

Transdisciplinary Research in Energetics and Cancer early career investigator training program: first year results

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Abstract

Energy imbalance increases cancer burden by increasing cancer risk and mortality. Training early career investigators on conducting impactful energy balance and cancer research is needed. We developed a Transdisciplinary Research in Energetics and Cancer (TREC) Training Program for early career investigators. This analysis examined program satisfaction, knowledge gained, publications, and awards among Year 1 participants (i.e., fellows). The program consists of an in-person course, followed by 1 year of mentorship. Faculty and fellows completed precourse and postcourse surveys. Following the mentorship period, we surveyed fellows for TREC-related research productivity, including publications and grant funding attributed to the program. Twenty fellows were accepted into the program: 3 basic, 7 clinical, and 10 population scientists. Sixteen fellows were junior faculty and four were postdoctoral fellows. The course included ~50 lectures, small group sessions, and faculty–fellow sessions. 96.7% of attendees rated the course in the highest categories of “good/very good.” Knowledge significantly improved in 37 of 39 research competencies (94.8%). In the 18 months following the course, fellows published 25 manuscripts, with 3 published in journals with impact factor ≥ 10 . Nineteen grants were funded to TREC fellows (i.e., 7 National Institutes of Health awards, 2 American Cancer Society [ACS] awards, and 10 foundation/pilot awards), and 7 fellows received career promotions. The program’s impact will be defined by the degree to which TREC fellows produce discoveries that could improve the health of populations at risk for and/or surviving cancer. Upon the conclusion of our fifth year in 2021, we will publicly disseminate the program material.

Keywords

Obesity, Weight, Diet, Physical activity, Exercise, Cancer, Survival, Recurrence, Mortality, Mentoring, Career development

INTRODUCTION

The prevalence of obesity in the United States and globally has increased significantly over the last three decades, with more than one third of US adults categorized as obese and two-thirds categorized as overweight [1]. Obesity is primarily caused by poor diet and physical inactivity, which are also independent risk factors for cancer development and mortality [2,3]. Taken together, obesity, poor diet, and physical inactivity are known as “energy balance” or “energetics.” The National Cancer Institute’s (NCI) definition of energy balance is,

Implications

Practice: Training early career investigators on conducting impactful energy balance and cancer research may lead to improved patient care and outcomes.

Policy: Training early career investigators on conducting impactful energy balance and cancer research may lead to policy changes in reimbursing weight management services for cancer survivors.

Research: Training early career investigators on conducting impactful energy balance and cancer research may result in more findings of a benefit of exercise, nutrition, and weight management on cancer risk and prognosis.

“In biology, the state at which the number of calories eaten equals the number of calories used. Energy balance is affected by physical activity, body size, amount of body fat and muscle, and genetics” [4]. The association of energy balance with cancer has motivated the scientific community to seek new research models and paradigms, as well as new transdisciplinary (TD) training opportunities for scientists and clinicians.

In 2015, the American Society of Clinical Oncology (ASCO) published a position statement on obesity and cancer, citing their commitment to reducing the impact of obesity on cancer [5]. ASCO proposed a multipronged initiative to increase education and awareness of the evidence linking obesity and cancer; provide resources to help oncology providers address obesity with their patients; build and foster a robust research agenda to better understand the pathophysiology of energy balance alterations, evaluate the impact of behavior change on cancer outcomes, and determine the best methods to help cancer survivors make effective changes in lifestyle behaviors; and advocate for policy and systems change to address societal factors contributing to obesity and improve access to weight management services for patients with cancer.

In response to building and fostering a robust research agenda, we developed an annual 1 week, in-residence NCI-R25-funded Transdisciplinary Research in Energetics and Cancer (TREC) Training Program that focuses on energy balance and cancer research across the cancer control continuum from cancer prevention to treatment and survivorship. The program is designed for early career investigators from diverse academic backgrounds (i.e., basic, clinical, and population sciences). Following the 1 week in-person course, the program continues with a 1 year TREC mentorship phase in which program participants receive continuing mentorship from the faculty. The goal of the TREC Program is to increase the number of researchers who will have TD expertise in energetics and cancer, thereby hastening the introduction of improved approaches for energetics and cancer research into everyday practice and patient care and could ultimately improve the health of the population at risk for cancer, as well as cancer survivors. This unique program builds upon the NCI U54 TREC Centers Initiative, which was a major scientific research effort that occurred from 2005 to 2016 [6,7]. The TREC goal was to synergize diverse disciplines to find effective interventions across the lifespan to reduce the burden of obesity and cancer and to improve population health. This was accomplished by building teams of scientists working from geography to genes to create sustainable solutions to address a complex societal problem. Eight academic institutions/cancer centers and a coordinating center were awarded TREC center grants that supported approximately 30 TD studies on energy balance and cancer (<https://cancercontrol.cancer.gov/brp/hbrb/trec/index.html>). While the TREC Centers Initiative ceased in 2016, the goal of the currently funded TREC Training Program is to continue to further the TREC mission of training scientists, especially early career investigators, in TREC.

Specifically, the overall goal of the TREC Training Program is to educate, train, and mentor more than 100 academically diverse early career investigators, called TREC fellows, in TREC. The annual 1 week in-person program provides state-of-the-art, evidence-based energetics and cancer education, placing a strong emphasis on mentoring and developing and applying TD competencies. TREC fellows work with more than 20 expert TREC faculty, who have expertise in the fields of basic, clinical, and population energy balance and cancer research, on establishing research priorities and developing studies that will fill key gaps in energy balance and cancer research. Following the course, fellows continue their TREC training via a yearlong mentorship program in which each fellow is paired with two TREC faculty with mentorship being conducted remotely via telephone, email, and/or video chats.

The purpose of this analysis was to examine course satisfaction, as well as the impact of the TREC Program on knowledge and skills related to

energy balance and cancer research. The impact of the TREC Program on publications and awards resulting from the program among TREC Year 1 fellows was also determined. We hypothesize that TREC fellows' increased knowledge in TD approaches to energetics and cancer research may lead to innovative research approaches and discoveries (through funding, presentations, and publications) that may assist in the dissemination and implementation of improved cancer prevention and treatment strategies for populations at risk for cancer, as well as cancer survivors.

METHODS

Content of TREC Training Course

The TREC Training Program is offered annually from 2017 to 2021. The workshop covers topics across the cancer control continuum, including prevention, detection, diagnosis, treatment, and survivorship. Given that the TREC Program is structured to maximize the potential for early career investigators to apply the skills they learn following the course, part of the program's application procedure involves submitting a concept for a research study to be developed during the weeklong course and over the yearlong program. Fellows receive critiques of their research grant applications from TREC Faculty.

Prior to the program, TREC fellows and faculty receive a web-based course packet containing course objectives, fellows' biosketches, preworkshop reading assignments, and the course agenda. Upon arrival, the 1 week course offers approximately 50 different sessions, including lectures, small research interest group sessions, one-on-one sessions, networking sessions, panel discussions, faculty "office hours," and breakout sessions (Table 1). There are sessions on mentoring, networking, publishing, and grant writing, as well as instructional components for responsible conduct of research, including topics related to conflict of interest, authorship, data management, human subjects and animal use, laboratory safety, research misconduct, and research ethics. The different educational formats help to serve a variety of didactic needs and also focuses on research protocol development sessions.

The TREC Training Program also focuses on the inclusion of and training in TD approaches. We intentionally recruit a diverse cohort of fellows conducting energy balance and cancer research from a basic, clinical, translational, and/or population science perspective, with the goal of having these fellows share ideas and approaches, in turn, increasing the potential for TD scientific breakthroughs. The design of the TREC weeklong workshop, including seminars, breakout sessions, and small group discussions, also fosters opportunities for collaboration between and among fellows and faculty trained in different disciplines.

At the conclusion of the weeklong course, TREC fellows should be able to: (a) incorporate an increased understanding of the biology and epidemiology of cancers in the United States and worldwide into his/her research, teaching, and/or practice; (b) incorporate into research, teaching, and/or practice an enhanced understanding of the three major energetic exposures (diet, physical activity, and obesity), including how to measure these factors and their putative relationship to cancer; (c) improve research productivity through collaborative, TD development of original research publications and research protocols; (d) incorporate into grant writing, publications, teaching, and practice an enhanced ability to critically evaluate evidence related to energetics and cancer; (e) understand human research protections, Health Insurance Portability and Accountability Act (HIPAA), informed consent, and the Institutional Review Board (IRB) process; (f) identify federal and foundation grant resources for carrying out energetics and cancer research; and (g) increase activity in relevant energetics and cancer health policy advocacy by acting on improved ability to recognize and evaluate the basis for policy and practice in cancer prevention. Details regarding the program are available via www.tretraining.yale.edu. An IRB exemption was obtained for the TREC Program.

TREC fellows

In an effort to increase the number of applications and participants from academically diverse organizations, we invite fellows through organizations and conferences that involve basic cancer scientists (e.g., American Association for Cancer Research), clinical cancer scientists (e.g., ASCO), and population cancer scientists (e.g., American Society of Preventive Oncology), as well as energy balance organizations (e.g., Obesity Society, American College of Sports Medicine, Academy of Nutrition and Dietetics, American Society of Nutrition, and Society of Behavioral Medicine). We outreach to these organizations by announcing our program in journals and newsletters with readers from underrepresented populations, advertising to historically Black colleges and universities and Hispanic-American colleges and universities. We are committed to recruiting participants who are members of underrepresented groups in the United States, and we have set a goal to recruit at least 20% African American and Hispanic applicants.

The selection of TREC fellows is based on academic, research, and clinical experience, an interest in energy balance, and cancer research as reflected in their application and their future career goals. Fellows chosen are from diverse academic backgrounds, including biomedical researchers, health care providers, medical, public health, nutrition, exercise physiology, psychology, and/or obesity health professions. Acceptance into the program is

competitive, with approximately 20 TREC fellows (postdoctoral or junior faculty) accepted annually. The call for applications is issued in October, with an application submission due date in January. A TREC Senior Advisory Board is responsible for reviewing applications and selecting the TREC fellows.

TREC faculty

More than 20 TREC faculty participate in the TREC Training Program, including investigators who are energetics and cancer experts in basic, clinical, and population-based scientists, including clinicians. All TREC faculty have research expertise and experience relevant to the TREC Program and a history of mentoring numerous early career investigators. TREC faculty participate in the course for at least one full day where they give a presentation and work in small groups with fellows, as well as in one-on-one faculty-fellow sessions. Each day, there are approximately six TREC faculty on site at the course.

Mentoring

Prior to the weeklong course, TREC faculty are assigned to mentor at least two TREC fellows (and, in turn, each fellow has two TREC faculty mentors) for up to 1 year following the course, assisting them in submitting manuscripts, grant applications, networking, and career development. Faculty provide guidance during and after the course via one-on-one meetings, email, phone calls, and video chats. This workshop component facilitates a supportive and developmental relationship with the TREC fellows.

TREC faculty and fellows receive documents based on the Mentor Training for Clinical and Behavioral Researchers [8]. A presentation on effective mentoring is also given during the course. Mentoring activities include: preparing and submitting grants, manuscripts, and presentations, responding to reviewer critiques and revising manuscripts, and finding funding opportunities; writing grant proposals, budget management, protocol development, and reviewing and critiquing manuscripts for a journal; designing a project, constructing aims, understanding statistics, study design, translational research skills, IRB submission, oral presentation skills, understanding appointment, and promotion criteria; CV preparation; navigating the institutional culture; joining professional societies; enhancing professional visibility; balancing personal and professional life; chairing a committee; and networking skills.

Location of the weeklong TREC Training Course

The weeklong TREC Training Course occurs in Westbrook, CT. Located on the Connecticut shoreline, and only a short distance from Yale University,

the location facility provides all the elements for a productive training course. For example, all faculty and fellows stay at the facility for the weeklong course, with meals and training activities occurring on site. Offering the course at an all-in-one location that provides hotel accommodations, dining, and a variety of meeting rooms maximizes interactions and provides opportunities for socialization, networking, and relationship building.

Evaluation and statistical analyses

The TREC Training Program is evaluated through quantitative and qualitative methods. The overall logic model for the evaluation of the program as a whole is presented in Fig. 1. The logic model details each activity of the proposed training, the expected outputs, principal tools and measures, the expected training outcomes, and long-term impact.

First, we evaluate the recruitment process by tracking the number of applicants and those accepted to participate in the program. To evaluate transdisciplinarity within the recruitment process, we track the home discipline(s) of the applicants. Benchmark goals include receipt of at least 60 applications each year, with 20 participants selected equally from basic, clinical, and population cancer sciences to mirror the TD nature of the course. We monitor the proportion of applicants from underrepresented populations, assess applicants' prior experience,

and the support of their home institutions and local mentors.

TREC faculty and fellows complete a paper-based anonymous survey that was adapted from a survey developed for evaluating TREC scientific meetings. The survey has three sections with 18 questions: Program Logistics (7 questions), Training and Networking (6 questions), Mentoring (3 questions), and Overall Satisfaction (2 questions). Additional satisfaction questions were asked about the 50 specific sessions given throughout the 5 days. Questions had six responses (very poor, poor, fair, good, very good, and not applicable). At the end of the survey, there was an opportunity to provide open-ended comments.

TREC fellows' knowledge and skills related to energetics and cancer are evaluated before and immediately after the course. Specifically, we assess the fellows' knowledge with a quantitative pre-evaluation and postevaluation tool that is based around competencies. The survey has three sections with 46 questions: Demographics (6 questions), TD Competencies (7 questions), Energy Balance and Cancer Research Competencies (11 questions), Other Research Competencies (21 questions), and Mentoring (2 questions). Changes were assessed via the Wilcoxon Signed Rank Test with statistical significance set at $p < .05$ using two-sided tests.

TREC fellow's beliefs about whether or not they have access to a mentor who meets his/her

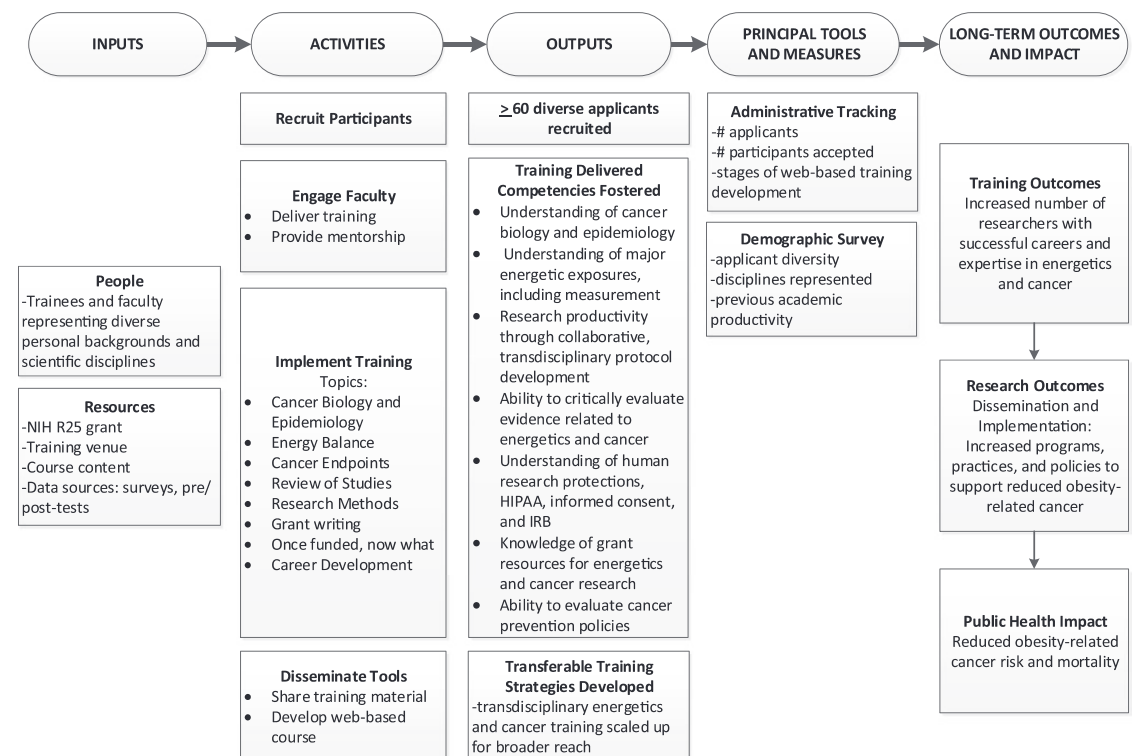


Fig 1 | Transdisciplinary Research in Energetics and Cancer (TREC) Training Course evaluation logic model.

professional needs, as well as about what roles are the most important for energy balance and cancer research mentors to fulfill, are also evaluated. Access to effective mentor(s), as well as mentor roles believed to be highest priority are assessed with a pre-evaluation and postevaluation tool. Access to an effective mentor is rated yes/no/not sure. Next, 17 specific mentor roles are presented (e.g., teach by example; improve my verbal communication skills; and facilitate networking with colleagues). An “other, specify” item is included if the fellow feels the most important mentor role is missing. Using the pre-evaluation and postevaluation tool, fellows are asked to indicate whether they have access to an effective mentor and to rank the three most important mentor roles. Changes in the mentor access and in each of the 18 roles are assessed via the Wilcoxon Signed Rank Test with statistical significance set at $p < .05$ using two-sided tests.

After the 1 year TREC mentorship period has concluded, we tracked scholarly achievements and career progress. Specifically, a survey was sent to TREC fellows, inquiring about indicators of scientific productivity, collaborations, and impact, including publications and awards that were a result of or inspired by the TREC Program. Number of publications, journal impact factors associated with these publications, and grant funding between June 2017 and December 2018 was compiled and summarized for the 20 TREC fellows participating in Year 1 of the TREC Training Course.

In an effort to compare publications and grants awarded to TREC Year 1 fellows to a comparison group, we chose to compare publications reported in PubMed and grants awarded (reported on National Institutes of Health [NIH] Report and clinicaltrials.gov) between TREC 1 applicants not accepted into the program and TREC 1 fellows accepted into and participated in the TREC workshop.

RESULTS

TREC fellows

Advertising of the TREC Training Program was shared with ~30 academic centers and other organizations, resulting in 77 applications for the inaugural 2017 year. Twenty TREC Fellows (26% acceptance rate) were accepted into the program, including 3 basic, 7 clinical, and 10 population scientists. Sixteen of the TREC fellows were junior faculty and four were postdoctoral fellows. Fourteen percent of the fellows self-reported minority race (Table 2).

TREC fellow's pre-post knowledge and skills

After participating in the weeklong TREC Training Course, knowledge related to conducting energy balance and cancer research, as well as TD research competencies, significantly improved in 37 out of 39 competencies (94.8%; Table 3). Before the

weeklong course, average baseline knowledge of TD competencies scored a 3.0 (“somewhat” category). After the course, TD competencies improved to an average 5.0 (“extremely” category; $p < .0001$). In examining all 39 knowledge questions, 37 showed a statistically significant improvement in knowledge and skills from before to after the course, with most scoring a 3 at baseline and improving to a score of 4 or 5.

TREC fellow's pre-post assessment of highest priority mentor roles

Fellows identified the three most important mentor roles as: providing constructive feedback; facilitating networking with colleagues; and providing guidance for career advancement. This assessment was unchanged after the course. However, after participating in the weeklong TREC Training Course, fellows reported a significant ($p = .03$) improvement in access to mentors who met their professional needs.

Course satisfaction

TREC faculty and fellows rated the overall course satisfaction as very high, with an average 93.3% of responses scoring in the “satisfied” or “very satisfied” category (Table 4). The remaining 6.7% did not answer the overall satisfaction question (nonresponses were allowed as this was a paper-based, anonymous survey). In addition to the quantitative responses, we compiled written testimonials gathered anonymously in the comments sections on the survey from Year 1 faculty and fellows. A representative sample of testimonials is: “The networking and collaborative opportunities at this meeting are unmatched!” “Feedback was invaluable, not just on my proposal but on career advice – beyond expectation!” “This is a meeting unlike any other. Allows many opportunities for networking and collaboration and one-on-one time with faculty.” “Caliber of faculty and fellows and NCI program staff made for an amazing week of high quality science, networking, career advice, and collaboration!” Table 5 presents opportunities for course improvement.

TREC fellow awards and accomplishments

Between the end of the TREC Year 1 Workshop in June 2017 and December 2018, TREC Year 1 fellows published 25 manuscripts [9–33], with 20 including coauthorship with other TREC fellows and/or TREC faculty. Twelve percent of the 25 manuscripts were published in journals with impact factors ≥ 10 . A total of 19 grant applications were funded: 7 NIH awards, 2 American Cancer Society (ACS) awards, 2 foundation awards, and 8 internal pilot awards. Seven TREC fellows were appointed or promoted in academic positions (Table 6).

Table 1 | Transdisciplinary Research in Energetics and Cancer (TREC) training workshop curriculum

	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday
Theme	Welcome!	Transdisciplinary research energy balance and cancer	Biobehavioral mechanisms	Patients, survivors, and personalized care	Furthering our impact across the cancer continuum	Coming full circle
7:00	Networking (group) breakfast and announcements					
8:00	What we know about energy balance and cancer	What we know about energy balance and cancer	Mechanisms	Survivor stories and patient advocacy	Health disparities and community-based participatory research	Fellows' reflections: workshop takeaways and action plan
Didactic lectures and panel discussion	Didactic presentations: • Epidemiologic and interventional studies • Clinical oncology • Modeling in animals Followed by panel discussion	Didactic presentations: • Animal modeling • Psychosocial/behavior • Novel biomarkers Followed by panel discussion	Didactic presentations: • Survivorship • Patient advocacy Followed by discussion from cancer survivors	Didactic presentations: • NCTN and NCCOR • NCCOR and NCI public data sets • KAISER and WHI Followed by panel discussion	Didactic presentations: • Intervening in diverse populations • Behavioral interventions • Cultural tailoring Followed by panel discussion	Opening Reflections: Fellows' reflections, course takeaways, and action plans
9:30	Beverage service with healthy snack					
10:00	What we do not know and future directions	Energy balance studies and disease-free survival	Energy balance studies and disease-free survival	National networks/large studies	TREC across the lifespan	Fellows' reflections
Didactic lectures and panel discussion	Didactic presentations: • Nutrition • Physical activity • Modeling in animals Followed by panel discussion	Didactic presentations: • The BWEL Trial • The CHALLENGE Study • The LIVES Study • The WINS Study Followed by panel discussion	Didactic presentations: • The BWEL Trial • The CHALLENGE Study • The LIVES Study • The WINS Study Followed by panel discussion	Didactic presentations: • NCTN and NCCOR • NCCOR and NCI public data sets • KAISER and WHI Followed by panel discussion	Didactic presentations: • Transgenerational animal models • Pediatric human studies • TREC in the older population Followed by panel discussion	Fellows' reflections
11:30	Walk break and networking group lunch					
1:00 pm	Faculty and NIH staff small group office hours					
2:00	Breakout session	Breakout session	Special topic	Breakout session	Special topic	Special topic
Breakouts and special topics	Challenges in assessment and measurement 1. Diet 2. Physical activity 3. Animal models	Challenges in assessment and measurement 1. Diet 2. Physical activity 3. Animal models	Standard of care: survivorship presentation on what is necessary to change standard of care and survivorship Followed by open discussion/Q&A	Special topics: 1. Genetics and epigenetics 2. Treatment side effects	Career development: progressing to independence and leadership Faculty presentation and group discussion about appointments, promotions, and preparing your professional dossier	Career development: progressing to independence and leadership Faculty presentation and group discussion about appointments, promotions, and preparing your professional dossier

(continued)

Table 1 | Continued

	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday
Theme	Welcome!	Transdisciplinary research energy balance and cancer	Biobehavioral mechanisms	Patients, survivors, and personalized care	Furthering our impact across the cancer continuum	Coming full circle
3:00 Special topics and grant writing	Hotel check in	Hallmark topic: Energy balance and cancer research—future directions and synthesizing perspectives	Grant writing NIH and faculty session opens with a 20 min talk; remainder of session fellows work on grants with faculty support	Grant writing NIH and faculty session opens with a 20 min talk; remainder of session fellows work on grants with faculty support	Grant writing NIH and faculty session opens with a 20 min talk; remainder of session fellows work on grants with faculty support	
4:00	Registration	Faculty and NIH staff small group office hours. Beverage service with healthy snack				
5:00	Welcome reception	Free time				
6:00 Dinner	Opening reception	Networking and group dinner	Kayaking on Long Island Sound!	Networking and group dinner	Farewell dinner and social outing	
7:00 Evening events	Dinner and introduction of fellows and faculty	From fellow to faculty: two former TREC fellows showcase how TREC has moved their careers forward.	Networking and group dinner	Evening off after dinner Free time		

NIH National Institutes of Health.

Table 2 | Demographic and academic characteristics of 20 Transdisciplinary Research in Energetics and Cancer Year 1–3 fellows

	All applicants	Year 1 (2017)		Year 2 (2018)		Year 3 (2019)	
		Accepted (%)	All applicants	Accepted (%)	All applicants	Accepted (%)	All applicants
Total N	77	20	58	24	88	21	
Academic domain							
Basic sciences	13	3 (15)	12	3 (13)	11	4 (19)	
Clinical sciences	11	7 (35)	12	6 (25)	16	6 (29)	
Population sciences	37	10 (50)	24	12 (50)	55	9 (43)	
Hybrid ^a	16	16 (80)	10	3 (13)	6	2 (10)	
Race/ethnicity							
Non-Hispanic White	Data not collected at the time of application	13 (65)	32	14 (58)	52	12 (57)	
African American		0 (0)	7	3 (13)	4	4 (19)	
Hispanic		2 (10)	5	3 (13)	8	0 (0)	
Asian		5 (25)	11	2 (8)	23	5 (24)	
Prefer to not answer		0 (0)	3	2 (8)	1	0 (0)	
Postdoctoral fellow	22	4 (20)	23	8 (33)	35	8 (38)	
Junior faculty	50	16 (80)	31	16 (67)	51	13 (62)	
Mid-career	0	0 (0)	2	0 (0)	1	0 (0)	
Senior faculty	0	0 (0)	2	0 (0)	1	0 (0)	
Predoctoral	5	Ineligible	0	0 (0)	0	0 (0)	
Female	52	16 (80)	38	18 (75)	29	15 (71)	
Male	25	4 (20)	20	6 (25)	26	6 (29)	

^aHybrid domain represents applicants with expertise in two or more of: basic, clinical, and population sciences.

Table 3 | Assessment of Transdisciplinary Research in Energetics and Cancer fellows pre–post knowledge and skills

Transdisciplinary (TD) research competencies	Median PRE ^a	Median POST ^{a,b}
Define and communicate the concept of transdisciplinarity	4	5
Identify what is and what is not TD research	4	5
Describe the potential impact on research productivity through collaborative, TD development and implementation of research protocols	3.5	5
Determine which evidence-based interventions are enhanced by TD testing	3	4
Assess, describe, and quantify (where possible) the context for effective TD research (setting, characteristics, culture, capacity, and readiness)	3	5
Identify existing gaps in TD research in energy balance and cancer	3	5
Formulate methods to address barriers in TD research	3	4
Energy balance and cancer research competencies	Median PRE ^a	Median POST ^{a,b}
Incorporate a thorough understanding of the biology and epidemiology of cancers in the United States and worldwide into research, teaching, and/or practice	3	5
Incorporate into research, teaching, and/or practice a thorough understanding of diet, physical activity, and obesity, including how to measure these factors and their relationship to cancer	4	5
Have a thorough understanding of cancer research endpoints	3.5	5
Have a thorough understanding of research methods and study design	4	5
Have a thorough understanding of grant writing	4	4
Have a thorough understanding of human research protections	4	4*
Have a thorough understanding of animal welfare	2	3*
Ability to critically evaluate evidence related to energetics and cancer	4	5
Ability to identify federal and foundation grant resources for energy balance and cancer research	3	5
Ability to recognize and evaluate the basis for policy and practice in cancer prevention	3	4
Ability to recognize and evaluate the basis for policy and practice in cancer survivorship	2	4
Other research competencies	Median PRE ^a	Median POST ^{a,b}
Epidemiologic study designs	4	4*
Behavioral studies	3	4
Biobehavioral mechanisms—medical/clinical	3	4
Biobehavioral mechanisms—psychosocial	2	4
Behavior change theories	2	4
Cellular/molecular mechanisms	3	4
Epigenetics, genetics, and miRNAs	2	4
Exposures and assessment—diet	3	4.5
Exposures and assessment—physical activity	4	5
Body composition	3.5	5
Patient advocacy, stakeholder engagement	2	4.5
The Precision Medicine Initiative (PMI)—general	3	4
PMI in the context of energy balance and cancer	2	5
Effect moderators	3	4
Side effects of cancer treatment	3	4
Cancer disparities	3	4
Community-based participatory research	2	4
Pediatric, elderly, and understudied populations	3	4
mHealth	1.5	4
Effective scientific presentations	4	5
Academic career trajectory	4	5

^a1—not at all; 2—slightly; 3—somewhat; 4—moderately; 5—extremely.

^bAll *p*-values <.05 except for * where *p* > .05.

Table 4 | Transdisciplinary Research in Energetics and Cancer (TREC) faculty and fellow's course satisfaction (%)

	Poor or very poor	Fair	Good	Very good	Not applicable	No reply
Program logistics						
Clarity of application materials	0	0	13.3	60.0	20.0	6.7
Timeliness of acceptance decisions	0	0	3.3	66.7	23.3	6.7
Adequacy of information prior to the workshop to facilitate preparation	0	0	6.7	80.0	6.7	6.6
Helpfulness of program staff with travel arrangements	0	0	0	83.3	10.0	6.7
Suitability of housing arrangements	0	0	0	93.3	0	6.7
Quality of meals provided	0	0	10.0	76.7	0	13.3
Utility of workshop website for accessing and downloading information	0	3.3	13.3	53.4	13.3	16.7
Informal training and networking						
Informal TREC research training: faculty office hours	0	0	6.7	80.0	3.3	10.0
Informal TREC research training: during mealtimes	0	0	13.3	73.4	3.3	10.0
Informal TREC research training: unscheduled consultations	0	0	6.7	60.0	20.0	13.3
Your [fellows'] interactions with faculty members / mentors	0	0	0	85.4	1.3	13.3
Your [fellows'] interactions/collaboration with other fellows	0	0	0	76.7	10.0	13.3
The professional caliber of other fellows	0	0	0	73.3	6.7	20.0
Mentoring during workshop						
Helpfulness of feedback from faculty on your [fellows'] ideas	0	0	3.3	63.4	20.0	13.3
Helpfulness of feedback from faculty on your [fellows'] grant proposal	0	3.3	20.0	43.4	20.0	13.3
Helpfulness of peer support from other fellows on your ideas	0	0	30.0	36.7	20.0	13.3
Overall satisfaction						
	Disappointed or very disappointed	Neutral	Satisfied	Very satisfied	No reply	No reply
How satisfied overall are you with the TREC workshop?	0	0	3.3	90.0	No reply	6.7
	Probably not or maybe	Probably	Definitely			
How likely are you to recommend the workshop to colleagues?	0	0	97.0	3.0		

Table 5 | Transdisciplinary Research in Energetics and Cancer (TREC) program: opportunities for improvements and potential solutions

Opportunities for program improvement	Solutions
Presentations going over time limit	Shorten and focus the talks more on future research needs and include panel discussions; limit faculty presentations to the AM, with grant proposals and one-on-one or small groups sessions in the afternoon
Too many breakout sessions	Intent of breakout sessions was to go more in depth with various topics among those interested in those topics, yet we reduced the number of breakout sessions from four to two
Faculty–fellow one-on-one sessions too short	Lengthened from 20 min sessions to 1 hr for the assigned mentee–mentors, with option for small group faculty office hours or 30 min sessions with other faculty
Consider including peer-to-peer collaborations or grant feedback	Include a fellow peer review of fellows grants, with a mid-week small group discussion of the grants
Limited time to discuss grant proposal	Ask assigned faculty mentor to review proposal prior to the workshop and provide written and oral feedback during the week and throughout the yearlong program; recommend fellows to submit revised proposal to their faculty mentor by the end of the workshop; have fellows give a 2 min elevator pitch of their grant proposal 2 times during the week to improve their “pitch”; quarterly webinars throughout the year with fellows volunteering to present their grant applications and/or research in progress to TREC faculty and fellows
More detailed guidelines on the mentor/mentee relationship and expectations	At the end of the workshop, fellows share their action items with the mentors to facilitate the mentoring relationship
Some faculty were only there for 1–1.5 days	Require that faculty attend for at least 2 days

Comparison of publications and grants awarded between TREC applicants and fellows

Publications reported in PubMed and grants awarded (as reported in NIH Report and clinicaltrials.gov) between TREC applicants and TREC fellows accepted into and participated in the program are presented in Table 7. Average publications and grants awarded per TREC applicant (not accepted into the TREC program) were 5.7 for publications and 0.23 for awarded grants compared with an average publication of 7.5 and grants awarded of 0.95 among TREC fellows accepted into and participating in the program.

DISCUSSION

There is increasing evidence for an association of obesity, poor diet, and physical inactivity with cancer risk and mortality [2,3]. Significant progress regarding energy balance and cancer risk will require continued commitment to TD research. Underlying the current TREC Training Program is the premise that communication, exchange of ideas and resources, and collaborations among scientists and across disciplines increase the potential for TD scientific breakthroughs. Results from our survey found that TREC fellows increased their knowledge as to what TD research is and how to apply innovative, integrated frameworks, and analytic approaches. They developed a broader perspective

that encompassed scientific approaches to multiple levels of translation while building disciplinary respect. The TREC Training Program also offered fellows a unique infrastructure that fostered collaboration between and among fellows and faculty and, consequently, provided fellows with opportunities for future collaboration and career growth.

An indication of such collaborations was that 80% of the 25 manuscripts published were coauthored by at least one other TREC fellow and/or faculty [8–32]. Highlights of the TREC fellows' published work includes prospective cohort analyses examining body composition and cancer risk and mortality; randomized trials of exercise, nutrition, and/or weight loss on cancer susceptibility biomarkers, body composition, and quality of life in cancer survivors; mHealth interventions; and cancer disparities [9–33].

While the 25 manuscripts and 19 grants awarded to the 20 TREC Year 1 fellows is not directly related to participation in the TREC Workshop, we did compare publications and grants awarded between TREC Year 1 fellows and TREC Year 1 applicants who were not admitted into the program. We found that the average publications per TREC fellow during July 2017 through December 2018 were 7.5 publications compared with 5.5 publications over the same time period per TREC applicant not admitted to the program. A limitation to this comparison is publication in PubMed and we included

Table 6 | Honors and awards from Year 1 Transdisciplinary Research in Energetics and Cancer (TREC) fellows, July 2017–December 2018

TREC Year 1 fellows	# contacts with TREC faculty mentors per year	# contacts with other TREC faculty per year	New funding	Peer-reviewed publications	Invited talks outside the fellows institution	New faculty appointments
N = 20	Average: 9.5	Average: 12.3	19 awards: National Institutes of Health: 3 RO1s 1 R37 MERIT 1 F32 1 Diversity Supplement 1 National Cancer Institute (NCI) NCORP Pilot ACS: 2 Research Scholar Foundations: 2 Internal Pilot Funding: 7 Unspecified: 1	N = 25	N = 28 invited talks American Society of Clinical Oncology American Association for Cancer Research American Society of Preventive Oncology Obesity Society San Antonio Breast Cancer Symposium (SABCS) International Society of Physical and Rehabilitation Medicine American Society of Hematology International Lymphoma Epidemiology Consortium Academic institutions NCI-designated cancer centers Global Conference on Breast Cancer	Assistant Professor: 6 Instructor: 1

all publications; thus, some were not specific to energy balance and cancer. We also compared grants awarded to TREC Year 1 fellows versus TREC applicants, with an average 0.95 grants awarded per TREC Year 1 fellow versus 0.23 grants awarded per TREC applicant. We were limited in our review of comparison of grants awarded to those listed in NIH Report and on clinicaltrials.gov; thus, we may have missed other grants awarded to TREC applicants. The higher number of publications and grants awarded among TREC Year 1 fellows compared to TREC applicants may be due to the fact that acceptance into the TREC Program was based on some preliminary experience in energy balance and cancer (e.g., publications, research experience, and grant funding), but such experience was not a requirement.

To our knowledge, no other training or educational course on energetics and cancer exists. However, there are numerous weeklong courses that focus on cancer (but not focused on energy balance), and one that focuses on physical activity (but not focused on cancer) [34]. However, limitations of the TREC Year 1 Program included a lack of racial/ethnic diversity and fewer basic/clinical scientists. However, in Year 2 of TREC, our advertising included a more targeted outreach to professional agencies representing underrepresented minorities. Of the applicants admitted into Year 2 of TREC, 25% were underrepresented minorities. Year 2 of TREC included 33% and 26% of applications from basic and clinical scientists, respectively, with the Year 2 TREC Cohort including 21% and 33% basic and clinical scientists.

Limitations of the TREC Program included our knowledge assessment. Competencies were evaluated quantitatively with a pre-post knowledge assessment. A more robust knowledge survey with multiple-choice questions is now being implemented and will inform us of areas of training that need improvement. The TREC Course Satisfaction survey also highlighted opportunities for program improvements. We have revised the course accordingly (Table 5).

In summary, the goal of the TREC Training Course is to train the next generation of scientists to conduct innovative and clinically significant TD and translational energy balance and cancer research. Upon completion of the fifth year of the TREC Training Workshop in 2021, we will disseminate our training material for widespread implementation. Faculty presentations are video recorded each year. Our goal is to develop web-based versions of the course with video faculty presentations available. Overall, the impact of the TREC Training Workshop will be defined by the degree to which TREC fellows produce innovative research approaches and discoveries that may improve the health of the population at risk of cancer, as well as cancer survivors.

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Table 7 | Comparison of manuscripts and awarded grants among Transdisciplinary Research in Energetics and Cancer (TREC) Year 1 applicants versus TREC Year 1 fellows^a

	Total Applicants <i>N</i>	Fellows ^b <i>n</i>	Not accepted ^b <i>n</i>
Total applicants	77	20	57
Manuscripts published ^c	474	150	324
Average publications per applicant		7.5	5.7
Grants Funded			
NIH-funded grants ^d	27	14	13
Average NIH grants per applicant		0.70	0.23
Other funded grants ^e	32	19	13
Average other grants per applicant		0.95	0.23

NIH National Institutes of Health.

^aTimeframe: July 2017 through December 2018.

^bFellows are those who were accepted into the program in Year 1 versus those not accepted.

^cPubMed.

^dNIH report.

^eClinicaltrials.gov.

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Compliance with Ethical Standards

Conflicts of Interest: The authors declare that they have no conflicts of interest.

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