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ORIGINAL ARTICLE

Clinical significance of weight changes at diagnosis in solid tumours

Niamh O'Donoghue[1,2] · Shiva Shrotriya[3] · Aynur Aktas[3,4] · Barbara Hullihen[3,4] · Serkan Ayvaz[5] · Bassam Estfan[3,4] · Declan Walsh[1,2,3,4]

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Abstract

Purpose Weight changes occur throughout the cancer trajectory. Most research has focused on changes during or after treatment, so clinical significance of change at diagnosis remains unclear. This study aimed to determine prevalence, predictors and prognostic significance of weight changes at diagnosis in outpatients with solid tumours presenting to a tertiary academic medical centre.

Methods A retrospective study of the electronic medical record was conducted ($n = 6477$). Those with weight recorded within 6 months of cancer diagnosis (pre-diagnosis, T_0) and 2 subsequent weights (diagnosis, T_1; final visit, T_2) were identified ($n = 4258$). Percentage weight change was categorised into four bands (0.1–2.4%; 2.5–5%; 5.01–9.9%; ≥ 10%) for gain and loss. A stable category was also included.

Results Mean age is 61 ± 12.5 years. Common tumour sites: breast (17%; $n = 725$), prostate (16%; $n = 664$), lung (14%; $n = 599$). 15% ($n = 652$) had metastatic disease at T_1. 98% ($n = 4159$) had weight change at T_1. Head & neck and upper gastrointestinal cancers were significantly associated with weight loss ($p < 0.001$). Worst survival occurred with ≥ 10% weight gain or ≥ 10% weight loss. Overweight or obese body mass index with any percentage weight change band was associated with better overall survival.

Conclusions Most had evidence of clinically significant weight changes at diagnosis. Weight loss at diagnosis was associated with a higher risk of further weight loss. A detailed weight history at cancer diagnosis is essential to identify and intervene for those most at risk of weight change-related early mortality.

Keywords Cancer · Prognosis · Survival · Weight gain · Weight loss

Introduction

Weight changes (loss or gain) may occur throughout the cancer trajectory. Most research has examined weight changes after treatment [1–3] and in advanced cancer [2, 4]. A landmark study quantified weight loss at diagnosis and demonstrated an association with lower response to chemotherapy and shorter survival [5]. Recent evidence revealed that weight loss before treatment is associated with increased treatment side effects [6–8]. Despite this, weight loss is infrequently assessed or actively managed [9, 10] and the high prevalence of obesity is not considered. As a consequence, the clinical significance of weight change at diagnosis remains unclear.

Unintentional weight loss is common in people with cancer and a predictor of disease outcome [5, 11]. It is associated with increased morbidity and mortality. Weight loss is the predominant characteristic of cancer cachexia, a syndrome associated with ongoing loss of skeletal muscle mass (with or without fat), progressive functional impairment, and deranged metabolism [12]. Awareness and understanding of cancer cachexia amongst healthcare professionals vary [13, 14]. There is no consensus on the severity of weight loss considered clinically significant [15, 16].

✉ Declan Walsh
Declan.Walsh@atriumhealth.org

1 School of Medicine, Trinity College Dublin, Dublin, Ireland

2 Academic Department of Palliative Medicine, Education & Research Centre, Our Lady's Hospice & Care Services, Harold's Cross, Dublin, Ireland

3 Department of Solid Tumor Oncology, Cleveland Clinic Taussig Cancer Institute, Cleveland, OH, USA

4 The Harry R. Horvitz Center for Palliative Medicine, Cleveland Clinic Taussig Cancer Institute, Cleveland, OH, USA

5 Department of ITD Analytics eResearch, The Cleveland Clinic Foundation, Cleveland, OH, USA

With the global trend towards overweight and obesity [17], it is increasingly difficult to clinically identify malnourished individuals. At diagnosis, some people with cancer present with a normal, overweight or obese body mass index (BMI). This may mask muscle wasting (sarcopenia) [18, 19]. Muscle wasting associated with simultaneous adiposity (sarcopenic obesity) has a negative survival impact [2, 3]. The effect of obesity is complex [20]. Although usually associated with greater all-cause mortality relative to normal BMI [21], it may confer a survival advantage in cancer [22]. Weight gain during treatment is a positive prognostic factor in ovarian cancer [1, 23]. However, obesity at breast cancer diagnosis [24, 25] and weight gain amongst breast cancer survivors [26, 27] are both associated with poorer outcomes. Obesity is associated with worse outcomes in colon cancer in the adjuvant setting [28].

A recent study investigated the survival impact of BMI and self-reported weight loss at presentation and subsequently proposed a cancer-associated weight loss grading system [22]. It supported the concept that weight loss severity be evaluated based on rate of weight loss and level of body reserve depletion. Previous work had demonstrated that weight gain was prognostic of reduced survival in advanced cancer [29]. That study focused on weight stable and weight loss groups, citing the difficulty associated with elucidating the true nature of weight gain as the reason for its exclusion. The same uncertainty exists with regard to how much weight loss is specifically tumour-driven. Although it is important to recognise the impact of weight loss, the consequences of weight gain should also be examined. Greater clarity on the clinical significance of a weight change spectrum at diagnosis would stimulate early recognition by oncologists of those most at risk and prompt intervention which may improve patient outcomes. To do this, we conducted a retrospective study of a large electronic medical record (EMR) data set of repeated weight measurements. We aimed to determine the prevalence, predictors, and prognostic significance of weight change at diagnosis in people with solid tumours.

Methods

Study design

This was a retrospective study of the EMR held at the Cleveland Clinic Taussig Cancer Institute (© Epic Systems Corporation, Verona, WI). Institutional Review Board approval was granted and the study met the criteria for waiver of informed consent as no protected health information was collected. Inclusion criteria were a primary diagnosis of solid tumour malignancy, age ≥ 18 years and a minimum of two consecutive outpatient weight measurements at the Cleveland Clinic Taussig Cancer Institute. Patients with a primary diagnosis of haematological malignancy, with a single recorded visit at the Cleveland Clinic Taussig Cancer Institute, who were reviewed at or were inpatients in other Cleveland Clinic facilities or those who attended for non-clinical encounters were excluded.

Data collection & handling

Data was extracted from the EMR by the Cleveland Clinic eResearch Team, a clinical informatics research technology group responsible for clinical data warehousing and electronic data extraction. It was downloaded to a Microsoft Excel spreadsheet (Microsoft Office Professional Plus 2013, Microsoft Corporation, Redmond, WA). Institutional regulations were followed for safe data storage and monitoring.

Those with a pre-diagnosis weight (T_0) recorded within 6 months of diagnosis date, a weight at diagnosis (T_1), and a final weight recorded ≥ 7 days after diagnosis date (T_2) were identified. 'Final weight' refers to the last encounter within the study period when weight was measured. At T_0, only weight data was extracted. At T_1 and T_2, age, gender, primary cancer site, metastatic disease, number of metastatic sites, treatment received, BMI, 'Abnormal Weight Loss' as per the International Classification of Diseases, 9th Revision (ICD-9) Code 783.21 and date of death data were extracted where available. 'Date of death' was obtained from the EMR; if unavailable, it was verified by Social Security Disability Insurance (SSDI) number. Patients were excluded if a secondary cancer was entered in 'Primary Cancer Site'; if 'Primary Cancer Site' was not specified as either primary or secondary; if BMI data was missing; if a discrepancy existed between EMR 'Date of Death' and SSDI 'Date of Death' or if recorded data was invalid.

BMI and weight history

BMI was calculated with the formula: current weight (kg)/height (m^2) and categorised into four groups as per the World Health Organisation (WHO) BMI Classification [30]: underweight (< 18.5), normal (18.5–24.9), overweight (25.0–29.9) and obese (≥ 30). Clinically significant weight loss or cancer cachexia was defined as weight loss > 5% in the previous 6 months [12].

Weight at each time point was recorded in kilogrammes (kg) to one decimal point. Percentage (%) weight change was calculated with the formula: [(current weight (kg) − previous weight (kg) / previous weight (kg)] × 100. This was categorised into four bands (0.1–2.4%; 2.5–5%; 5.01–9.9%; ≥ 10%) for both weight gain and weight loss; a

Table 1 Demographics and clinical characteristics at diagnosis and final visit ($N = 4258$)[a]

Characteristic	Diagnosis (T_1)		Final (T_2)	
	N	%	*N*	%
Gender				
Male	2315	54		
Female	1943	46		
Primary site				
Breast	725	17		
Prostate	664	16		
Lung	599	14		
Upper GI	470	11		
Head & neck	320	8		
Uterus	194	5		
Brain	191	4		
Kidney	165	4		
Colon	133	3		
Melanoma	104	2		
Other	693	16		
Treatment[b]				
Radiotherapy			2065	48
Chemotherapy			1868	44
Hormonal therapy			771	18
Biological modifier			762	18
Monoclonal antibodies			282	7
Age at diagnosis, years				
Mean	61		62	
SD	± 12.5		± 12.5	
Weight, kg				
Mean	82.7		81.2	
SD	± 21.2		± 21.4	
BMI, kg/m^2				
Mean	28.5		28.1	
SD	± 6.5		± 6.8	
BMI				
Underweight (< 18.5)	110	3	172	4
Normal (18.5–24.9)	1240	29	1319	31
Overweight (25.0–29.9)	1468	34	1374	32
Obese (≥ 30)	1440	34	1393	33
Weight change				
Weight gain	1705	40	1724	40
Weight stable	99	2	26	1
Weight loss	2454	58	2508	59
Weight change, %[c]				
Mean	− 0.7		− 1.6	
SD	± 3.7		±8.3	
Weight change, %[c]				
≥ 10% WL	65	1.5	673	15.8
5.01–9.9% WL	255	5.9	619	14.5
2.5–5.0% WL	542	12.7	497	11.7
0.1–2.4% WL	1592	37.4	719	16.9
0 (stable)	99	2.3	26	0.6
0.1–2.4% WG	1232	28.9	654	15.4
2.5–5.0% WG	335	7.9	456	10.7
5.01–9.9% WG	112	2.6	401	9.4
≥ 10% WG	26	0.6	213	5

Abbreviations: *BMI* body mass index, *SD* standard deviation, *WG* weight gain, *WL* weight loss

[a] Pre-diagnosis weight within 6 months of diagnosis; final visit ≥ 7 days after diagnosis

[b] > 1 treatment possible

[c] Percentage weight change based on weight recorded in previous 6 months

weight stable category was also documented. A categorical weight variable indicated weight loss, gain, or stability between time points.

Statistics

Demographic and clinical characteristics were analysed to establish if an association with weight change existed. All variables including age (< 65 years; ≥ 65 years) and weight change were analysed as categorical variables using Chi-square test. Overall survival was defined as the number of months from T_1 to date of death. All patients were observed to death or censored at T_2. Mean survival time was calculated as median survival time could not be used given the number censored. Survival analyses were calculated using Kaplan-Meier method (comparisons with Cox-Mantel log rank tests) and Cox proportional hazards model (estimated hazard ratios [HRs] and 95% confidence intervals [CIs]). Hazard ratios for combined BMI-%weight change categories at T_1 were also established. Analyses were completed using Microsoft Excel (Microsoft Office Professional Plus 2013, Microsoft Corporation, Redmond, WA), IBM SPSS Statistics for Windows Version 23 (SPSS, Chicago IL) and Stata Statistical Software: Release 14 (StataCorp. 2015. College Station, TX: StataCorp LP). Results were considered statistically significant if $p < 0.05$ (two-sided).

Results

A total of $n = 4258$ records were included in analysis. Demographic and clinical characteristics are in Table 1. Over half were male (54%) and mean age at diagnosis was

Table 2 Predictive value (survival) of categorical variables in a multivariable model at diagnosis (T_1)

Variable	B	SE	Wald	df	*p*	HR	95% CI for HR	
							Lower	Upper
Gender								
Male								
Female	0.06	0.07	0.67	1	.41	1.06	0.92	1.22
Primary site								
Breast			468.38	10	.00			
Lung	1.99	0.19	110.67	1	.00	7.36	5.07	10.67
Prostate	− 0.02	0.26	0.01	1	.93	0.98	0.59	1.62
Upper GI	2.55	0.19	175.72	1	.00	12.83	8.80	18.72
Head & neck	0.86	0.23	13.53	1	.00	2.36	1.49	3.74
Kidney	1.62	0.23	49.00	1	.00	5.03	3.19	7.89
Brain	2.85	0.21	182.02	1	.00	17.29	11.43	26.17
Uterus	1.44	0.29	24.03	1	.00	4.21	2.37	7.48
Colon	1.33	0.26	27.24	1	.00	3.79	2.29	6.26
Malignant melanoma	1.48	0.29	27.08	1	.00	4.41	2.52	7.71
Other	1.74	0.19	81.56	1	.00	5.69	3.90	8.30
Metastatic disease								
Yes	0.80	0.07	119.49		.00	2.23	1.930	2.57
No								
Weight change, %								
≥ 10% WL			36.80	8	.00			
5.01–9.9% WL	− 0.61	0.22	7.93	1	.01	0.55	0.36	0.83
2.5–5.0% WL	− 0.59	0.20	8.59	1	.00	0.55	0.37	0.82
0.1–2.4% WL	− 0.87	0.19	19.70	1	.00	0.42	0.28	0.61
Stable	− 0.91	0.32	8.12	1	.00	0.40	0.21	0.75
0.1–2.4% WG	− 0.93	0.20	21.27	1	.00	0.39	0.27	0.59
2.5–5.0% WG	− 0.78	0.22	12.54	1	.00	0.46	0.29	0.71
5.01–9.9% WG	− 0.59	0.29	4.21	1	.04	0.56	0.32	0.97
≥ 10% WG	− 0.19	0.37	0.26	1	.61	0.83	0.40	1.70
BMI								
Underweight (< 18.5)			23.57	3	.00			
Normal (18.5–24.9)	− 0.31	0.16	3.80	1	.05	0.73	0.54	1.00
Overweight (25–29.9)	− 0.59	0.16	13.29	1	.00	0.55	0.40	0.76
Obese (≥ 30)	− 0.55	0.17	11.17	1	.00	0.58	0.42	0.79
Age								
< 65								
≥ 65	0.44	0.07	43.24	1	.00	1.55	1.36	1.77

Abbreviations: *BMI* body mass index, *WG* weight gain, *WL*, weight loss

61 ± 12.5 years. The four most common primary sites (lung, breast, prostate and colorectal) accounted for 50% of all cases. Fifteen percent ($n = 652$) had metastatic disease. Twenty-three percent ($n = 981$) had died by T_2. Mean survival time was 24.4 ± 0.6 months.

Weight changes were nearly universal (98%) at T_1 (mean % weight change, − 0.7 ± 3.7%). More than half had weight loss but only 3% were underweight and 8% cachectic. Most (69%) were either overweight (35%) or obese (34%) at T_1. Only 3% had 'Abnormal Weight Loss' recorded at T_1. Although weight change was also prevalent (99%) at T_2, mean % weight change was more than twice that at T_1 (mean % weight change, − 1.6 ± 8.3%). Most (59%) had weight loss at T_2. Of those who had weight loss at T_1, 71% continued to lose weight. Forty-two percent of those who had weight gain at T_1, had weight loss at T_2. Despite that most (65%) were still overweight or obese at T_2. Only 4% were underweight and 14% cachectic.

Table 3 Predictive value (survival) of categorical variables in a multivariable model (final visit)

Variable	B	SE	Wald	df	*p*	HR	95% CI for HR	
							Lower	Upper
Gender								
Male								
Female	0.05	0.07	0.46	1	0.49	1.05	0.91	1.21
Primary site								
Breast			445.18	10	0.00			
Lung	2.17	0.20	113.88	1	0.00	8.71	5.86	12.97
Prostate	− 0.02	0.27	0.01	1	0.93	0.98	0.58	1.65
Upper GI	2.52	0.21	143.93	1	0.00	12.36	8.19	18.64
Head & neck	0.94	0.25	13.78	1	0.00	2.55	1.56	4.18
Kidney	1.75	0.25	49.64	1	0.00	5.77	3.54	9.39
Brain	3.11	0.23	183.05	1	0.00	22.49	14.33	35.31
Uterus	1.52	0.30	25.24	1	0.00	4.56	2.52	8.25
Colon	1.50	0.27	30.86	1	0.00	4.50	2.65	7.65
Malignant melanoma	1.59	0.29	28.47	1	0.00	4.91	2.74	8.81
Other	1.83	0.21	76.25	1	0.00	6.20	4.12	9.34
Metastatic disease								
Yes	0.73	0.08	86.66	1	0.00	2.07	1.78	2.41
No								
Biological therapy								
Yes								
No	0.01	0.09	0.01	1	0.92	1.01	0.85	1.21
Radiotherapy								
Yes								
No	− 0.31	0.07	17.69	1	0.00	0.73	0.64	0.85
Monoclonal therapy								
Yes								
No	− 0.15	0.13	1.49	1	0.22	0.86	0.67	1.09
Chemotherapy								
Yes								
No	− 0.05	0.08	0.35	1	0.55	0.96	0.82	1.11
Hormonal therapy								
Yes								
No	0.24	0.10	5.41	1	0.02	1.27	1.04	1.56
Weight change, %								
≥ 10% WL			62.89	8	0.00			
5.01–9.9% WL	0.14	0.09	2.24	1	0.14	1.15	0.96	1.38
2.5–5.0% WL	− 0.19	0.12	2.63	1	0.11	0.83	0.66	1.04
0.1–2.4% WL	− 0.17	0.12	1.93	1	0.17	0.85	0.67	1.07
Stable	0.38	0.51	0.56	1	0.46	1.47	0.54	3.99
0.1–2.4% WG	− 0.22	0.12	3.03	1	0.08	0.81	0.63	1.03
2.5–5.0% WG	− 0.45	0.15	9.42	1	0.00	0.64	0.48	0.85
5.01–9.9% WG	− 0.75	0.16	21.82	1	0.00	0.47	0.35	0.65
≥ 10% WG	− 0.91	0.18	25.17	1	0.00	0.40	0.28	0.57
BMI								
Underweight (< 18.5)			29.76	3	0.00			
Normal (18.5–24.9)	− 0.24	0.12	3.84	1	0.05	0.79	0.62	1.00
Overweight (25–29.9)	− 0.54	0.13	16.93	1	0.00	0.58	0.45	0.75

Table 3 (continued)

Variable	B	SE	Wald	df	*p*	HR	95% CI for HR	
							Lower	Upper
Obese (≥ 30)	− 0.58	0.14	17.77	1	0.00	0.56	0.42	0.73
Age								
< 65								
≥ 65	0.27	0.07	15.46	1	0.00	1.30	1.14	1.49

Abbreviations: *WL* weight loss, *WG* weight gain, *BMI* body mass index

BMI, metastatic disease and primary cancer diagnosis were significant predictors of % weight change ($p < 0.0001$) at T_1. At T_2, age, BMI, metastatic disease, primary cancer diagnosis ($p < 0.001$) and gender ($p < 0.005$) were significant predictors of % weight change. Treatment modality also predicted % weight change; chemotherapy, hormone therapy, radiotherapy, biological and monoclonal treatments were all significant predictors of % weight change ($p < 0.001$). Chemotherapy and radiotherapy were associated with weight loss ($p < 0.001$); hormone therapy with weight gain ($p < 0.001$).

Those with head & neck (OR = 5.54, $p < 0.001$) or upper gastrointestinal (GI) malignancy (OR = 4.46, $p < 0.001$) were

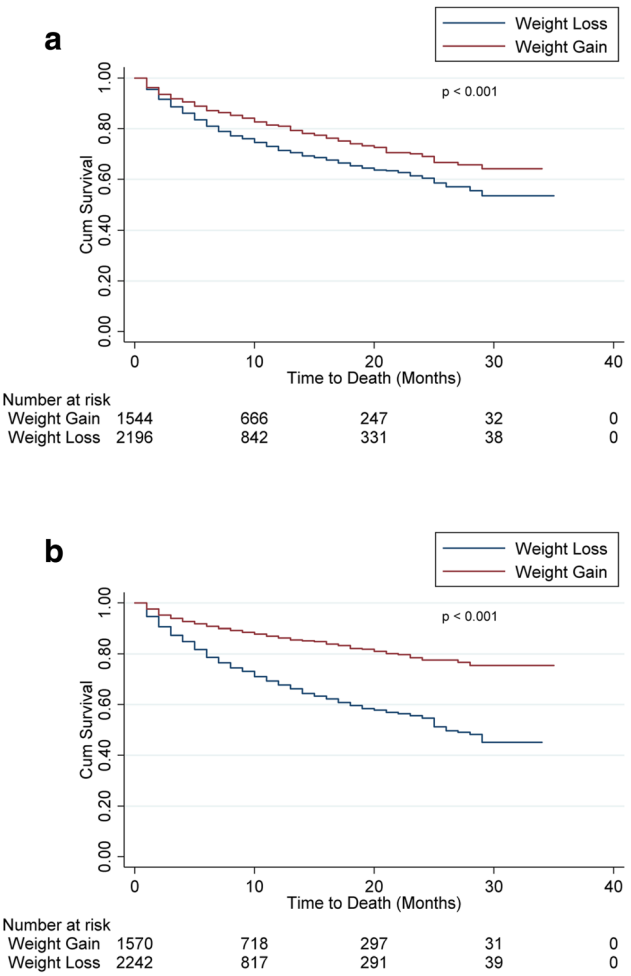

Fig. 1 Kaplan-Meier plot of overall survival by weight change category at (**a**) diagnosis (T_1) and (**b**) final visit (T_2)

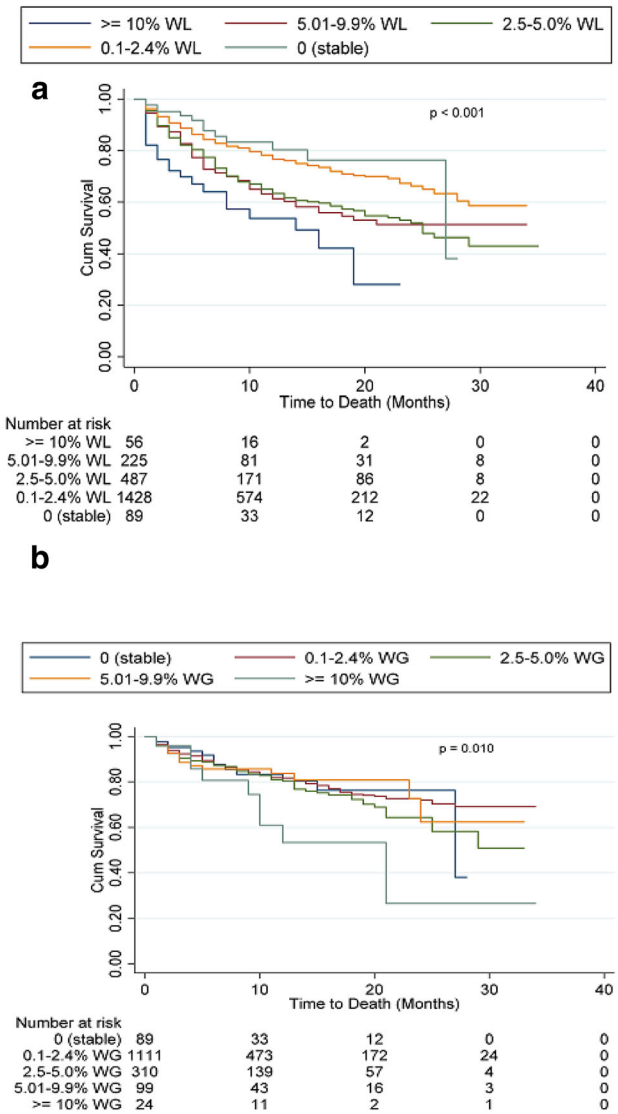

Fig. 2 Kaplan-Meier plot of overall survival by (**a**) percentage weight loss category and (**b**) percentage weight gain category at diagnosis (T_1)

Table 4 Combined BMI-percentage weight change categories at diagnosis: number of cases, median survival (months) and hazard ratio

BMI category		Underweight (< 18.5)			Normal (18.5–24.9)			Overweight (25–29.9)			Obese (≥ 30)			
		N	Median survival	HR	*N*	Median survival	HR	*N*	Median survival	HR	*N*	Median survival	HR	*N*
% Weight change	≥ 10% WL	8	16	2.8	26	8	3.6	17	19	2.0	14	9	3.0	65
	5.01–9.9% WL	14	31	1.4	104	11	2.3	80	34	1.1	57	15	2.0	255
	2.5–5.0% WL	16	8	3.3	204	14	1.9	198	22	1.5	124	26	1.3	542
	0.1–2.4% WL	38	17	2.4	428	29	1.4	545	33	1.1	581	34	0.7	1592
	Stable	2	5	4.8	22	21	0.5	35	23	1.0	40	28	0.7	99
	0.1–2.4% WG	23	9	2.6	310	34	REF	436	34	0.8	463	34	0.7	1232
	2.5–5.0% WG	6	25	2.2	111	27	1.2	116	29	1.2	102	32	0.8	335
	5.01–9.9% WG	1	2	14.9	28	23	1.0	36	33	0.7	47	25	1.1	112
	≥ 10% WG	2	13	3.2	7	10	3.4	5	15	0.0	12	21	1.6	26
		110			1240			1468			1440			Overall *N*

Abbreviations: *BMI* body mass index, *WL* weight loss, *WG* weight gain

most at risk of weight loss. Patients with metastatic disease were also more likely to have weight loss (OR = 1.68, $p < 0.001$) or be cachectic (OR = 1.36, $p < 0.05$) at T_1.

Cox multivariate analysis identified independent predictors of survival at T_1 (Table 2) and T_2 (Table 3) after controlling for known risk factors. Age (< 65 years), gender (male), primary site (breast, prostate) and loco-regional disease independently predicted better survival at T_1 and T_2. A weight gain of 0.1–2.4% at T_1 and > 5% at T_2 were also predictive of better overall survival. Brain, lung and upper GI malignancies had the shortest survival.

Survival analysis based on weight change (gain or loss) alone showed that those with weight gain at T_1 or T_2 (Fig. 1) had a better overall outcome compared to those who had WL. When individual % weight change bands were analysed, the worst survival was associated with ≥ 10% weight loss and ≥ 10% weight gain (Fig. 2). On analysis of combined BMI-%weight change (Table 4), there was considerable variation across categories but improved survival was associated with those who were overweight or obese at all % weight change bands. With normal BMI/0.1–2.4% weight gain considered best, worst outcomes were mostly associated with increased deviation from this category.

Discussion

Weight change at T_1 was highly prevalent. Weight loss was nearly universally undiagnosed or under-documented, despite an option to record Abnormal Weight Loss in the EMR. Those who had weight loss at T_1 continued to have further weight loss by T_2, but most were still overweight or obese. When weight change was considered in isolation, those who had weight gain were more likely to have longer survival compared to weight loss with one exception: ≥10% weight gain at T_1. More than two thirds of adults in the United States are overweight or obese [31] and both are increasingly seen in the cancer population [18, 32], a trend also evident in this study.

Head & neck and upper GI cancers were most likely to be associated with any weight loss. Nutritional deficits are common with these tumours: their location can cause dysphagia and metabolic changes which may alter appetite and chemosensation. In this study, those with head & neck and upper GI cancers were also more likely to be cachectic at both T_1 and T_2. Cachexia is associated with increased treatment toxicity, reduced quality of life and poorer survival. However, as weight history is not routinely assessed at diagnosis, it is likely that this would go undetected before treatment particularly in those with a high BMI. Given that treatment modality can further impact weight change, it again emphasises the critical need for early recognition of those most at risk to ensure delivery of appropriate supportive care and ongoing surveillance.

This study supports previous evidence of weight loss as a predictor of survival [5, 11]. It also highlights the role weight gain (which may mask sarcopenia) plays in sub-optimal identification of undernourished patients which may impair their survival. Weight gain and loss have both been linked with disease progression. In this study, those with metastatic disease were less likely to have weight gain at T_1 and significantly more likely to be cachectic at T_1 and T_2 than those with loco-regional disease. Although there was minimal change in the number who were overweight or obese from T_1 to T_2, those who were cachectic almost doubled. Cancer treatment and disease

progression may both account for this. It seems weight loss alone is an insufficient marker based on the proposed cancer-associated weight loss grading system [22]. We observed median survival based on combined BMI-%weight change at T_1 was greatest for those overweight at all % weight change bands (Table 4). Weight gain in the underweight group appeared to have a variable impact on survival, making it difficult to draw any definitive conclusions. The small numbers in these groups may have contributed to this variability.

Clinicians may be lured into a false sense of security in those with lesser degrees of weight loss or weight gain. This study shows that any weight loss at diagnosis (including those traditionally considered weight stable i.e. ± 2.5%) are at high risk of further weight loss. ESPEN Guidelines [33] recommend identification of 'nutritional disturbances' through regular evaluation of weight change and BMI beginning at cancer diagnosis. Although the clinician's instinct may be to prioritise those with weight loss, based on our results weight gain also warrants attention.

Perhaps in reality it is the early identification of any weight change which is important for identification of those most at risk. The optimal time is at diagnosis if the opportunity to intervene with timely, targeted interventions is to be taken. Given the negative relationship between survival and ≥ 10% weight gain observed (Fig. 2b), perhaps a spectrum of cancer-associated weight change should be established with stages of weight gain (i.e. pre-obese, obese, refractory obesity) like the proposed weight loss spectrum [12]. The proposed diagnostic criteria for cachexia [12] provided an initial framework and expanded beyond simple weight loss with the inclusion of muscle mass measurement. More recent research has built on this with the proposed BMI-weight loss matrix [33]. Further refinement of this concept may lead to the inclusion of other factors like inflammatory markers. Based on this research, further insight may be gained from the study of individual primary cancer sites and disease stages. Age and gender may also require further examination.

This study had several strengths. The data was representative of the most common primary cancer sites. It focused on the significance of weight change at diagnosis. This is important given the increased risk of additional weight loss for those with it at diagnosis, further increasing the risk of cachexia. Also, uniquely, it included a true weight stable category i.e. no weight gain or loss.

There were also limitations to this study. Performance status and tumour stage are recognised prognostic factors [1, 5, 29]. Additional data on these could have enabled greater stratification at diagnosis of those most at risk of weight change, potentially further improving patient selection for intervention. Weight change may be disproportionately associated with poorer performance status and more advanced disease stage. Refractory cachexia is associated with a low performance status score, which negatively impacts response to systemic treatment and survival [5], while tumour stage frequently dictates treatment options. However due to the retrospective nature of this study, this data was unavailable as neither performance status nor tumour stage were reliably recorded in the EMR. The generalisability of the results is also limited by this.

Given the important role cachexia and sarcopenic obesity play in treatment tolerability and survival, body composition at diagnosis should be established. To help identify those most at risk, greater emphasis should be placed on the evaluation of more individualised outcomes by diagnosis and disease stage. This will support the recognition of cancer-associated weight change early in the disease trajectory and allow the effectiveness of targeted treatments to be determined. Future studies should include comprehensive information not just on weight change but also performance status and stage of disease.

Conclusions

Many newly diagnosed patients with solid tumours had evidence of clinically significant, yet frequently undiagnosed, weight changes. Worst survival was seen with ≥ 10% weight gain or ≥ 10% weight loss. Survival analysis based on weight change alone showed that those who had weight gain at diagnosis or later had a better overall survival compared to weight loss. Any weight loss at diagnosis increased the chance of further weight loss with the additional risk of treatment toxicities and worse survival. For combined BMI-%weight change data, improved survival was associated with overweight or obese at all % weight change bands. Consideration should be given to the use of a weight change spectrum, which would reflect risk associated with various weight loss and weight gain bands. A detailed weight history at diagnosis and at each subsequent visit for every cancer patient is essential to promptly identify and intervene for those most at risk. Such research would be enhanced by in-depth analysis of the interplay between disease stage, performance status, nutritional status including BMI, and inflammatory markers such as C-reactive protein.

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Compliance with ethical standards

Ethical approval Institutional Review Board approval was granted for this study.

Informed consent This study met the criteria for waiver of informed consent.

Conflict of interest The authors declare that they have no conflicts of interest.

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