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Review

The "Saltin–Grimby Physical Activity Level Scale" and its application to health research

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The use of a four-level questionnaire to assess leisure time physical activity (PA) and its validation is reviewed in this paper. This questionnaire was first published in 1968 and has then been used by more than 600 000 subjects, especially in different population studies in the Nordic countries. A number of modifications to the questionnaire have been published. These are mostly minor changes, such as adding practical examples of activities to illustrate the levels of PA. Some authors have also added duration requirements that were not included for all levels of PA in the original version. The concurrent validity, with respect to aerobic capacity and movement analysis using objective measurements has been shown to be good, as has the predictive validity with respect to various risk factors for health conditions and for morbidity and mortality.

Physical inactivity is considered by the World Health Organization (WHO) to be the fourth most important risk factor for overall death globally (WHO, 2009). The increasing use of physical activity (PA) for prevention and treatment of disease highlights the importance of assessing the level of PA in the health care setting as well as in research. There is no general accepted "Gold standard" for PA assessment, but while more objective methods have been developed in recent years (i.e., accelerometry), different questionnaires remain common and easy to use both clinically as well as for research purposes.

One of the oldest existing such questionnaires, consisting of four levels of PA, was originally developed by Lindholm, Lundgren, and Saltin in Sweden and first published by Saltin and Grimby (1968). It was designed to estimate physical activity both occupationally and during leisure time. Here, we report the use and the modifications of the leisure time PA part and its validation. The intention of the present paper is not to perform a full formal systematic review.

Two different ways of data collection have been performed. Usually self-reported (or self-administrated) questionnaires, e.g., sent out by mail, have been used, but in some studies an interview has been conducted (Bengtsson, 1973; Tibblin & Wilhelmsen, 1975; Wilhelmsen et al., 1976; Engström et al., 2001; Matthiessen et al., 2008).

The original questionnaire (Saltin & Grimby, 1968) (Table 1) was used to estimate physical activity level in middle-aged former male athletes (orienteers). In population studies in Malmö (Lindgärde & Saltin, 1981), the original version was also used, as well as by Salonen et al. (1988, 1981) in Finland and in a recent Swedish study (Trimpou et al., 2010).

Modified versions and the use of the leisure time PA questionnaire (For details of all available modified versions, see Table S1 (published electronically)).

The questionnaire with different modifications became well spread in the Nordic countries. It has also appeared in few studies outside the Nordic countries, however, not included in the present report.

In *Sweden*, the questionnaire was used in a population study in Göteborg, which included 793 male subjects all born in 1913 (Tibblin & Wilhelmsen, 1975). Some more practical examples of activities were given and an average of at least 3 h/week for the activities in level 3 was introduced (Wilhelmsen et al., 1971). In population studies of 1405 women (Bengtsson, 1973), some other examples of activities,

Table 1. The original version of the leisure time physical activity questionnaire (Saltin & Grimby, 1968) and the version called SGPALS (Saltin–Grimby Physical Activity Level Scale) (Rödjer et al., 2012) with the modifications shown in bold

Level 1 **Sedentary.** *Being almost completely inactive*: reading, TV watching, movies, **using computers or doing other sedentary activities during leisure time.**
Level 2 *Some physical activity during at least 4 h/week as* riding a bicycle or walking to work, walking or skiing with the family, gardening**, fishing, table tennis, bowling, etc.**
Level 3 *Regular* ***physical*** *activity* ***and training (moderate PA)*** *such as* heavy gardening, running, **swimming,** calisthenics, tennis, **badminton and similar activities for at least 2–3 h/week.**
Level 4 *Regular hard physical training for competition* ***sports (vigorous PA)****:* running events, **orienteering, skiing, swimming,** soccer, racing, European handboll, etc. Several times per week.

Levels are in the original version called groups.

such as golf, aerobic exercise, and dancing were added for the activities in levels 3 and 4 (Lissner et al., 1996). The questionnaire was subsequently used in publications from different population studies originating from Göteborg, as in the Primary prevention study (Wilhelmsen et al., 1971). In the MONICA study, requirement of 2–3 h of activity was included for level 3 (Rosengren & Wilhelmsen, 1997). It was also used in population studies from the county of Skaraborg, Sweden (Persson et al., 1994) in a slightly modified form.

In addition, in a study by Byberg et al. (2001) the questionnaire used was referred to as originating from the Saltin–Grimby questionnaire. However, the questions were formulated somewhat differently and there was no duration requirement for level 2 and few or no examples of activities were given. In a small study by Johansson and Westerterp (2008), the required frequency and duration of activity differed rather markedly from the original version. Level 2 was divided into two 1. Light activities approximately once a week and 2. Moderate activities at least once a week or gardening or walking to work 10–30 min/day. For level 3, regular activities more than once a week were required.

In a study by Engström et al. (2001) on a cohort of men born in 1914 in Malmö, 2–3 h/week for level 3 was added to the original version and some modifications in the examples were made. Furthermore, in a publication by Jonsdottir et al. (2010) only 2 h and not as in the original 4 h were required for level 2. Duration requirements were also given for levels 3 and 4.

In a recent study based on the INTERGENE cohort by Rödjer et al. (2012) on 3588 men and women (25–74 years), some additional minor modifications of the questionnaire were made (Table 1). Computers were added as a modern example of sedentary activity and fishing, table tennis and bowling as examples of activities in level 2. In level 3, the duration requirement was at least 2–3 h/week and also exemplified by swimming and badminton. In level 4, orienteering, skiing, and swimming were added as examples. The questionnaire was given the acronym SGPALS (Saltin–Grimby Physical Activity Level Scale). The SGPALS is now being used in the ongoing large Swedish Cardiovascular Bioimage Study (SCAPIS), which will include around 30 000 middle-aged Swedes (Bergström et al., 2015). The aim of SCAPIS is to identify individuals with risks for different cardiovascular and pulmonary disease. The study includes extensive testing protocol, including assessment of PA level and various imaging methods.

In *Denmark*, the questionnaire has been used in studies by Schnohr and coworkers, also with modifications made, including changes in the wordings, but also adding number of hours per week for the activities in levels 3 and 4, particular that in level 3 light physical activity of >4 h/week was accepted as an alternative for more strenuous activity (2–4 h/week). The questionnaire was used in 14 223 healthy men and women aged 20–79 years in the Copenhagen City Heart Study (e.g. Schnohr et al., 2003), see also the doctoral thesis (Schnohr, 2009), and it was then renamed as "The Copenhagen City Heart Study Leisure Time Physical Activity Questionnaire" or "The Copenhagen City Heart Study LTPA-Questionnaire".

Other research groups in Denmark also modified the questionnaire, including Sjøl et al. (2003) and Christensen et al. (2006). In the later study, the required time periods for levels 2 and 3 differed slightly from the version used by Schnohr and coworkers. In Matthiessen et al. (2008), several modifications were made, as for level 1 the alternatives were "mainly sedentary" or "<2 h/week light physical activity". For level 3, alternatives were "light physical activity >4 h/week" or "vigorous activity 2–4 h/week. Hegaard et al. (2008), studying the association between leisure time PA and risk for preterm delivery time, used requirements of length of activity for level 2 of >3 h weekly and for level 3 of 3 h weekly.

In *Norway*, the PA questionnaire was first used by Hjermann et al. in the 1972–1973 Oslo study, followed by in the Tromsø study 1974. Later it was used in the large population-based cardiovascular surveys carried out by the National Health Screening Survey in cooperation with the universities and local health authorities in selected counties in Norway (Thelle et al., 1976; Bjartveit et al., 1979; Hjermann et al., 1981; Løchen & Rasmussen, 1992; Joakimsen et al.,1998, Morseth et al., 2011). Furthermore, Holme et al. (1981), Hansen et al. (2013) and others used it in the Oslo study. Both the Oslo study and the Tromsø Heart Study followed standardized procedures that laid the basis for the county studies.

Few or no additional examples of activities were included in the questionnaire. In some of the studies from these surveys, a duration requirement of at least 4 h a week was introduced for level 3, see, e.g., the analysis of data from 1975 to 2010 (n = 375 682) by Solbraa et al. (2014).

The surveys undertaken during the years 1994–2003, were later pooled into the COhort of NORway, or CONOR. The purpose of CONOR was to investigate causes of disease on a broad basis. The total number of participants was around 200 000 (Naess et al., 2008). CONOR contains health data including lifestyle, social variables and blood samples, and is based on collaboration between the Norwegian Institute of Public Health and the universities of Oslo, Bergen, Trondheim, and Tromsø. (Visit www.fhi.no for further details on CONOR.)

In *Finland*, the questionnaire was used by Salonen et al. (1981) when studying the relation between changes in PA level and changes in serum cholesterol and body weight. The scale was dichotomized with levels 1 and 2, and 3 and 4, respectively treated together. It was then used in the Helsinki Heart Study (Mänttäri et al., 1987) and the Helsinki Policemen study (Pyörälä et al., 1998) probably in a slightly modified form, however, no details on the modifications were presented. In the MONICA study, Hu et al. (2005) used duration requirements of at least 4 h/week for level 2, as in the original version, and for level 3 at least 3 h/week. In this study, the original levels 3 and 4 were treated together.

Validation of the questionnaire

The original questionnaire or variants of it have been studied with respect to concurrent validity, or by relating the level of PA to objective measures such as maximal oxygen uptake and recently to accelerometer data. The scale has also been used as a measure of predictive validity, i.e., to discriminate between different outcome measures, such as risk factors, general health, morbidity and mortality.

Reproducibility

Reproducibility studies with repeated assessments of the PA are few. Batty (2000), using duration requirements of at least 4 and 3 h/week for levels 2 and 3, respectively and with similar examples as in the original, reported a kappa-value of 0.64 with administration by personal interview 4–6 weeks apart in 41 men with maintained PA level. Sjøl et al. (2003) using self-reported questionnaire, also with duration requirements of at least 4 and 3 h/week for levels 2 and 3, respectively, found an agreement of 86% between two assessments 1 month apart in 29 subjects.

Concurrent validity

Maximal oxygen uptake has been shown to be positively correlated with leisure time PA, using the original scale, in 42 years old subjects with activity levels 1, 2, 3, and 4 corresponding to 36, 36, 38, and 44 for maximal oxygen uptake expressed in mL/kg/min, respectively (Saltin, 1977). The scale has also been validated against estimated maximal oxygen uptake from cycle tests in a population of 54 years old men (Wilhelmsen et al., 1976), showing a significantly higher ($P < 0.005$) maximal oxygen uptake, in persons reporting levels 3 and 4 than in those reporting levels 1 and 2. A moderate correlation (0.40–0.44) was found between the self-reported PA level and maximal oxygen uptake measured in a population of around 10 000 persons. Somewhat weaker correlation (0.25–0.28) was seen when PA level was related to accelerometer measured PA (Emaus et al., 2010). A poorer overall correlation (r = 0.24) between self-reported PA level and maximal oxygen uptake, was shown in a large Norwegian population study (near 4000 subjects 20–90 years of age), indicating that only 5.7% of the differences in maximal oxygen uptake could be explained by the PA scores (Loe et al., 2013), as also similar (r = 0.3) in a study by Graff-Iversen et al. (2008), but more strongly correlated with the International Physical Activity Questionnaire.

In a study from Denmark on 138 healthy subjects, a good correlation (0.64) was demonstrated between the PA level, assessed by a modification of the original questionnaire, and PA measured by the position and motion instrument ActiReg (Matthiessen et al., 2008). Another, smaller study, demonstrated a good agreement between measurement of PA with the double water method and the results from the questionnaire (Johansson & Westerterp, 2008), but using a rather modified version of the questionnaire. The SGPALS version was found to identify individuals fulfilling the national PA recommendations, with a sensitivity of 55% and a specificity of 70% (area under the curve, AUC 0.64) in a recent study by Ekblom et al. (personal communication).

Predictive validity

The predictive validity of the self-reported PA level scale was shown for coronary risk factors by Thelle et al. (1976). Thune et al. (1998) showed that maintaining or increasing the self-assessed PA-levels during 7 years of follow-up improved the cardiovascular risk factor profile. A population study of around 330 000 men and women aged 40–42 years, by Aires et al. (2003) showed that rating of PA level could discriminate between different levels of BMI and blood lipids, in particular HDL cholesterol. Changes in

leisure time PA during the period 1974–1999 was also recorded and a similar pattern of blood lipids and BMI in relation to the self-assessed PA level was seen, which indicates that the validity of the self-reported PA had remained stable over these 25 years. In 40 years old men, but not in women, a relationship between increasing levels of PA and risk for atrial fibrillation was seen (Thelle et al., 2013).

The current SGPALS scale was shown to discriminate between different levels of several major cardiovascular risk factors, for example smoking, triglycerides, high- and low-density lipoproteins, waist circumference, overweight, resting heart rate, resting plasma-glucose, but not to hypertension (Rödjer et al., 2012).

Leisure time PA has been shown to predict the risk for cardiovascular diseases, cancer, and all-cause mortality, assessed after 20 years of follow-up, and adjusted for major risk factors (Rosengren & Wilhelmsen, 1997; Thune et al.,1997; Schnohr et al., 2002; Hu et al., 2005). In a study on around 15 000 persons, the original version of the questionnaire was used to study the ability of leisure time PA assessment to predict the risk of death from ischemic heart disease (Salonen et al., 1988). The questionnaire has also been related to future stress-related disease (Jonsdottir et al., 2010) and to self-perceived stress (Rödjer et al., 2012), and self-perceived work ability (Arvidson et al., 2013). Reduced leisure time physical activity was shown to increase the risk for fractures (Joakimsen et al., 1998), for obesitas (Anderssen et al 2008), and for diabetes mellitus type 2 (Jacobsen et al., 2002). The leisure time physical activity, but not the occupational activity, assessed with the original version of the scale was associated with reduced risk for hip fractures in a 30-year follow-up study of around 7500 men (Trimpou et al., 2010). Concerning global health aspects there are distinct differences in health benefits from occupational versus leisure time PA with leisure time PA decreasing the risk for long-term sickness absence, whereas occupational PA increased the risk as shown for the Danish National working Cohort of more than 7000 workers (Holtermann et al., 2012).

Discussion

The development of a practical, user-friendly PA-self assessment questionnaire for clinical and research purposes, was achieved by the introduction of the four-level scale (Saltin & Grimby, 1968). The questionnaire has since then been modified, partly because it was necessary to incorporate more modern examples of leisure time activities. Importantly, several attempts to validate the questionnaire have been performed through the years. The questionnaire has mainly been used to grossly assess the physical activity levels in, e.g., population studies. However, the scoring with the questionnaire may not be sensitive enough for quantifying the changes in physical activity pattern and to study in intervention studies the causal relationship between different types and amount of physical activity and health issues.

There are important aspects to be considered regarding the various modifications of the original questionnaire. These modifications obviously make comparisons between studies more difficult. Modifications may, however, also have improved the specificity of the different PA levels of the questionnaire. The idea behind the questionnaire was to identify activity levels with possible physiological and health effects. The level of activity may indeed be of different importance for different types of health effects. Peter Schnohr (2009) pointed out that the assessment of the intensity of physical activity was based on the participants′ own perception and that a relative scale of intensity may in fact be more appropriate than an absolute scale, particularly when the age-span is large.

Comparisons of PA as assessed by the questionnaire and measurements or prediction of maximal oxygen uptake have been made (Wilhelmsen et al., 1976; Saltin, 1977; Emaus et al., 2010). However, the conclusions from such a comparison are limited as conceptually PA level and exercise capacity are different. The correlation between self-perceived PA and PA by accelerometry, is significant, but remains rather low. In general, individuals tend to substantially exaggerate their level of PA (Hagströmer et al., 2007).

The number of studies, that have validated the questionnaire, both for concurrent and predictive validity, has increased in later years, including the current version of the scale, SGPALS. However, still more such studies are needed, especially with regard to gender aspects.

In several reports, the questionnaire used has remained faithful to the original version without adding more than minor modifications. That being said, it may be useful to introduce duration requirements also for level 3 and maybe 4, which has been done in several modifications, and not only for level 2 as in the original questionnaire. However, this needs further validation. Mixing two intensities of activity within one activity level is not to recommend and makes the interpretation of the results difficult. The development of a 6-graded scale (Grimby, 1986; Mattiasson-Nilo et al., 1990) can be mentioned as a way to increase the discrimination of physical activity levels, especially for subjects with low levels. However, it has to be further validated in larger studies.

In summary, we are rather impressed by the extended use of the questionnaire (more than

600 000 subjects studied so far), especially during the last decades. Even though more detailed validation and reproducibility studies are needed, the questionnaire has been proven to reliably categorize individuals into four different self-assessed leisure time PA level groups, that are associated with different risk factors, morbidity and health as well as future mortality, i.e., the predictive validity is repeatedly high. The difference in impact of occupational and leisure time PA is to be noticed, although not further elucidated in the present report.

We would also like to stress the importance, when using the questionnaire, of clearly describing any modifications made to the original questionnaire, and also encourage the authors to offer an explanation of the rationale for the modifications. In the methodology section of such papers, our recommendation is to write "based on the idea of the questionnaire published by Saltin and Grimby in 1968" or similar, rather than saying that the original questionnaire was used, when this is not the case. The latest modification called SGPALS (Rödjer et al., 2012) with more modern examples of activities and a duration requirement also for level 3 in addition to level 2, can at present be recommended for use.

Key words: Physical activity, leisure time, questionnaire, validation.

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Supporting Information

Additional Supporting Information may be found in the online version of this article.

Table S1. Various modifications of the original leisure time physical activity questionnaire published by Saltin and Grimby (1968) and for historical reasons in chronological order, when new modifications have been published. The specific modifications are underlined. The procedure for data collection is presented under Comments.

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