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Interconversion of three measures of performance status: An empirical analysis

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ABSTRACT

Purpose: To construct empirically a conversion table to convert performance status scores among the Eastern Cooperative Oncology Group (ECOG), Karnofsky Performance Status (KPS) and Palliative Performance Scale (PPS) measures, using a large sample of patients with advanced cancer.

Methods: Seven physicians completed assessments on 1385 consecutive patients attending an oncology palliative care clinic, or admitted to an acute cancer palliative care unit. The three measures were distributed as a questionnaire package; the order in which they were presented was randomly assigned for each week. Scales were compared using the hit rate and the weighted kappa coefficient (κ_w). The KPS and PPS were compared directly; for comparisons of either scale with the ECOG, all 70 possible categorisations of KPS and PPS were computed. An 'ideal' categorisation was selected based on maximisation of both statistical methods.

Results: The KPS and PPS matched in 1209 out of 1385 assessments (hit rate 87%; κ_w 0.97). For both the KPS and the PPS, the categorisation of 100 (ECOG 0), 80–90 (1), 60–70 (2), 40–50 (3), 10–30 (4) had the highest hit rate (75%), and the second highest κ_w (0.84, $p < 0.0001$). One other combination had a slightly higher κ_w (0.85 for both KPS and PPS), but a lower hit rate (73% for KPS, 72% for PPS).

Conclusions: We have derived empirically a conversion scale among the ECOG, KPS and PPS scales. The proposed scale provides a means of translating amongst these measures, which may improve accuracy of communication about performance status amongst oncology clinicians and researchers.

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1. Introduction

Performance status represents a global assessment of a patient's functional capacity, which reflects the additive physical, physiological and psychological effects of the disease process. In research settings, measures of performance status are used to assess eligibility and stratify patients for cancer clinical trials[1] and to assess the predicted or actual efficacy of anti-cancer treatment. In clinical practice, performance status is used to estimate prognosis,[2–5] to predict toxicity and likelihood of response to therapy[6] and to assess needs for services such as home care.[7] Performance status assessments have also been incorporated into measures of quality of life.[8,9] Measures of performance status are generally completed by physicians, although inter-rater reliability among different disciplines is good.[10–13]

The scales most commonly used in oncology for performance status assessment are the Karnofsky Performance Status (KPS) and the Eastern Cooperative Oncology Group (ECOG) scales (Fig. 1).[14,15] The KPS, developed in 1948,[14] is an 11-point scale with scores ranging from 100 (normally active) to 0 (dead). The Eastern Cooperative Oncology Group (ECOG) scale was developed in 1960, and is a simpler 6-item scale that ranges from 0 (normal activity) to 5 (death).[15] More recently, the Palliative Performance Scale (PPS) was developed, based on a modification of the KPS, to aid decision making and communication in palliative care settings.[7] Similar to the KPS, it is an 11-point scale that includes assessment of ambulation, activity, extent of disease and self-care; in addition, oral intake and level of consciousness are also assessed (Fig. 1).

The reliability and validity of the KPS and PPS measures have been established in several studies,[16–19] as has the excellent intra- and inter-rater reliability of the KPS and ECOG scales among physicians.[16,20,21] The PPS is increasingly regarded as the scale of choice in palliative care settings,[22] while either the ECOG or the KPS scale is typically used in general oncology care. In order to improve communication among health care providers who use different measures, it is important to understand how scores on these measures correspond to each other.

Two prospective studies – both published more than a decade ago[23,24] – have assessed interconversion of the ECOG and the KPS measures. In one study, one physician conducted assessments on 150 patients attending a radiation therapy clinic.[23] Using linear regression, point estimates and confidence intervals were derived; these showed a high level of error, especially in the lower ends of performance status. In the other, two physicians conducted assessments on 536 patients with lung cancer accrued over 6 years, which were evaluated using non-parametric statistics.[24] More recently, investigators prospectively evaluated 75 patients with advanced non-small cell lung cancer with both ECOG and KPS; patients with ECOG 0–2 or KPS $\geqslant$60 were eligible.[25] Correlation of the two scales was fairly high ($r = 0.75$), but 21 patients with ECOG 2 were as likely to be rated as having KPS 60, 70 or 80. Conclusions from these studies are limited because they included small numbers of patients and/or only patients with lung cancer. No previous studies have examined systematically all possible KPS–ECOG combinations and none included the PPS measure.

The purpose of our study was to assess whether it was possible to construct an accurate conversion table to convert scores among the ECOG, PPS and KPS measures. Specifically, we hypothesised that there would be a high level of agreement between the PPS and the KPS measures, since the PPS was derived from the KPS.[7] For the conversion between PPS or KPS and ECOG, we made no assumptions about which combination would have the best agreement. Rather we empirically tested all possibilities.

2. Materials and methods

2.1. *Study setting and procedures*

The study was conducted at Princess Margaret Hospital, a comprehensive cancer centre which is a member of the University Health Network (UHN) in Toronto, Canada. Eligible patients were all those attending the Oncology Palliative Care Clinic (OPCC) or admitted to the Lederman Palliative Care Centre (PCC), a 12-bed acute palliative care unit. The study initially began in the OPCC; to increase the numbers of patients with poor performance status, the study was expanded to the PCC, concentrating on patients with poor performance status.

The OPCC and the PCC are components of a larger palliative care programme at UHN. Patients are referred to the OPCC by their medical, radiation or surgical oncologist, for assessment and management of pain, other symptoms and palliative care planning. In the OPCC, patients are routinely assessed first by a registered nurse (RN) case manager, who takes an initial history, and then by a palliative care physician who completes a full assessment lasting one to two hours. The PCC is staffed by an interdisciplinary team; most patients are admitted for symptom management (75%), while a smaller percentage are admitted for respite care, terminal care or transitional care to a longer term palliative care unit.[26] Approximately 40% of patients die on the unit; 40% are discharged home and 20% are discharged to community palliative care units or hospices.[26]

Seven physicians completed the PPS, ECOG and KPS for each of their respective patients at the end of the consultation (OPCC) or at the time of admission (PCC). The three measures were distributed as a questionnaire package to the physicians, who were instructed to circle the appropriate assessment score for each scale. The order in which the three scales were presented was randomly assigned for each week, and physicians were instructed to complete the measures in the order in which they appeared in the package. The physicians work exclusively in an oncology setting and were previously familiar with the measures. They received no formal training on completion of the measures, but written information about the scales was provided at the beginning of the study. The study was approved by the University Health Network Research Ethics Board.

Karnofsky Performance Status Scale (KPS)[14]	Eastern Cooperative Oncology Group Performance Status (ECOG)[15]	Palliative Performance Status Scale Version 2 (PPSv2)[7]					
		PPS Level	Ambulation	Activity & evidence of disease	Self-Care	Intake	Conscious level
100 – Normal; no evidence of disease	**0** – Fully active, no restriction in pre-disease performance	**100**	Full	Normal activity & work; no evidence of disease	Full	Normal	Full
90 – Minor signs or symptoms	**1** – Restricted in physically strenuous activity but ambulatory and able to carry out light work	**90**	Full	Normal activity & work; some evidence of disease	Full	Normal	Full
80 – Normal activity with effort; some signs or symptoms	**2** – Ambulatory; capable of all self-care but unable to work; up more than 50% of waking hours	**80**	Full	Normal activity with effort; some evidence of disease	Full	Normal or reduced	Full
70 – Cares for self; unable to carry on normal activity	**3** – Capable of only limited self care; confined to bed/chair > 50% waking hours	**70**	Reduced	Unable to do normal job/work; significant disease	Full	Normal or reduced	Full
60 – Occasional assistance required; capable of most self-care	**4** – Not capable of self-care; totally confined to bed/chair	**60**	Reduced	Unable to do hobby/house work; significant disease	Occasional assistance necessary	Normal or reduced	Full or confusion
50 – Requires assistance, frequent medical care	**5** - Dead	**50**	Mainly Sit/Lie	Unable to do any work; extensive disease	Considerable assistance required	Normal or reduced	Full or confusion
40 – Disabled; requires special care/assistance		**40**	Mainly in Bed	Unable to do most activity; extensive disease	Mainly assistance	Normal or reduced	Full or drowsy +/-confusion
30 – Severely disabled; hospitalisation indicated		**30**	Totally Bed Bound	Unable to do any activity; extensive disease	Total Care	Normal or reduced	Full or drowsy +/-confusion
20 – Hospitalisation necessary; requires active supportive care		**20**	Totally Bed Bound	Unable to do most activity; extensive disease	Total Care	Minimal to sips	Full or drowsy +/-confusion
10 – Moribund; progressing rapidly		**10**	Totally Bed Bound	Unable to do most activity; extensive disease	Total Care	Mouth care only	Drowsy or coma +/-confusion
0 - Dead		**0**	Death	-	-	-	-

Fig. 1 – The Karnofsky, Eastern Cooperative Group and Palliative Performance Status Scales.

2.2. *Statistical methods*

Demographic and clinical variables were summarised using descriptive statistics. To compare the performance scales, two statistical measures were used: the hit rate and the weighted kappa coefficient. The hit rate represents the proportion of cases for which the two performance scales agree. However, the hit rate alone does not account for the level of disagreement between the scales or for the agreement by chance.[27] We therefore also calculated the weighted kappa coefficient (κ_w), which is a chance-corrected measure of agreement, ranging from 0 (no agreement) to ±1 (perfect positive or negative agreement). Fleiss–Cohen weights were used to penalise disagreements further away from the diagonal.[28]

The possible values for the scales ranged from 100 to 10 (10 categories) for the KPS and the PPS, and from 0 to 4 (5 categories) for the ECOG. The KPS and the PPS could be directly compared due to their equal number of categories, but for comparison with the ECOG it was necessary to categorise scores on both KPS and PPS into 5 groups. In order to select the ‘ideal’ categorisation, all 70 possible categorisations of KPS and PPS were computed. For example, one possible

Table 1 – Demographic characteristics of study population.

Characteristic ($N = 1385$)	
Sex	
Male *n* (%)	655 (47)
Female *n* (%)	730 (53)
Age in years *median* (*range*)	63 (20–100)
Primary disease site *n* (%)	
Gastrointestinal	356 (26)
Lung	239 (18)
Genitourinary	165 (12)
Breast	154 (11)
Gynaecological	133 (10)
Brain	80 (6)
Head/neck	76 (6)
Haematology	66 (5)
Skin	59 (4)
Other[a]	23 (2)
Unknown primary	22 (2)
Endocrine	12 (1)

[a] Other tumours/disease sites included sarcoma, thymus, chordoma and germ cell tumours.

categorisation of KPS is: 10–20, 30–50, 60, 70–80 and 90–100. Each possible categorisation was separately compared against the ECOG scale using the hit rate and the weighted kappa coefficient. The categorisation that maximised both the hit rate and the absolute weighted kappa coefficient was selected as the best conversion between KPS or PPS versus ECOG.

Statistical analyses were performed using SAS version 9.1 (SAS Institute, Cary, NC) and R version 2.7.1 (www.r-project.org). All statistical tests were two-sided and *p*-values less than 0.05 were considered statistically significant.

3. Results

3.1. *Study population and patient characteristics*

From April 1, 2007, to December 31, 2008, 3291 complete performance status assessments were made on 1385 patients. Out of 3291 performance evaluations, 3108 were measurements for outpatients and 183 were measurements for inpatients. The overall completion rate was 80% (82% for outpatients and 56% for inpatients). In order to reduce the cohort to a single measurement per patient, the assessment with the poorest performance status was selected per patient; in case of a tie in performance, the earliest assessment was selected. This selection method was used to obtain a more even distribution of performance scores, which would otherwise be weighted heavily towards patients with good performance status. Thus, in the selected cohort, there was a single assessment for each of the 1385 patients; of these 145 (11%) were for inpatients and 1240 (89%) were outpatients.

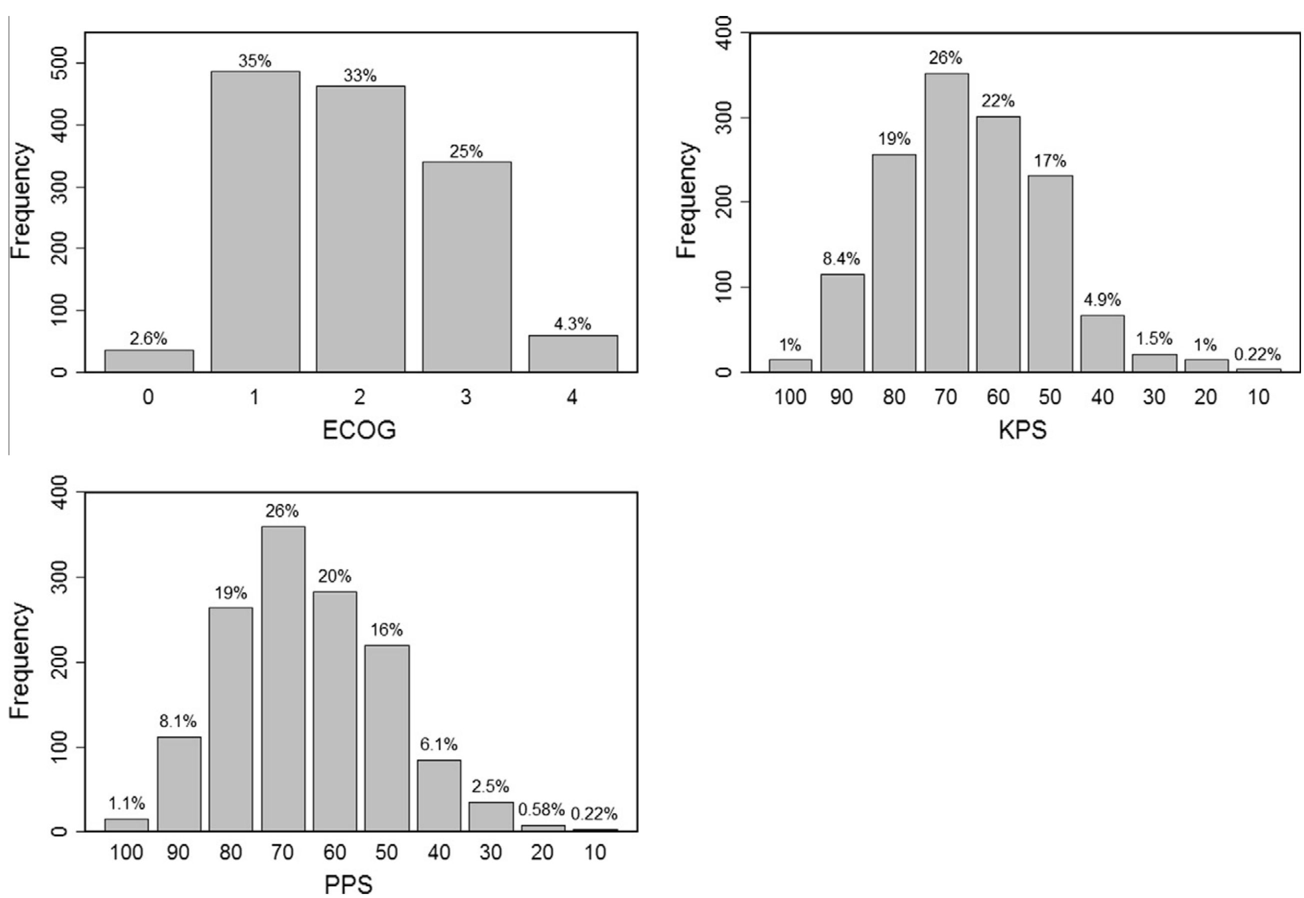

Fig. 2 – Summary of Performance Status Scales ($N = 1385$).

Table 2 – Comparison of KPS and PPS scales.

KPS	PPS										Total
	100	90	80	70	60	50	40	30	20	10	
100	14										14
90	1	101	13								115
80		11	232	13							256
70			18	323	11						352
60			1	23	264	12	1				301
50				1	8	194	28				231
40						14	47	6			67
30							7	24	1		32
20							2	5	7		14
10										3	3
Total	15	112	264	360	283	220	85	35	8	3	1385

Hit rate = 1209/1385 = 87%.
Weighted kappa coefficient = 0.97.
p-Value < 0.0001.

Patient characteristics are outlined in Table 1. The median age was 64 (range 20–100) and 53% were female. The majority of patients had a primary tumour of gastro-intestinal (26%), lung (18%), genitourinary (12%), breast (11%) or gynaecologic source (10%). Frequencies of individual scores for the three performance scales are summarised in Fig. 2. The ECOG assessments ranged from 0 to 4, with 35% and 33% having ECOG scores of 1 and 2, respectively. The distribution of KPS and PPS ranged from 100 to 10 with a median score of 70.

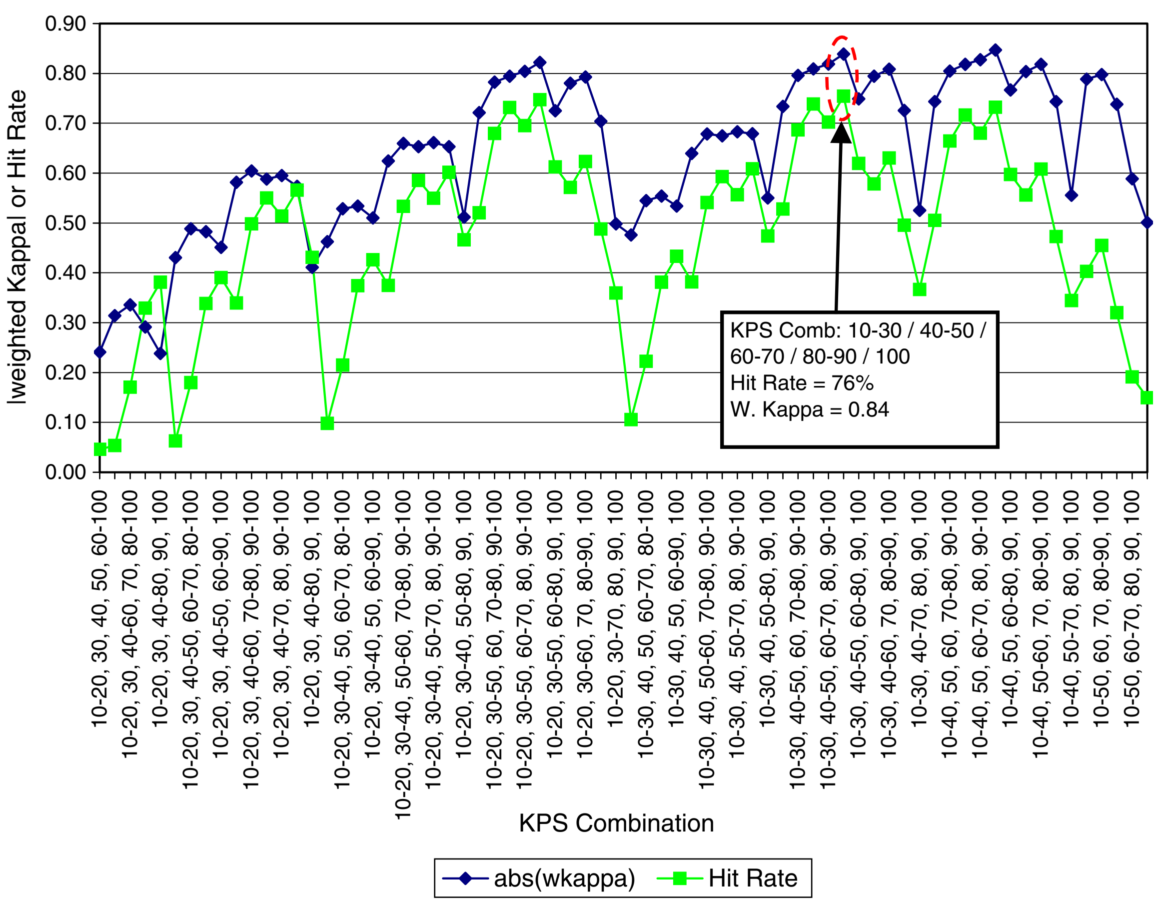

Fig. 3 – Weighted kappa coefficient and hit rate for all 70 possible categorisations of KPS versus ECOG, including the best possible combination. *Note*: the red circle highlights the best categorisation of KPS, which maximises both hit rate and κ_w. For clarity of presentation, only every second combination is labelled in the *x*-axis. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

Table 3 – Hit rates for the proposed conversion between ECOG and KPS or PPS.

ECOG	KPS					PPS				
	KPS	MHR	(%)[a]	MHR	(%)[b]	PPS	MHR	(%)[a]	MHR	(%)[b]
0	100	14/14	(100)	14/36	(39)	100	15/15	(100)	15/36	(42)
1	80–90	314/371	(85)	314/486	(65)	80–90	314/376	(84)	314/486	(65)
2	60–70	415/653	(64)	415/463	(90)	60–70	410/643	(64)	410/463	(89)
3	40–50	264/298	(89)	264/340	(78)	40–50	273/305	(90)	273/340	(80)
4	10–30	38/49	(78)	38/60	(63)	10–30	40/46	(87)	40/60	(67)
Hit rate	1045/1385 (75%)					1052/1385 (76%)				

Abbreviation: MHR, marginal hit rate.
[a] Number and percentage of KPS or PPS scores correctly predicted by ECOG.
[b] Number and percentage of ECOG scores correctly predicted by KPS or PPS.

3.2. *Conversion analyses: KPS versus PPS*

Table 2 displays the comparison between KPS and PPS scores. The KPS and the PPS ratings matched in 1209 out of 1385 assessments, resulting in a hit rate of 87%. The weighted kappa coefficient of 0.97 corroborated this finding ($p < 0.0001$).

3.3. *Conversion analyses: KPS versus ECOG*

Fig. 3 displays the individual hit rates and the absolute weighted kappa coefficients for all 70 possible categorisations of KPS when compared to ECOG ratings, including the categorisation with the highest combined hit rate and kappa value. The KPS categorisation of 10–30, 40–50, 60–70, 80–90 and 100 had the highest hit rate (75%, ranging among individual physicians from 71% to 79%), and the second highest absolute weighted kappa coefficient (0.84; $p < 0.0001$), indicating a high level of agreement with ECOG scores. There was one other combination (10–40, 50, 60–70, 80–90 and 100) with a slightly higher absolute weighted kappa coefficient (0.85), but the hit rate for that combination was lower at 73%.

Table 3 shows the marginal hit rates between this 'ideal' KPS categorisation and the corresponding ECOG scores. Marginal hit rates describe the proportion of cases, within a specific category of the referent scale, correctly predicted by the other scale. For example, out of 298 patients with KPS 40–50, 264 were correctly predicted by the ECOG 3 category, resulting in a marginal hit rate of 89%. Alternatively, out of 340 patients with ECOG 3, 264 were correctly predicted by the KPS 40–50 category, resulting in a marginal hit rate of 78%.

3.4. *Conversion analyses: PPS versus ECOG*

Similar to the KPS versus ECOG analysis, all 70 possible categorisations of PPS were compared to the ECOG scale (figure not shown). The best categorisation of PPS was the same as the ideal KPS categorisation: 10–30, 40–50, 60–70, 80–90 and 100. This categorisation again had the highest hit rate (76%; range among physicians from 72–80%) and the second highest absolute weighted kappa (0.84; $p < 0.0001$). Table 3 presents the comparison between this PPS combination versus ECOG. Again, the combination (10–40, 50, 60–70, 80–90 and 100) had a higher absolute weighted kappa coefficient (0.85), but the hit rate for that combination was lower at 72%.

4. Discussion

In this study, we have derived empirically a scale to convert scores among the ECOG, KPS and PPS scales using a large sample of patients with advanced cancer (Table 4). Although other studies have compared the ECOG and KPS,[23–25] this is the first study to include the PPS, and the first to include a large number of patients with different tumour types. It is also the first study to assess KPS–ECOG performance scale equivalences by testing the level of agreement for all possible combinations of KPS, and selecting the optimal categorisation based on the empirical results, rather than by starting from a previous non-empirically derived scale. This method reduces investigator bias in determining the optimal conversion between KPS/PPS and ECOG.

The level of agreement between the KPS and the PPS scales was high, as hypothesised. Of the 176 disagreements between the two scales, only 6 (3%) measurements were more than one level apart. These disagreements were equally likely to be due to an overestimation or an underestimation of PPS versus KPS scores (52% versus 48%). Overall, these two measures are roughly equivalent and assessments can be used interchangeably.

The levels of agreement for the ECOG–KPS/PPS conversions were also high at 75% and 76%, respectively. When KPS/PPS scores were predicted by the ECOG, most disagreements occurred in the ECOG 2, KPS 60–70 categorisation (64% marginal hit rate). Upon inspection of cross-tabulations, it was determined that this was generally due to KPS 70 being

Table 4 – Proposed conversion table for KPS, PPS and ECOG.

KPS	PPS	ECOG
100	100	0
90	90	1
80	80	
70	70	2
60	60	
50	50	3
40	40	
30	30	4
20	20	
10	10	

scored as ECOG 1 rather than as ECOG 2. This ambiguity can be explained by the wording of the scales. For example, it might vary according to the patient and/or scoring physician, whether someone who cares for themselves but is 'unable to carry on normal activity or to do active work' (KPS 70) is classified as 'ambulatory, and capable of all self care but unable to carry out any work activities' (ECOG 2) or 'restricted in physically strenuous activity but ambulatory and able to carry out work of a light or sedentary nature, e.g. light house work, office work' (ECOG 1).

In predicting ECOG scores from the KPS/PPS, the greatest discrepancies were for very high scores, likely due to the smaller numbers of patients in these categories. For example, there were small numbers of patients in the oncology palliative care clinic with KPS 100 ('normal, no complaints, no evidence of disease'). Thus, patients with ECOG 0 ('fully active, able to carry on all pre-disease performance without restriction') might be less likely to be marked KPS 100, because there were only a few patients with KPS 100 attending the clinic.

Other investigators have proposed conversion scales and/or assessed them empirically. The originally proposed conversion scales between ECOG and KPS were based on inspection of the scales, rather than on empirical data. In 1977, the American Joint Committee for Cancer (AJCC) proposed a conversion scale of KPS 10–20 (ECOG 4), 30–40 (3), 50–60 (2), 70–80 (1), 90–100 (0). This conversion was presented in the first edition of the AJCC Cancer Staging Manual and appeared in subsequent editions,[29] but was not empirically derived and no longer appears in the most recent edition.[30] In the 1980s, Minna and colleagues proposed a conversion of KPS 20–30 (ECOG 4), 40–50 (3), 60–70 (2), 80–90 (1), 100 (0).[31] Although the KPS categorisations were based on a study of predictors of survival by Stanley,[32] the latter study did not include the ECOG; thus this ECOG–KPS conversion was again not empirically derived. As far as we are aware, no published scale exists for conversion among the PPS and the ECOG scales.

Two studies empirically compared the ECOG–KPS interconversions proposed by AJCC and Minna and colleagues[23,24]: Verger and colleagues assessed 150 patients in a radiation oncology clinic and Buccheri and colleagues assessed 536 patients with lung cancer. In both studies, the conversion scale proposed by Minna and colleagues was found to be superior. For example, in the study by Buccheri and colleagues, the overall hit rate for the conversion proposed by Minna and colleagues was 79%, whereas the conversion proposed by the AJCC had an overall hit rate of 45%. Verger and colleagues derived point estimates for conversion from the ECOG to KPS, and from KPS to ECOG. For example, the point estimate for ECOG 2 was KPS 70, with a 66% confidence interval of 60–80 and a 95% confidence interval of 50–90. Of note, the point estimates for conversion from KPS to ECOG correspond precisely to the results for interconversion of the two scales obtained in our study, and our results correspond to the scale proposed by Minna and colleagues, with the expansion of the 20–30 category to 10–30 in our version.

Our study has several limitations. Despite instructions to rate performance status according to the descriptions of the measures provided in the study packages, physicians might have had preexisting conceptions of equivalent scores. However, this would have been even more likely in other studies, where physicians completed measures by memory rather than in study packages,[23–25] or where only one physician made assessments.[23] Due to the relatively few patients with very low or very high performance scores, categorisation and conversion may be less accurate at the two extremes. However, previous studies have had even lower numbers of patients with poor performance status. For example, in the study by Buccheri and colleagues, only 11 patients had an ECOG score of 4,[24] whereas in our study there were 60 patients in this categorisation. In the study by Verger and colleagues, which had a total sample size of 150, the low numbers of patients with poor performance status are stated as a limitation, though the exact numbers are not given.[23] We attempted to address this problem by extending the study to include inpatients with poor performance status, and by selecting the assessment with the lowest performance status when multiple assessments were available. Because the large majority of assessments were performed on outpatients, with a small, select percentage of inpatients, this study is most representative of an outpatient setting.

Another limitation of our study is the lack of information on patient survival. Our purpose was to create categories based on physician assessments, rather than on survival data. Survival categorisations are distinct from those of clinically derived equivalencies, and may be confounded by the predictive capacity of each scale. Although Minna and colleagues cite survival data for their KPS–ECOG categorisations,[33] these data were based exclusively on the KPS, as the study from which they were derived did not include the ECOG measure.[32] Buccheri and colleagues compared the predictive validity of the ECOG and the KPS measures for categories of $\geqslant$80 versus <80 and 0, 1 versus 2–4 and found that the ECOG scale was more predictive.[24] These categorisations were chosen because there were equal numbers of patients in the higher and the lower performance status groups; further comparative studies are needed in this area.

It would be ideal, for comparative purposes among trials and cancer centres, to establish a common international measure of performance status. This is particularly the case for the PPS and the KPS, which have a high level of agreement. One solution would be to determine which measure has the greatest prognostic predictive capacity. However, there is no evidence in the literature of convergence towards a single measure. In that regard, a recent PubMed search (June 2010) of 'Karnofsky Performance Status or KPS' limited to clinical trials or randomised controlled trials in the last 5 years, retrieved 297 citations; 'Eastern Cooperative Oncology Group or ECOG' with the same limitations retrieved 545. For the PPS, 28 citations were retrieved. Although the PPS might be most relevant in palliative care settings, its introduction has created further heterogeneity in assessment at a time of increasing integration of palliative care into general oncology.[34–36] All the three scales reduce a multidimensional construct into categories of observed variables that are not necessarily discrete. However, the proposed conversion scale provides an empirically derived means of translating amongst these measures, which has the potential to improve the accuracy of communication about performance status amongst oncology clinicians and researchers.

Conflict of interest statement

There were no conflicts of interest for any of the authors.

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