in all 1,589 filled in the short LPA questionnaires at both occasions (see figure 1). The attendees from the intervention district were invited to a fitness test [20] conducted after each of the surveys.

The main survey questionnaire (Q1) provided information on general health, specific diseases, tobacco smoking, education and LPA according to the short instruments. Participants filled in Q1 at home, prior to any of the survey measurements. A supplementary form was handed out by the survey team (Q2). This form included the long usual week form of IPAQ adapted to Nordic seasonal variation with separate answering alternatives for summer and winter [19]. Both questionnaires were available in

Norwegian, English, Urdu, Turkish, Vietnamese and Tamil. Three sport science students encouraged the filling-in. Of the 2,950 participants, and 2,318 had also completed IPAQ-L in Q2 so that energy expenditure on LPA could be calculated.

The short LPA instruments

In the Gothenburg instrument participants are asked to describe the extent of movement and exertion in their spare time in an average week during the last year. Four answering alternatives include *1) Read, watch TV or other sedentary activities, 2) walk, cycle or move about in some other way at least 4 hours per week – including commuting to work and Sunday walks, 3) take part in physical exercise or sport, do heavy gardening work etc – at least 4 hours a week, 4) exercise hard or take part in competitive sport regularly and several times a week.*

The CONOR instrument consists of two separate questions on leisure time spent on hard and light intensity LPA, respectively, in an average week during the last year, including commuting to work. The duration of *hard LPA, defined by "making you sweat or feel out of breath" was to be quantified on a four-category scale (zero, < 1 hour, 1-2 hours, or ≥ 3 hours per week). Light LPA "not making you sweat or feel out of breath"* was to be quantified on the same scale.

Measurements

Body weight (in kg, one decimal) and height (in cm, one decimal) were measured in light clothes with an electronic device (DS 102, Arctic Heading, Norway) [16]. Body mass index (BMI) was calculated as kg/m^2. The waist and hip circumferences were measured in standing position with a flexible steel device to the nearest 0.1 cm. The waist was measured at the level of umbilicus or, in obese persons, at the maximum between the iliac crest and the lowest rib. The hip was measured at its maximum. Waist-to-hip ratio was computed as waist/hip circumference. Non-fasting serum was analysed for total cholesterol, HDL-cholesterol, triglycerides and glucose.

Physical fitness was estimated by the UKK walk test, implying two kilometres of fast walking at constant speed and measurements of time and heart rate at the finish line [20]. VO_{2max} (maximal oxygen consumption in millilitre per kg body weight per minute,) and a fitness index (aerobic power as a percentage of the predicted age mean) were calculated.

Statistical analysis

Low education was defined as nine years or less of formal education and low income as less than 18,750 EURO per year. Persons born in Western Europe, North America, Australia and New Zealand were categorised as westerners. Exercise categories according to the Gothenburg and the CONOR instrument were expressed as ordinal groups. Metabolic equivalents (METs) were computed according to LPA reported in IPAQ-L. Linear trends across ordinal groups were tested using ANOVA. All p-values are two tailed.

Each short instrument was compared with biological and anthropometric measurements at baseline and with changes during 2000-2003. Correlations were measured by Spearman's rank correlation coefficient (rho) using Z-test for significance testing. We used linear regression for comparing the association of LPA measured by each of the short instruments (in ordinal groups) and LPA according to IPAQ-L (in METs-min). In these analyses LPA according to the Gothenburg instrument and according to IPAQ-L were included in parallel so that one measurement could be controlled for by the other. The same procedure was made for the CONOR instrument on hard LPA and LPA according to IPAQ-L. Data analyses were performed with SPSS 14.0 (SPSS, Inc. Chicago, IL, USA).

Results

In all 1238 men and 1550 women (95% of participants) filled in the Gothenburg instrument. Among men, 38% reported the lowest level of LPA, while 47% did light exercise at least four hours a week and 15% did heavier exercise regularly (category 3 and 4 merged). In women these figures were 29%, 62% and 8%, respectively. In both genders, the more physically active had longer education and were more likely to be westerners, and waist- to-hip ratio and triglycerides decreased slightly across the ordinal groups (all p-values <0.001). A similar pattern was seen for the CONOR instrument on hard LPA. In women, mean BMI decreased by higher volumes of LPA, but in men no significant difference in BMI was seen between the four LPA categories for any of the short instruments.

The correlations of the short LPA instruments with biological and anthropological measurements are shown in Table 1. The Gothenburg and the CONOR instrument on hard LPA showed rho values around -0.1 with waist-to-hip ratio, triglycerides and total-to-HDL-cholesterol ratio and HDL-cholesterol (rho 0.12) for men. In women these values were slightly higher, up to - 0.19 for triglycerides, and significant correlations were seen also with BMI. The CONOR instrument on light LPA showed significant correlations with these measurements in women only, and the correlations were slightly weaker than for hard LPA.

Among the 422 persons (176 men and 246 women) who attended the walking test, the mean fitness index was 84 (SD 29) in men and 91 (SD 22) in women. The correlation coefficients for the Gothenburg and the CONOR hard LPA instruments with age-adjusted VO_{2max} were all 0.3 in both sexes (all $p<0.001$). In men reporting no hard LPA (N = 53) no significant association was found between light LPA and VO_{2max} while in women (N =84) the rho value was 0.3 ($p<0.01$).

Table 2 shows rho values around -0.1 for the correlation of changes in reports by the Gothenburg instrument with changes in body weight and total-to-HDL-cholesterol ratio in both sexes. In women a similar correlation was found also with triglycerides and waist-to-hip ratio. For the CONOR instrument we found weak correlations of changes in reported LPA with changes in relevant measurements. The total volume of METs from LPA (Figure 2a) and METs from hard LPA (Figure 2b) in IPAQ-L were consistently increased by the four categories of the Gothenburg instrument. Calculations showed statistically significant differences in METs between each category of the short questionnaire (Figure 2 a and b).

Similarly, the relation of METs computed from light to moderate LPA in IPAQ-L was consistently increased with light LPA categories according to the CONOR instrument (Figure 3a), and hard LPA in IPAQ-L was consistently increased with the CONOR instrument categories on hard LPA (Figure 3b). Linear trends were seen in all these panels.

We finally assessed the associations of LPA according to the Gothenburg instrument and the CONOR instrument on hard LPA with waist-to-hip ratio, triglycerides and HDL-cholesterol as dependent variables, controlling for LPA measured by IPAQ-L (Table 3). Both short LPA instruments were significantly associated with the dependent variables when controlling for IPAQ-L, with beta values around -0.1 for all three outcomes (Table 3). With the short LPA instruments included in the model, LPA measured by IPAQ-L showed by far weaker associations with the outcomes and only the association with waist-to-hip ratio in men was statistically significant.

Discussion

The main finding in this study was that LPA measured by the Gothenburg instrument or by the CONOR instrument on hard LPA correlated strongly with LPA measured by IPAQ-L and weakly, but consistently, with relevant anthropometrical and biological measurements. The rho values were around 0.1-0.2 with lipids and anthropometric measurements and 0.3 with fitness index and VO_{2max}. In women only, similar correlations were found for the CONOR instrument on light LPA. Thus, except for light LPA according to the CONOR instrument in men, the pattern for the short LPA instruments was consistent with positive correlations for LPA with cardio-respiratory fitness and HDL-cholesterol and negative correlations of LPA with lipids and weight-related indicators. The least weak correlations were found with waist-to-hip ratio, triglycerides and HDL-cholesterol, indicators that are all known to be associated with PA [21-23]. This indicates that the short instruments give some, but far from the full information on real volumes of LPA.

Weak associations of PA questionnaires with indirectly related measures have been found by others as well. In Harvard Alumni Activity Validity Studies, the correlation coefficients were around 0.2 for HDL-cholesterol, -0.1 to -0.2 for BMI and 0.3-0.6 for VO_{2max}. The Minnesota Leisure Time Physical Activity Survey Validation Studies found correlations of -0.2 with percent body fat and 0.5 with VO_{2max} [24]. The main reason for the weaker associations of LPA with lipids and anthropometric measurements is probably influence by other factors than PA, such as diet, inheritance and general health. Such influence may be relatively large in a population like ours, with rather low volumes of PA [16, 17]. Correlations of PA questionnaires with simultaneous directly recorded PA by the double-labelled water method, motion sensors or activity diaries are stronger, with rho values around 0.3-0.7 in most studies [15, 18, 24, 25], comparable with our findings for vigorous LPA with fitness index and VO_{2max} (rho=0.3). It should be noted that the participants in the fitness test constituted a self-selection of probably more physically fit persons, and that there is fairly strong evidence for a graded dose response relationship between PA and VO_{2max} [26].

The Gothenburg instrument

It is worthy to note that the indirect validity of the global Gothenburg instrument was at least on the level of the more specific CONOR question of hard LPA. In particular, when comparing the changes in LPA with changes in body weight, waist-to-hip ration and serum lipids during 2000-2003, the rho values were higher for the Gothenburg instrument. An advantage of the Gothenburg instrument could be that the answering alternative for the lowest LPA volume introduces other praiseworthy leisure-time interests, such as reading, as an example. This could counteract over-reporting by making the bottom LPA alternative more comfortable to choose, compared with IPAQ and the CONOR instrument offering “zero”. As Romsås in Motion was an intervention project, a majority of “zero” answers could even be linked with a feeling of shame.

The CONOR instrument

The CONOR instrument on hard LPA was thought to be more specific for measuring activity related with cardio-respiratory fitness and to discriminate LPA volumes more precisely than the Gothenburg instrument, implying that a stronger correlation with fitness index and VO_{2max} could be expected. For the baseline correlations no difference was suggested between these instruments, but for correlations of changes the rho values were slightly higher for the CONOR instrument on hard LPA.

A recent validation study in young men concluded that the utility of the CONOR light LPA instrument remains to be established [15]. Light PA is in general less easily remembered and reported [24] and more prone to overestimation compared with heavier activities [25]. We found in this study, somewhat surprising, that the indirect validity in women was nearly the same for light and hard LPA, although no correlation was seen in men. Slightly more women (46%) than men (40%) reported some light, but no hard LPA on regular basis, and women are, possibly, more likely than men to remember and report activity considered as light. Interestingly, a recent Danish study showed a linear dose-response relationship between PA and indirectly related cardiovascular risk factors from low PA to moderate PA, but no associations by still higher volumes of PA [23], in contrast to the dose-response relationship of PA and VO_{2max} [26].

LPA measured by the two short questionnaires and by IPAQ-L

In the baseline data, each of the short PA instruments was significantly associated with waist-to-hip ratio, triglycerides and HDL-cholesterol when controlling for IPAQ-L. On the other hand, LPA measured by IPAQ-L did not show significant associations when controlled by the short instruments. This result was unexpected as the more detailed IPAQ-L was thought to be superior. In the interpretation, it should be noted that the univariate associations with lipids and anthropometric measures for IPAQ-L [19] did not differ much for IPAQ-L and the short instruments. Second, the association between changes in LPA reported by IPAQ-L and changes in fitness index and VO_{2max} from 2000 to 2003 were less weak, with rho values 0.1-0.3 [19], compared with the not statistically significant rho values between zero and 0.2 for the short LPA instruments. However, the associations of changes in lipids, body weight and waist-to-hip ratio were weaker for IPAQ-L [19] than for the short instruments. The findings are consistent with a hypothesis of IPAQ being the best alternative for measuring recent, cardio-respiratory related LPA, and the short instruments being the slightly better at measuring habitual LPA within a broader range of intensity.

If the result of our regression analysis presented in Table 3 really reflects a slightly higher indirect validity for the short instruments than for IPAQ-L, it may be explained by IPAQ-L being particularly prone to over-reporting in the population we studied. Over-reporting has been strongly suggested as a problem by use of IPAQ, and for the long version in particular [18, 19, 25]. This problem may well be exaggerated in a low-income, multi-ethnic population like the one we studied. It has been shown, for the short version of IPAQ that those who over-reported tended to be more abdominally obese, to have poorer physical fitness and to have less education [27]. When evaluating the main result of the Romsås in Motion intervention study, we chose to rely on the short instruments rather than IPAQ-L because of indications of over-reporting in the baseline data [28].

All taken together, both short LPA instruments were more feasible than IPAQ-L in the population we studied. The response rates for the short instruments were higher, and IPAQ-L was possibly more prone to over-reporting. However, an obvious limitation of the Gothenburg instrument is that PA levels below four hours a week cannot be quantified, and both short instruments fail to give details which are important for PA monitoring and health promotion. For health surveys in multi-linguistic settings, a relatively short personal interview or a short questionnaire on types and arenas of PA may be a good choice, together with motion detectors for quantitative purposes.

Limitations

The methodological limitations of a study like this are, in principle, selection bias, information bias and confounding. Surely, the participants we studied (48%) were not fully representative for the total population in the two suburbs. An analysis based on record linkage for all invited to the Oslo Study, of which our cohort was a part, found indications of lower socioeconomic status and less good health in non-participants compared with participants, but concluded that associations between variables were most probably not flawed by selective participation [29].

Confounding refers to one or more "third factors" that might influence the reported LPA and as well biological and anthropometric measurements in a way that flaws the results. Here, regular use of alcohol and the use of oestrogen in women could be thought to act in this way, as both are known to increase HDL-cholesterol [30, 31]. However, the overall systemic oestrogen use was low, 10.4% of the women, and no more than 8.8% of men and 6% of women reported to use alcoholic beverage 2-3 times in a week or more often. Measurement errors and imprecise measurements, including random errors and variation between measurers, are known to dilute true associations. In this study, variability between study nurses was found for waist measurement [28], but for the purpose of this study it is considered to be random. The blood samples were taken non-fasting, after a mean of 2.3 hours' fast [28]. A study comparing fasting and non-fasting lipid values concluded that total cholesterol and HDL-cholesterol were similar while non-fasting and fasting triglycerides were closely related (fasting triglycerides = 36.6 + 0.61 x non-fasting triglycerides) [32].

Conclusions and potentials

In conclusion, the Gothenburg questionnaire and the CONOR instrument on hard LPA showed weak, but consistent associations with relevant biological and anthropometric measurements. For women this was found for light LPA as well. These findings update and supplement earlier knowledge about LPA instruments used in large European cohorts which will continue to be used for research.

In the multi-linguistic population we studied, the indirect validity of the short questionnaires on LPA was at least on the level of IPAQ-L. For future cohort studies which include PA among many covariate factors, one of the short questionnaires we studied can be used for ranking people by habitual LPA. But the short instruments fail to give information on details which are important for PA monitoring, research and health promotion. For public health surveys in multi-linguistic settings, motion detectors are perhaps the best choice for quantitative purposes and a relatively short personal interview or a short questionnaire on types and arenas of PA may be a good choice, together with motion detectors for quantitative purposes.

Competing interests

The authors declare that they have no competing interests.

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Figure legends

Figure 1. Flow chart for the Romsås in Motion participants.

Figure 2. Mean METs values calculated for total (a) and hard (b) LPA reported by IPAQ-L by the four categories in the Gothenburg instrument, both sexes.

Figure 3. Energy expenditure on total light to moderate LPA according to IPAQ-L by the four categories in the CONOR instrument (a, left panel) and total hard LPA in IPAQ-L by categories of the CONOR instrument on hard LPA (b, right panel), both sexes.

Table1. Correlation of leisure-time physical activity measured by the Gothenburg and the CONOR instruments with body mass index (BMI), waist-to-hip ratio, triglycerides, HDL-cholesterol and total-to-HDL-cholesterol ratio.

	BMI	*Waist/hip*	*Triglycerides*	*HDL-chol.*	*Total/HDL*
Men, N=1238					
Gothenburg, LPA	.01	-.10**	-.11***	.12***	-.12***
CONOR, hard LPA	-.01	-.12***	-.12***	.13***	-.12***
CONOR, light LPA[1]	-.01	-.01	-.05	.02	-.01
CONOR, light LPA[2]	-.04	-.01	-.03	.03	.00
Women, n=1550					
Gothenburg, LPA	-.15***	-.13***	-.19***	.16***	-.14***
CONOR, hard LPA	-.08**	-.13***	-.14***	.08**	-.08**
CONOR, light LPA[1]	-.13***	-.08**	-.10***	.11***	-.07*
CONOR, light LPA[2]	-.12**	-.08**	-.11**	.14*	-.01

[1]Adjusted for hard LPA; [2]478 men and 677 women with no hard LPA included in analysis; *p < 0.05; ** p < 0.01; *** p< 0.001

Table 2. Correlation of changes in reported LPA with changes in measurements 2000-2003.

	Weight	Waist-to-hip	Triglycerides	Total/HDL	Fitness index	VO_{2max}
Men, N=721					N=47	
Gothenburg	-.10**	-.05	-.06	-.08*	.04	-.00
CONOR hard	-.09*	-.01	.01	-.04	.11	.16
CONOR light[1]	.04	.02	-.02	.02	-.05	.03
Women, N=864					N=55	
Gothenburg	-.08*	.07*	-.09**	-.10**	.03	.05
CONOR hard	-.04	-.05	-.02	-.05	.18	.07
CONOR light[1]	-.09	-.06	.00	-.04	.09	.21

[1]In 223 men and 312 women with no hard LPA at T1; *p < 0.05; ** p < 0.01.

Table 3. Associations of the Gothenburg instrument and the CONOR instrument on hard LPA with anthropometric measurements and serum lipids, controlling for LPA according to IPAQ-L and vice versa. Results of linear regression analysis.

	Waist- to-hip ratio		Triglycerides		HDL-cholesterol	
Men, N=1020	Beta[5]	P-value[6]	Beta[5]	P-value[6]	Beta[5]	P-value[6]
Gothenburg instrument[1]	-0.11	0.001	-0.15	< 0.001	0.13	< 0.001
Total LPA, IPAQ-L[2]	-0.07	0.03	-0.04	0.2	0.00	0.9
Hard LPA, CONOR[3]	-0.10	0.002	-0.12	< 0.001	0.10	0.002
Hard LPA, IPAQ-L[4]	-0.06	0.06	-0.05	0.1	0.01	0.7
Women, N=1298						
Gothenburg instrument[1]	-0.13	< 0.001	-0.17	< 0.001	0.16	< 0.001
Total LPA, IPAQ-L[2]	-0.03	0.3	-0.01	0.8	0.02	0.5
Hard LPA, CONOR[3]	-0.13	< 0.001	-0.11	< 0.001	0.07	0.02
Hard LPA, IPAQ-L[4]	-0.02	0.54	-0.01	0.7	0.02	0.5

[1]Controlled for total LPA measured by IPAQ-L; [2]Controlled for LPA measured by the Gothenburg instrument; [3]Controlled for hard LPA measured by IPAQ-L; [4]Controlled for hard LPA measured by the CONOR instrument; [5]Standardised coefficient; [6]p-value for the regression.