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Can Karnofsky Performance Status be Transformed to the Eastern Cooperative Oncology Group Scoring Scale and Vice Versa?

Eugenia Verger, Manel Salamero and Carlos Conill

There is no consensus regarding the equivalence of performance status between the Karnofsky (KPS) and the Eastern Cooperative Oncology Group (ECOG) scales. In the present study KPS and ECOG scores were compared in 150 consecutive cancer patients. An empirical relation was established through regression analysis in a subsample of 75 patients and the results tested in the second subsample. Transformation tables including 95 and 66% confidence intervals were calculated. Both performance scales are highly correlated, but inferences about individual patients were subject to a high level of error. These results stress the difficulty of translating one score to another, especially in the range of lower performance status where a wide spread is observed.
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INTRODUCTION

THE KARNOFSKY performance status (KPS)[1] and the Eastern Cooperative Oncology Group (ECOG) [2] scales are the most widely used methods of assessing functional status in cancer patients. Both scales have been shown to correlate well with patient survival [3–7]. They have also been used as an outcome measure to compare differences in the functional abilities of patients before and after treatments, as well as patient selection and stratification of cancer clinical trials.

In the last 5 years according to Medline database, 227 (34.1%) of the 666 papers published regarding performance status assessment mention in the abstract the scale used. Of these, 114 (50%) employed the KPS scale and 113 (50%) used the ECOG scale.

In spite of the widespread use of these scales, data regarding the relationship between scores are limited. Oncologists usually use one of the two scales in clinical practice, and only seldom have both scales been referred to in the same study.

We have found no prospective study regarding the relationship between the two scales in the literature and there is no agreement in different equivalences derived from clinical experience. In fact, the equivalence proposed by the American Joint Committee of Cancer (AJCC) [8, 9] differs from that published in oncology text books [10, 11] (Table 1).

As KPS has more categories and is more specific than ECOG scoring, each ECOG value should correlate with more than one KPS scale value. Location of patients in high and low performance status does not represent a major problem. There is considerable disagreement concerning the intermediate valis, which are used as a cut off point to recruit patients in clinical trials. For instance, for a KPS between 30 and 50, the corresponding ECOG will vary from 3 to 2 in the AJCC equivalence to a 4–3 in Minna *et al.* [10, 11] correlation. This may produce bias in patient selection criteria and could contribute to the differences found between studies.

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Table 1. Comparison between AJCC and Minna et al. equivalences. Hits and misses in a patient sample (n = 150)

ECOG score	AJCC [8, 9] KPS score	AJCC [8, 9] Hits (%)	Minna *et al.* [10, 11] KPS score	Minna *et al.* [10, 11] Hits (%)
0	90–100	100.0	100	96.7
1	70–80	12.2	80–90	93.9
2	50–60	36.7	60–70	50.0
3	30–40	35.0	40–50	50.0
4	10–20	0.0	20–30	52.4

KPS = Karnofsky performance status, ECOG = Eastern Cooperative Oncology Group.

Table 2. Equivalences between ECOG and KPS

KPS	Expected ECOG: Point estimation	66% confidence interval	95% confidence interval
100	0	0–1	0–1
90	1	0–1	0–2
80	1	1–2	0–2
70	2	1–2	1–3
60	2	2–3	1–3
50	3	2–3	2–4
40	3	3–4	2–4
30	4	3–4	3–4
20	4	4	3–4

KPS = Karnofsky performance status, ECOG = Eastern Cooperative Oncology Group.

The aim of the study was focused on the equivalence between both scales, translating one score to another, and to infer an empirical relationship by means of regression analysis including confidence intervals.

PATIENTS AND METHODS

150 consecutive out-patients between the ages of 23 and 91 (mean 60.0 years) attending the radiotherapy clinic were assigned both KPS and ECOG scores by one physician.

The inspection of the plots of KPS vs. ECOG scores (Fig. 1) suggest a linear relationship. Tentative linear regression analyses were therefore proposed. In order to assess the transformation models in independent groups, the total sample of patients was randomly subdivided into two subsamples each of 75 patients. Linear regression analysis was performed in both groups which provided the expected ECOG score from KPS, and another linear regression analysis was performed to obtain the expected KPS score from the ECOG evaluation. Both sets of regression coefficients and their confidence intervals were compared. In addition, the Brown–Mood simultaneous contrast of β_0 (intercept) and β_1 (slope) were performed to assess statistically significant differences between the coefficients.

To reach the final equation, the linear regression analysis was repeated in the whole sample. Student's residual plots were examined to search for violations of linearity or equality of variance assumptions. Standard error estimated as an overall measure of error was used to construct the confidence intervals. The real curvilinear distribution of errors which affects extreme scores was disregarded because the evaluation of both scales reached a ceiling level.

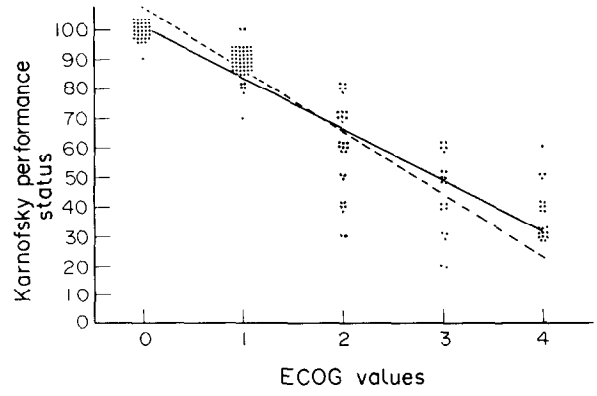

Fig. 1. Plot of Karnofsky performance status (KPS) and Eastern Cooperative Oncology Group (ECOG) values for each patient (n = 150) and regression lines for expected KPS and ECOG scores. _ Expected KPS; ---- expected ECOG.

RESULTS

Pearson's correlation between KPS and ECOG scores were −0.90 and −0.89, respectively, in each subsample, which indicates a good linear relationship between the two sets of scores.

The coefficients of the regression equation for the expected KPS as function of the ECOG scores were $\beta_0 = 101.628$ and $\beta_1 = -17.661$ in the first subsample and $\beta_0 = 101.229$ and $\beta_1 = -17.294$ in the second one.

The coefficients in the second subsample were within the 95% confidence interval of the first sample. The Brown–Mood simultaneous contrast of these coefficients did not reach statistical significance.

The following coefficients were obtained for the expected ECOG as function of the KPS score: $\beta_0 = 4.938$ and $\beta_1 = -0.046$ in the first subsample and $\beta_0 = 5.166$ and $\beta_1 = -0.048$ in the second.

The coefficients in the second sample were within the 95% confidence interval of the first sample. The Brown–Mood test was not statistically significant.

For the global sample (n = 150), the regression analysis yielded the following transformation equations: expected KPS = 101.427 − 17.447 × ECOG (S.E. = 10.650) and expected ECOG = 5.087 − 0.047 × KPS (S.E. = 0.554). The inspection of the student's residuals did not reveal any systematic trend, suggesting a non-linear relationship.

Both regression lines are represented in Fig. 1, in addition to the observed relations between KPS and ECOG scores. From these equations and its respective standard errors two tables (Tables 2 and 3) were constructed, one for KPS to ECOG and another for ECOG to KPS transformations. Each table contains the point estimation and the 66 and 95% confidence intervals.

The level of agreement between the two equivalence tables was strong with the correlation proposed by Minna *et al.* [10, 11], but not with the AJCC as is shown in Table 1.

Table 3. Equivalences between ECOG and KPS

ECOG	Expected KPS: Point estimation	66% confidence interval	95% confidence interval
0	100	100–90	100–80
1	80	90–70	100–60
2	70	80–60	90–50
3	50	60–40	70–30
4	30	40–20	50–10

KPS = Karnofsky performance status, ECOG = Eastern Cooperative Oncology Group.

DISCUSSION

Performance status assessment is a well-recognised prognostic factor and is used to assign the patient to controlled clinical trials. We have found some difficulties in evaluating studies from different institutions, as some assess patient status with the KPS scale and others with the ECOG scale. There has been agreement to date among different authors regarding the equivalences between scales. Moreover, for research and clinical purposes, not only a transformation table but also an estimation of the error probability is necessary.

Equivalence between these scales gives rise to several questions. From the metric point of view, it is firstly difficult to delimit the measurement level, and secondly, both scales have a different range of scoring. Regarding the former, KPS and ECOG are strictly speaking ordinal scales, formed by discrete categories which explore patient performance status. Moreover, the span between contiguous values does not represent the same magnitude of dysfunction. For instance, in the ECOG scale, the difference between score "5" (death) and "4" (bedridden 100%) is difficult to consider as equivalent to the difference between the "1" category score (symptomatic but ambulatory) and score "0" (normal activity). Nevertheless, both scales attempt to assess the patients' functional ability which is a continuum with infinite graduations between extremes. This last concept is assumed in our statistical procedures.

Another aspect worthy of comment is the possible linear relationship between the two tools. The data plotted in Fig. 1 suggest linear model statistics. In the present study, the correlation between the two scales indicates great common variance, which fully justifies obtaining an equivalence system to aid comparisons. Nevertheless, the transformation tables (Tables 2 and 3) derived from regression equations, and the observed score distributions (Fig. 1) express that in spite of the high correlation, the expected values are submitted to important levels of error. As shown in Fig. 1, the correlations between KPS 100 and 90 with ECOG 0 and 1 are excellent, while the lesser performance statuses show a pronounced variation and do not translate easily into each other. If an investigator needs to convert a KPS to an ECOG score with 95% confidence a wide ECOG interval of three values must be used, which represents a high level of inaccuracy (Table 2). If one uses a narrower interval of two points, as is usual in practice, the accepted confidence is 66%, which means accepting error in one of every three cases. From the two existing equivalence tables compared here, Minna *et al.* [10, 11] tables are strongly adjusted to our empirical data, but correspond with an error risk of 33%. The same is true for the conversion of ECOG scores to KPS (Table 3).

In summary, although a high level of interjudgement reliability and a high correlation between the two scales have been demonstrated in a previous study [12], the inferences about individual patients is open to many pitfalls. Since performance status scales have been recognised as an important prognostic factor in survival and consequently used as a trial selection criterion, it is mandatory in multicentric studies to choose one or another scale, because any possible equivalence system implies a high error level. This paper stresses the difficulty of translating one score to another, especially in the range of lower performance statuses where a wide spread is observed. The decision about which scale better fulfils the aims of a study is beyond the scope of this paper.

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