Nutrición Hospitalaria

Nutr Hosp. 2013;28(5):1468-1474
ISSN 0212-1611 • CODEN NUHOEQ
S.V.R. 318

Original / *Cáncer*

Excessive adiposity and sedentary lifestyles are prevalent in cancer patients; a pilot study

Ana Isabel Almeida[1], Dina Raquel João[1], Andreia Rolão[1], Isabel Monteiro-Grillo[1,2], Maria Camilo[1] and Paulo Ravasco[1]

[1]*Unidade de Nutriçao e Metabolismo. Instituto de Medicina Molecular. Faculdade de Medicina da Universidade de Lisboa.*
[2]*Serviço de Radioterapia do Hospital Universitário de Santa Maria. Lisboa. Portugal.*

Abstract

Cancer aetiology is multifactorial; risk factors comprise obesity, central adiposity, physical inactivity and excessive/deficient intake of foods and/or nutrients with procarcinogenic/protective effects. We aim to analyze the pattern of nutritional status, food intake and physical activity in a cohort of cancer patients. This pilot cross-sectional study was conducted in 64 outpatients referred for Radiotherapy. Nutritional parameters evaluated: BMI, waist circumference, body composition by tetrapolar bioimpedance (Xitron®). Usual food intake was collected with a short food frequency questionnaire and physical activity was assessed with Jacksons' questionnaire. Overweight/obesity and excessive body fat mass prevalence was of 53% and 61%, respectively. Central obesity, which indicates moderate/high cardio-metabolic risk, was found in 78% of patients. Food frequency analysis showed a poor intake in vegetables and a high intake in meat and carbohydrates. Physical inactivity was prevalent. This pilot study in cancer patients, showed a high prevalence of overweight/obesity, excessive fat mass and central obesity, simultaneously with sedentary lifestyles and an inadequate diet, poor in protective foods and excessive in deleterious ones. Thus, these patients exhibit a high risk pattern for cancer development and for a poorer prognosis. The implementation of measures to promote balanced and protective diets and to encourage physical activity practice is urgently needed.

(*Nutr Hosp.* 2013;28:1468-1474)
DOI:10.3305/nh.2013.28.5.6690

Key words: *Cancer. Nutritional assessment. Body composition. Overweight/obesity. Waist circumference. Dietary food pattern. Physical activity.*

Correspondence: Paula Ravasco.
Unidade de Nutrição e Metabolismo.
Instituto de Medicina Molecular.
Faculdade de Medicina de Lisboa.
Avda. Prof. Egas Moniz.
1649-028 Lisboa. Portugal.
E-mail: p.ravasco@fm.ul.pt

Recibido: 12-V-2013.
Aceptado: 26-VI-2013.

LA ADIPOSIDAD EXCESIVA Y LOS ESTILOS DE VIDA SEDENTARIOS SON PREVALENTES EN LOS PACIENTES ONCOLÓGICOS; UN ESTUDIO PILOTO

Resumen

La etiología del cáncer es multifactorial; los factores de riesgo comprenden la obesidad, la adiposidad central, la inactividad física y el consumo excesivo/deficiente de alimentos y/o nutrientes con efectos procarcinógenos/protectores. Nos propusimos analizar el patrón del estado nutricional, el consumo de alimentos y la actividad física en una cohorte de pacientes oncológicos. Este estudio piloto transversal se realizó en 64 pacientes ambulatorios remitidos a radioterapia. Se evaluaron los parámetros nutricionales: IMC, circunferencia de la cintura, composición corporal mediante bioimpedancia tetrapolar (Xitron®). La ingesta alimentaria habitual se recogió mediante un cuestionario abreviado de frecuencia de alimentos y la actividad física se evaluó mediante el cuestionario de Jackson. La prevalencia de sobrepeso/obesidad y de exceso de masa corporal grasa fue del 53% y del 61%, respectivamente. La obesidad central, que indica un riesgo cardiometabólico moderado/alto, se encontró en el 78% de los pacientes. El análisis de la frecuencia de alimentos mostró una ingesta escasa de verduras y un consumo elevado de carne e hidratos de carbono. La inactividad física fue prevalente. Este estudio piloto en pacientes oncológicos mostró una prevalencia elevada de sobrepeso/obesidad, un exceso de masa grasa y de obesidad central, simultáneamente con estilos de vida sedentarios y una dieta inadecuada, pobre en alimentos productores y un exceso de los deletéreos. Por lo tanto, estos pacientes muestran un patrón de riesgo elevado para el desarrollo de cáncer y un peor pronóstico. Se requiere urgentemente la implantación de medidas que promuevan dietas equilibradas y protectoras así como la promoción de la actividad física.

(*Nutr Hosp.* 2013;28:1468-1474)
DOI:10.3305/nh.2013.28.5.6690

Palabras clave: *Cáncer. Evaluación nutricional. Composición corporal. Sobrepeso/obesidad. Circunferencia de la cintura. Patrón dietético pobre. Actividad física.*

Abbreviations

BMI: Body Mass Index.
%FM: Percentage of fat mass.
%FFM: Percentage of fat free mass.
WC: Waist circunference.
WHO: World Health Organization.

Introduction

Cancer accounted for 7.6 million deaths, from the 58 million that occurred worldwide in 2008. Deaths from malignant disease are projected to continue on rising, estimated to reach 12.9 million by 2030.[1] Similarly to the global scenario, cancer was the second cause of death in Portugal according to the National Health Plan of 2004-2010.[2]

Several risk factors for cancer are well documented, namely obesity, physical inactivity, high intake of deleterious nutrients/carcinogenic components and/or deficient intake of protective ones, tobacco use and stress.[3,4] In Portugal, the high incidence of stomach cancer has been associated to the excessive salt intake and Helicobacter pylori infection,[5] whereas the high incidence of breast, lung, colorectal and oral cavity cancers, has been associated with obesity, alcohol abuse, tobacco and poor intake of foods with a high content in fibre and other protective nutrients, e.g. antioxidants and flavonoids.[3,4] Taking into account this reality, there has to be a clinical valorisation of the patients's nutritional status; the latter can be evaluated through anthropometric methods, such as the easy and quick to obtain height and weight essential to calculate Body Mass Index (BMI) (highly reproducible and enables comparisons between studies).[6] Additionally other nutritional parameters have to be valued in clinical practice, e.g. waist circumference that is an indirect measure of central obesity that indicates cardio-metabolic risk,[7] and body fat mass and fat free mass easy to asses by bioimpedance.[6] Regarding usual and current dietary intake as well as the level of physical activity, validated questionnaires may be used.[8]

Based on this background, this pilot cross-sectional study in a heterogeneous population of cancer patients aimed: 1) to evaluate the potential cardio-metabolic risk associated with waist circumference, %fat mass and BMI; 2) to characterise the pattern of usual food intake, focusing on high density foods, vegetables, fruits and fish; 3) to assess and characterise the physical activity pattern.

Methods

This analytical cross-sectional study, approved by the Hospital Ethics Committee, was conducted in accordance with the Helsinki Declaration, adopted by the World Medical Association in 1964, amended in 1975 and updated in 2002; all participants gave their informed consent. This study was carried out in the Radiotherapy Department of the University Hospital of Santa Maria-Centro Hospitalar Lisboa Norte, EPE, Lisbon, Portugal. Exclusion criteria comprised inability to answer questions or patients who were not autonomous and/or could not be weighed and bedridden patients. All data were collected through clinical interviews and completed with the patient's clinical file consultation. Data were recorded on individual forms pre-constructed for statistical analysis.

Study parameters

Demographic, clinical data and chronic medications were collected from the patients' files; anthropometric measures, weight changes, food intake and physical activity were individually assessed via structured questionnaires and validated methods. Data collection and evaluations were always performed by a trained medical student (AR).

Nutritional assessment

BMI. Height was measured in the standing position using a stadiometer and weight was determined with a calibrated Jofre® floor scale. Patients were shoeless and with light clothing during measurements. BMI was calculated using the formula [BMI = weight (kg)/ height $(m)^2$], and further categorized according to WHO's criteria in patients aged 18-64 years: underweight if < 18.5 kg/m^2, adequate 18.5-24.9 kg/m^2, overweight 25-29.9 kg/m^2 and obese ≥ 30 kg/m^2.[9] For patients aged ≥ 65 years, BMI was classified as follows: underweight if < 24 kg/m^2, adequate if 24-26.9 kg/m^2 and overweight/obesity if ≥ 27 kg/m^2.[10]

Weight change was calculated by comparing patients' usual weight in the previous 3-6 months, with their current weight. Changes were expressed as percentage of weight loss or weight gain, and categorized: ≤ 5%, between 5-10% and ≥ 10%.[11]

Waist circumference (WC) was measured at the midpoint between the iliac crest and last floating rib in a horizontal plane using a flexible not elastic tape, with patients in expiration. The values were further categorized according to international cut-offs, by sex and age; WC evaluated patients' cardio-metabolic risk. For men, WC was categorized as without risk if < 94 cm, moderate risk if ≥ 94 cm and < 102 cm, and as high risk if ≥ 102 cm; for women, WC values were categorized as low risk if < 80 cm, as moderate risk if ≥ 80 and < 88 cm, and as high risk if ≥ 88 cm.[12]

Body composition. Tetrapolar bioimpedance analysis (multifrequency equipment Xitron®) was used to assess patients' body composition. Percentage of fat mass (%FM) and % fat free mass (%FFM) were determined

and categorized according to standardized values for sex and age. For men aged 35-64 years or ≥ 65 years, %FM was categorized as normal if 10-25% and 10-23%, respectively; %FFM was categorized as normal if 90-75% and 90-77%, respectively. For women aged 35-64 years and ≥ 65 years, %FM was categorized as normal if 25-38% and 25-35%, respectively; %FFM was classified as normal if 75-62% and 75-65%, respectively. Values below the normal ranges were categorized as deficit of body fat or of lean mass, while values above the normal ranges were categorized as excess of body fat and of lean body mass.[7]

Food intake

The usual food intake was assessed by a modified short food frequency questionnaire, developed specifically for this study, which evaluated the weekly intake of meat, fish, vegetable soup, vegetables (cooked or as salads), carbohydrates; it evaluated the daily intake of bread, fruit and dairy products. Daily intake values were converted into a weekly intake for comparisons. Patients' reported intake was further classified as high intake if ≥ 5 times/week and as low intake if 1-4 times/ week.

Physical activity

Patients' physical activity assessment was conducted through a questionnaire based on Jackson s questionnaire. Usual and/or current physical activity were assessed by: commonly used transportation, time spent walking/day, hours of physical exercise per week and reasons to exercise regularly.[8]

Statistical analysis

Statistical analysis was performed using SPSS 16.0 for Windows (SPSS Inc, Chicago, USA 2003). Categorical variables were expressed as number and percentage, while numerical variables were expressed as mean ± standard deviation (range). Correlations between numerical variables were evaluated by the non parametric Spearman method. Associations between numerical and categorical variables were explored by the non parametric Mann-Whitney method. Categorical variables were compared with the Chi-square test. P values were always two-sided and statistical significance was set for a p value < 0.05.

Results

Demographic and clinical data

The study cohort comprised 64 patients with various types of cancers referred for radiotherapy with curative intent, adjuvant to surgery and/or combined with chemotherapy or with palliative intent. Overall, there were 31 (48%) men and 33 (52%) women with a mean age of 63 ± 12 (36-87) years; 34 (53%) were ≥ 65 years. Patients' diagnoses and distribution according to sex are shown in table I. Overall, breast and colorectal cancer were the most prevalent, each presenting a prevalence of 22%. In men, prostate cancer was the most prevalent diagnosis, whereas breast cancer was the most prevalent in women.

Table I
Patients' distribution by diagnosis and sex

Diagnosis	*Total n (%)*	*Men n (%)*	*Women n (%)*
Tumour breast	14 (22%)	0	14 (22%)
Tumour colon-rectum	14 (22%)	8 (13%)	6 (9%)
Tumour prostate	9 (14%)	9 (14%)	0
Tumour lung	7 (11%)	5 (9%)	2 (3%)
Tumour uterus	7 (11%)	0	7 (11%)
Tumour head-neck	6 (9%)	4 (6%)	2 (3%)
Others	7 (11%)	5 (8%)	2 (3%)

Results expressed as number (%) of patients; "Others" include: brain, pancreas, stomach, biliary tract, Hodgkin and non Hodgkin lymphomas.

Regarding co-morbidities, 47 (73%) patients had at least one: high blood pressure (n = 20, 31%) and dyslipidaemia (n = 20, 31%) were the most prevalent, followed by cardio-cerebrovascular diseases (n = 15, 23%) and type 2 diabetes mellitus (n = 12; 19%). Patients with colorectal and breast cancers had the highest prevalence of co-morbidities.

Nutritional assessment

Mean BMI was 26 ± 4 (16-37) kg/m^2; 34 (53%) patients were overweight/obese, 24 (38%) had an adequate BMI and only 6 (9%) were underweight. It is worth mentioning that 17 (27%) patients were obese. No significant difference was found between BMI categories according to gender. Yet, according to diagnosis, patients with colorectal, uterus or breast tumours were more frequently identified as overweight/obese ($p < 0.05$).

Weight variation is shown in figure 1. A variation of current weight by comparison with the usual weight was observed in 97% of patients. The majority of patients gained weight (64%); of those, 54% gained more than 10% of their usual weight. Weight gain occurred mainly in patients with tumours of the breast, uterus, prostate or colon-rectum, $p < 0.01$; moreover, weight gain was correlated with overweight/obesity, $p < 0.005$. Conversely, weight loss was reported by 33% of patients; half of them lost more than 10% of their usual weight. Patients with lung and head-neck tumours had the highest frequency of weight loss, $p < 0.05$.

Cardiometabolic risk according to WC distributed by sex is depicted in table II. Most patients presented a

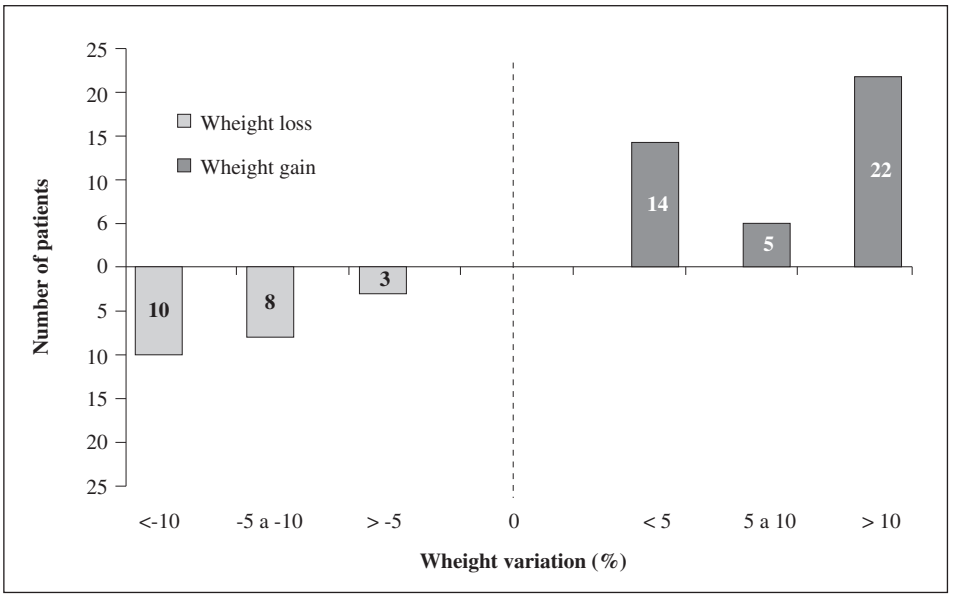

Fig. 1.—Weight variations by comparison with patients' usual weight.

Table II
Cardio-metabolic risk by sex according to waist circumference

Cardiometabolic risk	*Total n (%)*	*Men*		*Women*	
		WC cut-offs (cm)	*n (%)*	*WC cut-offs (cm)*	*n (%)*
Low risk	14 (22%)	< 94	10 (32%)	< 80	4 (12%)
Moderate risk	16 (25%)	94-101.9	10 (32%)	80-87,9	6 (18%)
High risk	34 (53%)	≥ 102	11 (35%)	≥ 88	23 (69%)

Results expressed as number (%) of patients; WC: Waist circumference.

WC above the recommended cut-off values, leading to a high prevalence of moderate/high cardiometabolic risk vs low risk, $p < 0.01$. Women presented a higher incidence of cardio-metabolic risk, when compared to men, $p < 0.05$. Additionally, the presence of overweight/obesity, weight gain and cardio-metabolic risk were significantly correlated, $p < 0.007$.

Body composition analysis results are shown in table III. Similarly to other measures of nutritional status and cardiometabolic risk results, most patients presented excessive body fat mass and low fat free mass; indeed, 39 (61%) patients presented simultaneously excessive fat mass and a depleted fat free mass. Of those, most were men aged > 65 years, $p < 0.01$.

Table III
% fat mass and % fat free mass sex

Age (years)	*% fat mass*			*% fat free mass*		
	Low n (%)	*Normal n (%)*	*High n (%)*	*Low n (%)*	*Normal n (%)*	*High n (%)*
Men						
35-65	0	7 (23%)	10 (32%)	11 (35%)	6 (19%)	0
> 65	0	1 (3%)	13 (42%)	13 (42%)	1 (3%)	0
Women						
35-65	0	11 (33%)	6 (18%)	6 (18%)	11 (33%)	0
> 65	1 (3%)	5 (15%)	10 (30%)	9 (27%)	5 (15%)	2 (6%)

Results expressed as number (%) of patients. Distribution according to cut-offs for age and sex.

Table IV
Food intake distribution by frequency of eating

Food	*Low intake n (%)*	*High intake n (%)*
Meat	14 (22%)	50 (78%)
Fish	32 (50%)	32 (50%)
Soup	19 (30%)	45 (70%)
Cooked vegetables	35 (55%)	29 (45%)
Raw vegetables	38 (59%)	26 (41%)
Starches	3 (5%)	61 (95%)
Fruit	11 (71%)	53 (83%)
Dairy products	9 (14%)	55 (86%)

Results expressed as number (%) of patients: low intake: 1-4 times/week; high intake: ≥ 5 times/week.

Moreover, only 1/3 of patients had a %FM and %FFM within the reference values.

Food intake

Usual food intake analysis according to the frequency of intake per week is shown in table IV. Patients reported a high intake of starchy foods, meat, dairy products and fruit; in contrast, fish intake was moderate, whereas raw and cooked vegetables intake was low.

Physical activity

Usual and current physical activity were very low (table V). Indeed, most patients reported a usual and current activity of less 15 minutes/day walking, and did not engage in any physical activity. Furthermore, current physical activity was even lower and less prevalent than the usual physical activity: a high percentage of patients currently walked less than 15 minutes/day, did not climb stairs or did not practice any physical exercise. Additionally, the percentage of patients who used their own transport increased from 55% (usual) to 67% (current); conversely, those who reported walking as their main way of transport decrease from 20% (usual) to 6% (current), $p < 0.05$.

Regarding the usual physical activity, 11 (17%) patients reported to practice already structured sports. Of those, only 6 (54%) climbed stairs, 3 (27%) walked more than 15minutes/day and only 1 (9%) maintained his regular physical exercise practice.

Table V
Usual and current physical activity

Phisical activity	*Usual n (%)*	*Current n (%)*
Walking (minutes)		
< 15	35 (55%)	48 (75%)
15-30	15 (23%)	8 (13%)
30-60	9 (14%)	6 (9%)
> 60	5 (8%)	2 (3%)
Climb stairs (floors)		
0	23 (36%)	37 (58%)
1-5	36 (56%)	25 (39%)
6-10	1 (2%)	2 (3%)
> 10	4 (6%)	0
Physical exercise (hours/week)		
0	49 (77%)	60 (94%)
1	4 (6%)	0
2-3	6 (9%)	2 (3%)
> 3	5 (8%)	2 (3%)

Results expressed as number (%) of patients.

Discussion

This pilot study in a heterogeneous cohort of patients with solid tumours, showed a high prevalence of overweight/obesity, excessive fat mass and central obesity, along with sedentary lifestyles, simultaneously with an inadequate diet poor in protective foods (e.g. vegetables) and excessive in meat. According to the data so far, these patients exhibit a pattern in their nutritional status and lifestyle potentially associated with cancer development as well as with the disease progression and poorer prognosis. Nutritional counselling may open new insights in reduction or even prevention of carcinogenesis; thus, future research should also focus on how to develop and promote an efficient counselling to foster and promote a balanced and protective diet, and for the encouragement of physical activity practice and other healthy and protective lifestyles. Moreover, given the high and increasing incidence of cancer in Portugal, our study reinforces the importance and need of a national multicenter study in this research field.

Undeniably, environmental factors comprise obesity, central obesity, excessive fat mass, deficient/excessive intake of specific foods and/or nutrients with pro-carcinogenic vs anti-carcinogenic actions and sedentarism. Overweight/obesity is pointed out by several studies as a risk factor for oesophagus, colon-rectum, pancreas, endometrium, breast, kidney and gallbladder cancers;[13] moreover, overweight/obesity has been associated with a unfavourable disease course and poorer disease prognosis.[14-18] On the other hand, obesity is also associated with hyperglycaemia, hyperinsulinaemia and insulin resistance.[19] There is evidence that the link between insulin and mitogenic activity by increasing IGF-1 bioavailability, may contribute to increase cell proliferation and carcinogenesis.[20] Indeed, in this study we found a high prevalence of overweight/obesity, together with a high prevalence of excessive abdominal adiposity; moreover, most patients reported to

have gained weight in the last 3-6 months. All these parameters are identified as risk factors for cancer.[13]

Regarding body composition, most patients presented excessive fat mass and only 37% of patients had normal fat mass values for their sex and age. Conversely, the majority of patients had a depleted fat free mass and only 37% had values within the reference values for age and sex. Excessive fat mass concomitantly depleted fat free mass was found in 61% of patients; this body composition pattern is characteristic of sarcopenic obesity[21] that has been associated with an increased risk of disease recurrence and with a worse prognosis.[17]

Epidemiological studies on dietary patterns and cancer incidence identified some deficits of essential nutrients, as well as excessive intake of harmful nutrients as risk factors.[13] A high intake of n-3 polyunsaturated fatty acids, found in nuts, fish and vegetables, have shown to decrease the risk of developing cancer;[13] in fact, immunomodulators n-3 fatty acids may play a protective role through their potential anti-carcinogenic effect, possibly as an arachidonic acid antagonist with a possible reduction of pro-inflammatory eicosanoids' synthesis, as well as by their pro-apoptotic action.[22-24] On the other hand, excessive intake of saturated fatty acids, found in meat and whole dairy products, has been associated with the development of some specific tumours: breast, prostate, lung, endometrium, pancreas and colon-rectum;[13] furthermore, excessive intake of sugars has been linked an increased risk of colorectal tumours.[13]

Fibre has also been considered an anti-carcinogenic nutrient; it may play a protective role: 1) by acting as an adjuvant in eliminating carcinogenic compounds from the intestinal lumen; 2) by contributing to the production of short chain fatty acids; 3) by decreasing insulin resistance and 4) by decreasing blood concentration of free estrogens due to their lower intestinal absorption from the billiary tract.[23] It has also been suggested that carotenoids may play an anti-carcinogenic role due to their antioxidant properties and by a direct inhibition of potential endogenous compounds of carcinogenesis.[25] In this study, the food intake pattern was characterized by a low intake of vegetables, which have a high content in vitamins, minerals, carotenoids and fibre, and by a moderate intake of fish, which is a very rich source of n-3 polyunsaturated fatty acids.

In what concerns physical activity, several benefits have been assigned to its regular practice: contributes to maintain a healthy weight, increases peristalsis, improves immune function and increases insulin sensitivity.[13] Evidence has consistently shown that regular physical activity reduces the risk of cancer, especially colorectal, endometrial and postmenopausal breast cancer.[13] Our findings show that the majority of the cancer patients did not practice any regular physical activity before diagnosis; and moreover, there were no significant differences between the usual and the current physical activity habits. Overall, we found a pattern of marked inactivity and sedentarism among cancer patients.

According to the World Cancer Research Fund & American Institute for Cancer Research, cancer is the second cause of death worldwide, with an alarming rising incidence. Nonetheless, systematic reviews indicate that 40%-50% of cancers are preventable; although cancer aetiology is multifactorial, environmental factors are today known to play an important role in cancer prevention or act as significant risk factors.[13] Alarmingly, this pilot study demonstrated this pattern in patients that already have cancer and corroborated that their life styles, eating and nutritional status was very likely unhealthy and inadequate long before their cancer diagnosis.

Acknowledgement

We are indebted to the helpful medical, nursing and technical staff of the Radiotherapy Department of the University Hospital of Santa Maria.

This study was partially supported by a Grant from the "Fundação para a Ciência e Tecnologia" (RUN 437).

All authors hereby disclose any financial and personal relationships with other people or organization that could inappropriately influence our work.

References

1. World Health Organization. Cancer. Available at: http://www.who.int/mediacentre/factsheets/fs297/en/index.html
2. Ministry of Health, General Directorate of Health. Current health status of the Portuguese population. In: General Directorate of Health, editors. National Health Plan 2004-2010: better health for all. Lisbon: General Directorate of Health; 2004, pp. 29-32.
3. Longmore M, Wilkinson I, Rajagopalan S. Oxford handbook of clinical medicine. 6th edition. Oxford: Oxford University Press; 2004.
4. Heber D, Blackburn GL, Go VLW, Milner J. Nutritional oncology. 2nd edition. Amsterdam: Elsevier; 2006.
5. Ferreira AC, Isomoto H, Moriyama M, Fujioka T, Machado JC et al. Helicobacter and gastric malignancies. *Helicobacter* 2009; 13: 28-34.
6. Heymsfield S, Baumgartner R. Body composition and anthropometry. In: Shills ME, Shike M, Ross AC, Caballero B, Cousins RJ, editors. Modern nutrition in health and disease. 10th edition. Philadelphia: Lippincott Williams & Wilkins; 2006, pp. 751-70.
7. Lean ME. Pathophysiology of obesity. *Proc Nutr Soc* 2000; 59: 331-6.
8. Arroll B, Jackson R, Beaglehole R. Validation of a three-month physical activity recall questionnaire with a seven-day food intake and physical activity diary. *Epidemiology* 1991; 2: 296-9.
9. WHO. Consultation on Obesity. Geneva: World Health Organization; 2005.
10. Heiat A, Vaccarino V, Krumholz H. An evidence-based assessment of federal guidelines for overweight and obesity as they apply to elderly persons. *Arch Intern Med* 2001; 161: 1194-203.
11. Stratton RJ, Hackston A, Longmore D, Dixon R, Price S, et al. Malnutrition in hospital outpatients and inpatients: prevalence,

concurrent validity and ease of use of the "malnutrition universal screening tool" ("MUST") for adults. *Br J Nutr* 2004; 92: 799-808.
12. Ravasco P, Monteiro-Grillo I, Camilo M. [Cancro colo-rectal e factores de risco numa população portuguesa: estudo de caso-controlo]. *J Port GE* 2002; 9: 311-20.
13. World Cancer Research Fund, American Institute for Cancer Research. Food, nutrition, physical activity and the prevention of cancer: a global perspective. Washington DC: AICR, 2007.
14. Chaves M, Boléo-Tomé C, Monteiro-Grillo I, Camilo M, Ravasco P. The diversity of nutritional status in cancer: new insights. *Oncologist* 2010; 15: 523-30.
15. Flegal K, Carroll MD, Ogden CL, Johnson CL. Prevalence and trends in obesity among US adults, 1999-2000. *JAMA* 2002; 288: 1723-7.
16. Meyerhardt J, Catalano P, Haller D. Influence of body mass index on outcomes and treatment-related toxicity in patients with colon carcinoma. *Cancer* 2003; 98: 484-5.
17. Schlienger JL, Luca F, Vinzio S, Pradignac A. Obésité et cancer. *Rev Med Interne* 2009; 30: 776-82.
18. Majed B, Moreau T, Asselain B. Overweight, obesity and breast cancer prognosis: optimal body size indicator cut-points. *Breast Cancer Res Treat* 2009; 115: 193-203.
19. Kahn B, Flier F. Obesity and insulin resistance. *J Clin Invest* 2000; 106: 473-81.
20. Schiel R, Beltschikow W, Steiner T, Stein G. Diabetes, insulin, and cancer risk. *Methods Find Exp Clin Pharmacol* 2006; 28: 169-75.
21. Prado C, Lieffers JR, McCargar LJ, Reiman T, Sawyer MB et al. Prevalence and clinical implications of sarcopenic obesity in patients with solid tumours of the respiratory and gastrointestinal tracts: a population-based study. *Lancet Oncol* 2008; 9: 629-35.
22. Latham P, Lund EK, Brown JC, Johnson IT. Effects of cellular redox balance on induction of apoptosis by eicosapentaenoic acid in HT29 colorectal adenocarcinoma cells and rat colon in vivo. *Gut* 2001; 49: 97-105.
23. Willet W. Cancer prevention: diet and chemopreventive agents. In: DeVita Jr VT, Hellman S, Rosenberg SA, editors. Cancer-Principles and practice of Oncology. 7th edition. Philadelphia: Lippincott Williams & Wilkins; 2005, pp. 507-54.
24. Chen Z, Istfan N. Docosahexaenoic acid is a potent inducer of apoptosis in HT-29 colon cancer cells. *Prostaglandins Leukot Essent Fatty Acids* 2000; 63: 301-8.
25. Zanardi S, Serrano D, Argusti A, Barile M, Puntoni M et al. Clinical trials with retinoids for breast cancer chemoprevention. *Endocr Relat Cancer* 2006; 13: 51-68.