Accelerating Translation of Physical Activity and Cancer Survivorship Research into Practice: Recommendations for a More Integrated and Collaborative Approach

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Abstract

Physical activity has been deemed safe and effective in reducing many negative side effects of treatment for cancer survivors and promoting better overall health. However, most of this research has focused on highly controlled randomized trials and little of this research has been translated into care or policy for survivors. The purpose of the present article is to present a research agenda for the field to accelerate the dissemination and implementation of empirically supported physical activity interventions into care. We provide rationale for the role of basic, behavioral, clinical implementation, and population scientists in moving this science forward and call for a more coordinated effort across different phases of research. In addition, we provide key strategies and examples for ongoing and future studies using the RE-AIM (reach, efficacy/effectiveness, adoption, implementation, and maintenance) framework and pose recommendations for collaborations between researchers and stakeholders to enhance the integration of this research into policy and practice. Overall, we recommend that physical activity and cancer survivorship research use additional study designs, include relevant stakeholders, and be more collaborative, integrated, contextual, and representative in terms of both setting and participants. Cancer Epidemiol Biomarkers Prev; 23(5); 687–99. ©2014 AACR.

Introduction

There are an estimated 14 million cancer survivors in the United States with this number expected to increase to 18 million over the next decade (1, 2). Cancer and its treatment are associated with deleterious psychosocial and physical side effects that may be chronic or have a delayed onset and result in compromised quality of life (QOL; ref. 3). In addition, cancer survivors are at increased risk for developing comorbid conditions (4, 5) and second primary cancers (6, 7) as well as premature mortality (8). Evidence indicates increased physical activity in cancer survivors is associated with reduced negative treatment-related side effects, enhanced QOL, and improved disease-specific outcomes (i.e., longer survival, reduced risk of recurrence, and mortality; refs. 9–17). Consequently, guidelines recommending physical activity for all cancer survivors are at least as inactive, or more inactive, than the general population (20–22) and other populations with chronic conditions (23–25). Population-based estimates indicate that only about one-quarter to one-third (20–22, 26) of survivors meet the public health recommendations for aerobic or strength training activities. Although many factors (e.g., demographics, prediagnosis activity, disease and treatment characteristics, symptoms, and behavioral and socioenvironmental factors; refs. 27–32) may contribute to dismal activity levels in this population, the lack of widely available disseminable evidence-based physical activity programs for cancer survivors (33) may be particularly detrimental. A good example of this is the fact that only one such program has been included in the Research-Tested Intervention Programs database (http://rtips.cancer.gov/rtips/index.do). This is likely reflective of most physical activity interventions for cancer survivors being designed as randomized clinical trials (RCT) that, by design, are time and resource intensive and often ignore, or hold constant, individual (e.g., intervention delivery preferences, motivational factors, comorbidities, and symptoms) and contextual (e.g., resources, safety, and cost) factors that influence real-world intervention uptake and sustainability (33). Although efficacy studies have been important to establish the evidence base for the beneficial effects of physical activity, the inherent limited generalizability of this research precludes widespread dissemination and implementation (D&I; ref. 19). Although some recent studies have adopted more practical study designs in real-world settings (34–38), increasing the number of these types of studies and enhancing the...
generalizability of new and existing efficacy/effectiveness studies is a critical next step for moving research in this area forward (39–44). We recognize that there are some trials (e.g., those answering biologic mechanism or dose questions) in which not all suggestions provided are feasible to implement (e.g., these likely need to be conducted in controlled laboratory settings). However, even in these cases, investigators can take some steps to improve the eventual translation of their findings, for example, by including a more representative sample of survivors.

Factors limiting D&I of physical activity and cancer survivorship research are consistent with other scientific disciplines and include a predominant focus on discovery; limited study relevance and efficiency; and inadequate collaboration and coordination among scientists (basic, clinical, population, and implementation) and stakeholders (45–47). Fortunately, many existing limitations can be addressed through the application of two frameworks: (i) the translational research process (45–48) and (ii) RE-AIM (reach, efficacy/effectiveness, adoption, implementation, and maintenance; ref. 49). The translation research process identifies five phases for translating scientific discovery to population health impact (see Fig. 1; refs. 45–48). Each phase answers a different question, uses different methods, and informs every other making this framework particularly useful for identifying exactly what research is needed and how research at every phase (e.g., basic, clinical, behavioral, implementation, and population) can be more collaborative and coordinated (45–48). RE-AIM is a conceptual model designed to enhance quality, speed, and public health impact of efforts to move research into long-term effectiveness in real-world settings (49) and can be used to provide specific study design recommendations to enhance the contribution of each translational phase (T0–T4) in achieving the ultimate goal of translating physical activity and cancer survivorship research into practice.

The purpose of the present article is to (i) summarize key facilitators for translating physical activity and cancer survivorship research into practice; (ii) recognize the importance of each T0 to T4 phase, highlight its role in translating research in this area to practice and argue for a more coordinated approach to advance this science; and (iii) provide specific recommendations for each RE-AIM element to accelerate the translation of physical activity and survivorship research into policy and practice.

Five Phases of Translational Research

The translational research process consists of five phases (T0–T4; see Fig. 1) that provide guidance about what is needed to successfully develop, implement, and sustain evidence-based approaches in real-world settings (45, 46). The translational process starts with the “discovery” of an opportunity to approach a health issue (T0). The first phase (T1) involves research from, mechanistic, basic behavioral, or clinical research resulting in the development of tests or clinical and nonmedical (i.e., policy, behavioral, social, or other public health interventions) interventions (45, 46). The second phase (T2) involves rigorous analysis and investigation of new intervention...
effects for improving health outcomes resultant in evidence-based guidelines and recommendations (45, 46). The third phase (T3) consists of investigations to increase uptake and implementation of evidence-based recommendations into practice. The final phase (T4) involves evaluation of intervention effectiveness/cost-effectiveness in real-world settings and population or public health impact.

A key characteristic of the translational research process is that it is nonlinear. Each phase is important and necessary, leads to new insights that fuel discoveries and contributes to knowledge integration by informing each and every other phase to, ultimately, enhance translation of science into practice (see Table 1). The translation process is driven by (i) ongoing and updated knowledge integration from basic, clinical, and population sciences; (ii) collaboration and transdisciplinary team science (50); (iii) multilevel analyses and interventions; and (iv) technology (51). Consequently, to accelerate translation, a collaborative, coordinated approach is needed among stakeholders and researcher across phases. Although studies must be designed to answer phase-specific research questions, the other phases and overall end goal of translating discovery into practice should be kept in mind. For example, although the main purpose of a T2 study may be to determine the efficacy of physical activity for fatigue reduction, the study may be delivered remotely (i.e., web based) with limited on-site appointments, if appropriate, thereby facilitating T3 and T4 research by using a more practical and feasible approach. Table 1 provides detailed examples, research needs, and role in translation for physical activity and survivorship research for each T0 to T4 phase.

Most physical activity and survivorship research has consisted of observational studies and phase II clinical trials (T0–T2) examining the effects of physical activity on specific health and disease-related outcomes (45, 46). It is essential for research in this area to progress beyond T2 to include activities to drive translation of research findings into practice and policy (47). However, it is also necessary to balance the requirement for more practical, effectiveness research with the limited efficacy data currently available for the many potential combinations of activity characteristics and health outcomes (43). Because the current funding environment limits the feasibility of conducting RCTs for every exposure and outcome (52), it may be necessary to adopt the Institute of Medicine mantra “to act on the best evidence available” (53) and draw from studies other than traditional RCTs, including systems’ dynamic models (54), N-of-1 (55, 56), comparative effectiveness research (CER; ref. 57), and fractional factorial designs i.e., multiphase optimization strategy trials (MOST) and sequential multiple assignment randomized trials (SMART; ref. 58). This approach embraces the nonlinear nature of the translational research process and has the potential to simultaneously contribute to the evidence base, inform practice and policy, and, ultimately, move research in this area forward.

Factors Influencing D&I of Physical Activity Research in Cancer Survivors across T0 to T4

Figure 2 presents examples of factors that have constrained widespread D&I of physical activity interventions for survivors across T0 to T4 research. These factors include intervention characteristics, target setting context, research design, healthcare system factors, knowledge about physical activity behavior, physical activity measurement, and definitions and interactions among these factors (59–62). In addition, most studies have not engaged stakeholders (e.g., survivors, oncologists; and community organizations; nurses, administrators, and families; ref. 43). Failure to address these factors limits potential D&I and sustainability of existing interventions by reducing their feasibility, adaptability, and relevance to cancer survivors and intervention delivery systems (e.g., hospitals, community centers; refs. 52, 63).

Enhancing D&I Potential of Physical Activity and Survivorship Research across T0 to T4

Ongoing and future research can contribute to overcoming barriers to D&I of physical activity and survivorship research. As detailed in Table 1, researchers at every T0 to T4 phase can contribute to translation without becoming a D&I scientist. This is only possible, however, if researchers adopt a collaborative coordinated transdisciplinary approach (50) and involve relevant stakeholders to integrate knowledge, ask novel research questions and design innovative and transformative studies (51). To optimize chances of success, investigators in every phase should consider the real-world context in which survivors live and attempt to incorporate this context in their science (52) by adequately mimicking the real-world clinical context (e.g., treatment protocols, symptoms), disease experience (e.g., cooccurring conditions, treatment toxicities), patient diversity/complexity (e.g., multiple chronic conditions, age), and variability in protocol adherence (64). These factors should be considered by T1 researchers in developing preclinical and human models (64) and alongside practice-based evidence (i.e., characteristics of interventions that have previously worked or failed in real-world settings) for T2 to T4 researchers (59).

Figure 3 uses cardiovascular disease (CVD) prevention to illustrate how these principles can be applied in a more coordinated and collaborative manner. The initial step would be to form transdisciplinary scientific and stakeholder teams who will be actively engaged throughout the research process. First, scientists would corroborate with stakeholders to understand their needs, experiences, resources, and expectations with regard to factors that may influence the likelihood a physical activity program would be adopted, implemented, and maintained at both an individual (e.g., intervention setting, time commitment, and type of activity) and systems/setting level (e.g., staffing, time, and resources). It is important to recognize that stakeholder and researcher needs may not always be complementary. For example, although
Table 1. Physical activity and cancer survivorship—stages of translational research examples, research needs, and translational impact

<table>
<thead>
<tr>
<th>Research phase</th>
<th>Example(s)</th>
<th>Research needs</th>
<th>Translational impact</th>
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<tbody>
<tr>
<td>T0</td>
<td>• Discovery that exercise is associated with reductions in metabolic syndrome in cancer survivors</td>
<td>• Examine physical activity in relation to chronic conditions, functional outcomes, cancer progression, survival, and potential intermediary endpoints</td>
<td>• Provide scientific justification for future research</td>
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<tr>
<td></td>
<td>• Discovery that exercise is associated with increased disease-free survival</td>
<td>• Examination of these relationships in diverse cancer types</td>
<td>• Identify exercise dosage for future intervention studies</td>
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<td>T1</td>
<td>• Initial pilot physical activity intervention trial to examine the relationship between exercise and development of metabolic syndrome</td>
<td>• Cost–benefit analyses of physical activity in comparison with other currently available approaches to symptom and disease management</td>
<td>• Provide scientific justification for widespread implementation of physical activity interventions</td>
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<tr>
<td></td>
<td>• Initial pilot physical activity intervention trial to examine inflammation as a potential mechanism underlying the survival benefits of physical activity</td>
<td>• Animal and human models of exercise and cancer survivorship that mimic one another and the real-world</td>
<td>• Determine safety of physical activity interventions</td>
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<td></td>
<td>• Replication of efficacious physical activity interventions in low-resource settings</td>
<td>• Determination of potential mechanisms underlying the health benefits for physical activity (e.g., aerobic fitness) and identification of intermediary markers for prognosis and survival</td>
<td>• Mechanism data provide evidence for third party reimbursement and more personalized physical activity recommendations</td>
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<td></td>
<td>• Development of evidence-based physical activity programs and physical activity guidelines</td>
<td>• Common metrics for comparison</td>
<td>• Strengthen evidence base</td>
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<td></td>
<td></td>
<td>• Innovative; more practical study designs</td>
<td>• Provide evidence-based interventions to be tested in diverse settings</td>
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<td></td>
<td></td>
<td>• More diverse participants</td>
<td>• More generalizable findings; reductions in health disparities</td>
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<td></td>
<td></td>
<td>• Multisite collaborations</td>
<td>• Reduce implementation costs and increased intervention uptake</td>
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<td></td>
<td></td>
<td>• Fractional factorial and pragmatic trials to determine most effective intervention components and physical activity dosage</td>
<td>• Facilitate development of individualized physical activity program recommendations</td>
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<td></td>
<td></td>
<td>• Studies to determine the MINC for specific health benefits</td>
<td>• Increase focus on context and boundary conditions of effects</td>
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<td></td>
<td></td>
<td>• Use of technology to increase intervention reach</td>
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<td></td>
<td></td>
<td>• Synthesis of evidence to overcome barriers to physical activity participation</td>
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<td></td>
<td></td>
<td>• Evidence of long-term efficacy of physical activity intervention on behavioral and health outcomes</td>
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<td></td>
<td></td>
<td>• Multilevel analyses of factors influencing physical activity participation and intervention effectiveness</td>
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<tr>
<td>T2</td>
<td>• Large intervention trial to test the effects of physical activity on lymphedema in breast cancer survivors</td>
<td>• Prevent and reduce side effects of cancer and its treatments at a more global level</td>
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<tr>
<td></td>
<td>• Replication of efficacious physical activity interventions in low-resource settings</td>
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<tr>
<td></td>
<td>• Development of evidence-based physical activity programs and physical activity guidelines</td>
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<tr>
<td>T3</td>
<td>• Implementation of evidence-based physical activity programs in multiple, diverse. and low-resource real-world settings</td>
<td>• Implementation of evidence-based programs in multiple, real-world settings</td>
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<tr>
<td></td>
<td></td>
<td>• Contextual assessment</td>
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<td></td>
<td></td>
<td>• Standardized intervention and training materials</td>
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Table 1. Physical activity and cancer survivorship—stages of translational research examples, research needs, and translational impact (Cont’d)

<table>
<thead>
<tr>
<th>Research phase</th>
<th>Example(s)</th>
<th>Research needs</th>
<th>Translational impact</th>
</tr>
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<tbody>
<tr>
<td>T4</td>
<td>• Measurement of physical activity and prevalence of targeted intervention outcomes (e.g., diabetes, depression) in survivors at the population level • Cost-effectiveness analyses for implementing evidence-based interventions in practice</td>
<td>• Pooling of data resources that monitor physical activity behavior of cancer survivors • Pooling of data resources with behavioral and medical usage data • Focus on key institutions providing cancer care to conduct quality improvement projects</td>
<td>• Inform policy development, future discovery, and intervention development • Potential improvements in quality of care/patient experience and population health and reduced healthcare costs</td>
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</tbody>
</table>

researchers and clinicians may be interested in CVD risk as an outcome, this may not be an important outcome to survivors. Thus, compromise may be required to achieve interventions and assessments amenable to both groups. Next, researchers would conduct rapid and recursive studies to refine preclinical and human models integrating data from the laboratory, stakeholders, and real-world implementation. This process would continue until the intervention strikes the proper balance of feasibility and effectiveness and maximizes the likelihood clinical and real-world environments mimic one another and effect estimates are accurate. The resulting physical activity intervention and prescription(s) would be safe, efficacious for improving CVD risk factors (e.g., cardiorespiratory fitness, lipid profile), and supported by stakeholders (52). The intervention could then be replicated in diverse settings to determine feasibility and effectiveness. Finally, when appropriate, interventions would be broadly disseminated and effects on CVD in cancer survivors could be monitored at the population-level using existing data sources (e.g., Behavioral Risk Factor Surveillance System; National Health Interview Survey; ref. 65).

Although an integrated collaborative approach incorporating D&I from the start may be ideal, (66) it may not always be possible and is not without challenges. Regardless, immediate steps can be taken to enhance study relevance and D&I potential. We use RE-AIM to outline specific recommendations for enhancing D&I of physical activity and survivorship research across the T0 to T4 phases.

**RE-AIM**

RE-AIM has been used in more than 200 studies to plan, evaluate, and review health promotion and disease management interventions (67, 68) and is intended for use at all stages of research, from planning to evaluation to syntheses (68, 69). The five dimensions (RE-AIM) are related to internal and external validity and incorporate individual and setting levels. Applying these five dimensions to physical activity and survivorship research can address key issues in translation and increase the probability of D&I of this research into policy and practice.

**RE-AIM recommendations for enhancing D&I potential across T0 to T4**

Elements of these recommendations are intended to apply across T0 to T4, including basic, behavioral, clinical, and population sciences (45, 46). Overall, we recommend research in this area maintain its rigor, but strive to be more rapid, relevant, robust, recursive, and transparent (47, 70). Recommendations for each RE-AIM element are intended to encourage clinically relevant research that leverages existing resources and infrastructure, uses more efficient and innovative research designs and mixed methods (52, 71), and incorporates relevant stakeholders (43). Furthermore, adoption of a solution-oriented approach focused on
improving the health of cancer survivors through physical activity in a sustainable way is encouraged over a problem-oriented, reductionist approach focused solely on understanding cause and effect relationships between activity and health outcomes (72). Finally, as single interventions are generally insufficient to create sustainable change, multilevel and multistrategy approaches are recommended (73, 74). Key strategies for addressing each RE-AIM element and examples of how to use these strategies in ongoing and future studies are detailed in Table 2 and described below.

**Reach**

Although well-defined homogenous samples are often considered hallmarks of rigorous research, they also may limit applicability of findings to real-world heterogeneous populations (75). Existing physical activity and cancer survivorship study samples mainly consist of breast cancer survivors who are middle-aged, White, English-speaking, and high socioeconomic status (33), which is not entirely representative of the survivor population (2). The representativeness of experimental, intervention, and observational study samples should be increased to provide more accurate estimates of effects and cost-effectiveness (76).

Specific strategies and recommendations for improving reach are detailed in Table 2. First, concerted and iterative efforts should be made to recruit harder to reach cancer survivors using methods including bilingual staff, translated and culturally adapted intervention materials, community leaders (77), and snowball sampling techniques (78). Second, study eligibility criteria should be expanded to include survivors over age 65, beyond 5 years after diagnosis and/or those with other chronic conditions (2, 79). Data also need to be collected to compare participants and nonparticipants. Ideally, this would be accomplished through waivers of informed consent to obtain basic demographic and health status data on nonparticipants for comparison. If this is unfeasible, study samples should be compared with the local survivor population.

![Interaction among factors](image-url)
Assessment of population-level effects

Scientists: Analyze effects on health outcomes, costs/benefit of interventions, and sustainability
Stakeholders: Support sustainability

Example(s)/outcome(s)
Program is maintained and risk factors for CVD decline as measured by existing national surveys

Figure 3. A more coordinated and integrated approach for translating research into practice: Exercise to prevent CVD in cancer survivors as an example.
### Table 2. Key strategies across T0 to T4 research phases for ongoing studies

<table>
<thead>
<tr>
<th>Definition</th>
<th>Key strategies</th>
<th>Examples—both ongoing and future studies</th>
<th>Examples specific to future studies</th>
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</thead>
<tbody>
<tr>
<td><strong>Reach</strong></td>
<td>The absolute number, proportion, and representativeness of individuals who are willing to participate in a given initiative</td>
<td>- Collect data on nonparticipants and use mixed methods to understand why people do not participate or dropout&lt;br&gt;- Increase recruitment efforts to hard to reach populations&lt;br&gt;- Expand eligibility criteria for interventions and observational analyses</td>
<td>- Incorporate evaluability procedures to assess Reach and other components below&lt;br&gt;- Collect data on nonparticipants and use mixed methods to understand why people do not participate or dropout&lt;br&gt;- Increase recruitment efforts to hard to reach populations&lt;br&gt;- Expand eligibility criteria for interventions and observational analyses</td>
</tr>
<tr>
<td><strong>Efficacy/effectiveness</strong></td>
<td>The impact of an intervention on important outcomes, including potential negative effects, QOL, and economic outcomes</td>
<td>- Track unanticipated/adverse events&lt;br&gt;- Study moderating factors and subgroup effects&lt;br&gt;- Determine MINC&lt;br&gt;- Use practical, standardized measures</td>
<td>- Collect data on contextual and individual factors and other behaviors&lt;br&gt;- Interview participants and dropouts&lt;br&gt;- Assess if participants using any other physical activity supports or resources&lt;br&gt;- Report on outcomes by key health disparities</td>
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<tr>
<td><strong>Adoption</strong></td>
<td>The absolute number, proportion, and representativeness of settings and intervention agents willing to initiate a program</td>
<td>Setting level&lt;br&gt;- Collect data on nonparticipating sites or reasons excluded*&lt;br&gt;- Build partnerships with survivors, clinicians, and organizational leadership&lt;br&gt;- Collect information on characteristics of participating and nonparticipating staff&lt;br&gt;- Track staff participation</td>
<td>Setting level&lt;br&gt;- Track important characteristics (e.g. population served, location, size, etc.) of all sites approached to participate and reasons for ineligibility&lt;br&gt;- Interview staff at participating and nonparticipating sites&lt;br&gt;- Use nontraditional practitioners as intervention delivery-agents</td>
</tr>
<tr>
<td><strong>Implementation</strong></td>
<td>The intervention fidelity of agents to the various elements of the protocol of an intervention, including consistency of delivery as intended</td>
<td>Setting level&lt;br&gt;- Assess resources and monetary costs&lt;br&gt;- Document adaptations needed&lt;br&gt;- Create standardized training and delivery materials&lt;br&gt;- Assess consistency of intervention implementation</td>
<td>Setting level&lt;br&gt;- Track costs, including training, staffing, assessments, physical resources, and time&lt;br&gt;- Document challenges, barriers, and adaptations/solutions and any changes in the study protocol&lt;br&gt;- Allow for tailoring of intervention components to setting&lt;br&gt;- Use nontraditional research designs (e.g., MOST, SMART, and CER) as appropriate to address likely challenges</td>
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Finally, data on factors influencing participation decisions should be collected from participants, nonparticipants and dropouts. These recommendations are all relatively obtainable through protocol amendments for ongoing studies.

**Efficacy/effectiveness**

Most physical activity and survivorship studies have been designed to maximize efficacy and effectiveness (33). Thus, recommendations in this area are focused on reporting of broader and potential negative, or unanticipated, outcomes and "understanding what works for whom in what situation for which outcomes" (80). Key strategies and examples of how to increase efficacy/effectiveness are provided in Table 2.

Although adverse events are typically tracked in accordance with data safety and monitoring plans, these numbers are not always reported in publications (33). Tracking and reporting of these events is crucial for identifying specific individual, delivery, or setting characteristics influencing adverse events rates. In addition, broader and unanticipated consequences of physical activity interventions (e.g., increased sedentary behavior or caloric consumption) should be measured periodically as they may have important implications beyond intended effects (81, 82). Data should also be collected on use of physical activity resources other than the assigned intervention to distinguish true intervention effects (83).

A key factor in discerning what works for whom under what conditions for which outcomes is understanding the context in which interventions are (and are not) effective (84). Investigators should collect and report data on contextual (e.g., organizational, environmental) and individual (e.g., demographic, motivation) factors that may influence intervention efficacy/effectiveness. These data can also be used to conduct subgroup and moderation analyses to clarify differential intervention or dosage effects (84). Physical activity measurement should also be enhanced to test effects of activity characteristics (e.g., type, volume) on various outcomes. This may consist of (i) supplementation of intervention adherence measures with objective and/or self-report measures; (ii) evaluation of physical activity at more frequent time intervals beyond pre- and postintervention; and (iii) incorporation of a wide range of physical activity dosages in analyses. Ultimately, these techniques could support identification of the minimal intervention necessary for change (MINC; refs. 85, 86). In this case the MINC would represent the lowest intervention intensity, expertise, and resources needed to achieve a clinically significant improvement.
in activity or a specific outcome for a specific group of survivors under a particular set of conditions, when delivered in a specific way (85, 86). Identification of the MINC for various outcomes would provide a standard for comparison for outcome improvements based on the relative cost of more intensive interventions as well as more personalized activity recommendations for survivors in terms of program/prescription characteristics (86). Finally, use of practical, standardized outcome measures such as validated single-item symptom assessments is recommended to facilitate knowledge integration and monitor congruence at multiple assessment levels (e.g., clinical and population; ref. 87).

Adoption
Specific recommendations for increasing adoption of physical activity interventions for cancer survivors at the setting and staff level are detailed in Table 2. First, researchers conducting single- and multisite interventions should focus on building partnerships within universities, hospitals, cancer centers, and communities to garner support for their programs to increase eventual adoption potential. Future and ongoing interventions should track participating and nonparticipating sites (e.g., populations served, location, and size) and staff (e.g., education, training) characteristics (68). Staff adherence and qualitative data on contextual factors they feel influenced adoption should be collected. Finally, future studies should use a more pragmatic approach to intervention design, including using diverse real-world and low-resource settings (i.e., YMCAs, rehabilitation facilities, community centers, and worksites), clinically relevant comparison groups (76), and practitioners as delivery agents (e.g., American College of Sports Medicine–certified cancer exercise trainers, community health workers; ref. 39).

Implementation
Implementation can be facilitated through the use of technology, replication in diverse settings, collection of data on intervention adaptations or protocol changes, costs, resource requirements (e.g., training, staffing equipment, and time), and value added (see Table 2; ref. 88). In addition, standardized training and intervention materials similar to EnhanceFitness (89) and Fit and Strong (90) physical activity programs for older adults should be created for widespread D&I of programs for cancer survivors. To increase adherence, future studies should consider permitting tailoring of intervention components such as modality (e.g., onsite, telephone, and internet), start date, setting (e.g., group, individual), or physical activity type (e.g., walking, swimming, and aerobics) to meet setting or participant needs (61). Investigators should also consider using more innovative intervention delivery and data collection methods (e.g., internet, mHealth) and nontraditional research designs [e.g., MOST (ref. 58), SMART, and CER (ref. 57)] to increase potential feasibility and sustainability (91). Use of systems science models (92) and/or simulation modeling are also recommended for identifying points of maximum leverage for interventions, effects of physical activity policies, and programs on a variety of outcomes, and unintended consequences (82). Finally, future studies should incorporate D&I models and measures in the study design (93, 94).

Maintenance
Few trials in cancer survivors incorporate any maintenance period or assessment (33, 43). Table 2 provides specific strategies and examples for monitoring and evaluating intervention maintenance at individual and setting levels. Follow-up after intervention is necessary to evaluate behavior change maintenance, program sustainability and maintenance, and potential delayed onset of intervention effects. At a minimum, brief individual and setting level physical activity behavior and/or program maintenance assessments should be conducted at least 6 months after intervention. In addition, individual and setting level data should be collected to examine potential contextual (e.g., organizational support, intervention cost) or individual (e.g., health status, motivation) factors that may differentiate those who maintain from those who do not (68). For settings or individuals that maintain programs, intervention changes or modifications should be examined.

Projects in the planning phase should consider using mHealth or related lower cost, technologies to deliver interventions to enhance their potential maintenance (52). Finally, significant effort should be directed toward enhancing setting level maintenance and sustainability. Promising approaches to enhance setting sustainability are (i) stakeholder involvement from the outset; (ii) modest intervention costs and resource demands; and (iii) alignment with the setting’s business core values and relevant reimbursement or return on investment policies.

Discussion
Despite the benefits of physical activity for cancer survivors, population-specific physical activity recommendations (19) and a process for implementing these guidelines into clinical practice (95), most physical activity research has not been, and is not likely to be, disseminated and implemented into practice. If this research is to move beyond T0 to T2 to have population-level effects, it is imperative researchers consider the broader implications of their work within the larger translational context and collaborate to advance science in this area.

It is strongly recommended that investigators at all T phases (i) adopt a more relevant, transparent, collaborative, and transparent approach; (ii) attempt to address elements of RE-AIM or other D&I frameworks; and (iii) consider these elements in planning, design, and throughout study execution. We highlight key contributions of each T phase of translational research and provide key
strategies for incorporating RE-AIM elements across all phases with the goals of improving external validity of ongoing and future studies and increasing the speed and likelihood research will influence practice and policy. In addition, we have provided recommendations for how scientists from different phases can collaborate with one another, survivors, and stakeholders to enhance research value and relevance.

A potential reaction is that the actions called for seem unrealistic or impractical, especially given competing demands, bad reporting, institutional requirements and potentially limited funding mechanisms, and review panels with expertise to facilitate these types of studies. Our response to this likely objection is 4-fold. First, several recommendations do not require additional time, effort or funding mechanisms, but recommend doing things differently from the outset (e.g., thinking about eventual users and the context in which they are working). Second, many recommendations do not require additional resources, but, rather, taking the perspective of stakeholders and transparently reporting information likely available from implementation notes of project staff. Some things such as collecting intervention costs and sustainability data will require additional resources or doing things differently. Third, several recent funding announcements provide support for a more innovative and integrated approach [e.g., “Innovative research methods: Prevention and management of symptoms in chronic illness” (PAR-13-165); “Systems science and health in the behavioral and social sciences” (PAR-11-314/5) and “Short-term mentored career development of investigators in the physical activity and weight control dissemination and implementation research in health” (RFA-DA-14-002); “Cross-training at the intersection of animal sciences: Cross-training at the intersection of animal models and human investigation” (PAR-12-228/9)].

Finally, we assert that the present paradigm of each T stage, and often each research laboratory, doing things in their own silo has been demonstrably ineffective at stimulating translation. If we are serious about making research more broadly applicable and having a population health impact (45, 46), business as usual will not achieve these goals.

We do not expect every study at every T phase to incorporate all the recommendations in the tables and text. Incremental progress is needed and will be helpful. However, given the magnitude of the challenges and important goal of eventually broadly disseminating effective and sustainable physical activity programs for cancer survivors, multiple actions are required. Like other useful guides, such as the chronic care model (96, 97) greater and more rapid progress will be made if future research uses a majority of the strategies above in conjunction with each other, rather than in isolation.

Disclosure of Potential Conflicts of Interest
No potential conflicts of interest were disclosed.

Disclaimer
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References


Physical Activity and Cancer Survivorship Research


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