Review

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Parental involvement in exercise and diet interventions for childhood cancer survivors: a systematic review

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Childhood cancer survivors (CCS) are at risk of becoming overweight or obese due to treatment effects and/or post-treatment behaviors. Parents are key agents influencing child diet and physical activity (PA), which are modifiable risk factors for obesity. A systematic literature review following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines was undertaken to evaluate current interventions that include diet and PA elements for CCS to determine if and to what extent parents were included, and whether parent involvement had a significant effect on behavioral outcomes or adiposity. A total of 2,386 potential articles were reviewed and 25 individual studies fulfilled inclusion criteria. Parental involvement was classified into three categories and varied across studies, although most had indirect or no parental involvement. The studies that included direct parental involvement showed positive outcomes on a variety of measures suggesting that increasing parental involvement in interventions for CCS may be one way to promote long-term lifestyle changes for pediatric cancer patients. However, additional research directly addressing parental involvement in obesity prevention and treatment among CCS is warranted.

Childhood cancer survivors (CCS) are a growing population with over 100,000 survivors under age 19 living in the United States as of January 2014 (1). In the last 30 y, treatments have improved survival rates for childhood cancer patients from 58 to 83% (1). However, CCS are experiencing a host of post-treatment sequelae, including increased risk of becoming overweight or obese due to effects of their treatment and unhealthy lifestyle practices (2–6). Obesity potentially modifies the iatrogenic cardiovascular, pulmonary, and second malignancy effects of treatment (7,8), emphasizing the need for obesity prevention among CCS.

Modifiable risk factors for obesity include dietary intake and physical activity (PA). While the majority of research on obesity and pediatric cancer survivorship has focused on acute lymphocytic/lymphoblastic leukemia (ALL), several studies have demonstrated poor dietary and PA behaviors in patients and survivors across different cancer diagnoses (4–6). Despite CCS' risk factors for obesity and other chronic conditions (i.e., cardiovascular disease), CCS are not more likely to adhere to diet and PA recommendations than the general population, despite their increased risk for associated chronic conditions (9,10). On average, CCS consume excessive calories (4), inadequate folate, calcium, and iron (4,5) and do not meet the national minimal PA guideline of 60 min of activity per day (5,11).

In noncancer populations, parents and caregivers have been shown to influence their children's dietary habits (12,13) and PA levels (14). The socioecological model specifies the multiple layers that influence childhood obesity including both individual and environmental factors (15). Thus, parent characteristics, household characteristics, and parental perceptions of food and PA environments can be significant contributors to childhood obesity (15). Parents influence their children both by their parenting style and context-specific parenting practices. Parenting style describes the emotional climate that one establishes during interaction with their child, based on individual values and actions (16), whereas parenting practices are goal-oriented behaviors used to influence a child's actions in a specific context (such as eating or exercising) (16). Reviews of parental involvement in diet and PA interventions for healthy children found higher intensity, direct parental involvement in such programs was promising, though the number of studies were limited (17,18). Parental involvement increased success of weight management studies targeting children/adolescents in noncancer settings (19,20). These issues have not yet been examined among CCS. This review explores two main research questions (i) To what extent have parents of CCS been involved in CCS diet and PA interventions? and (ii) Does parental involvement indicate better outcomes in diet and PA interventions for CCS?

RESULTS

The search strategy identified 2,386 articles (**Figure 1**). After the initial titles and abstracts were screened, 84 articles were retrieved for full text review. Of those, 30 articles met the

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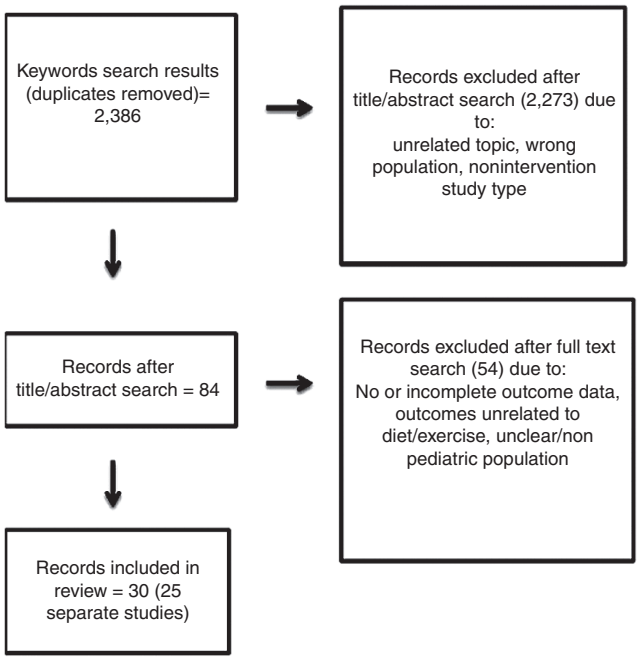

Figure 1. Scheme depicting the search methodology for this review. Combinations of keywords were entered into the three databases; only papers from peer-reviewed journals were included. Keywords (combinations of) included: infant, child, adolescent, pediatric, survivor, neoplasms, cancer, leukemia, cns, tumor, carcinoma, health behavior, health promotion, health attitudes, health practice, health knowledge, intervention, evaluation studies, program evaluation, validation studies, exercise movement techniques, exercise therapy, exercising, physical activity, physical exertion, swimming, nutrition, nutrition therapy, nutrition surveys, child nutrition sciences, diet, feeding behavior, and eating. The resulting articles were consolidated into a single document and duplicate articles removed. The titles and abstracts were screened for content. Papers that were off topic, targeted the wrong population or were not intervention studies were removed. The full texts of remaining studies were reviewed based on the inclusion criteria. Reasons for exclusion included unclear population, incomplete or lack of outcome data and unrelated primary outcomes.

inclusion criteria for review. Five of these were secondary analysis or follow up reports on already included studies, so they were combined with the original publication. This resulted in a total of 25 unique interventions to be included. A summary of characteristics of these studies is presented in Table 1. While diet was included as part of five of the interventions identified, most studies focused exclusively on PA through exercise classes.

We assessed parental involvement for each individual study. Nearly half of the total studies did not include parental involvement (21–34). Eleven studies were characterized as using indirect parental involvement (35–47). Three studies used direct parental involvement (48–51). None of the studies directly compared interventions with and without parental components. All studies were combined and categorized by type of parental involvement to determine if different levels of involvement had an impact on reported results (Table 2). Outcomes were categorized by positive or mixed results and displayed with study characteristics by level of parental involvement. Positive results indicated that changes occurred in the desired direction. Mixed results indicate that there were some positive changes, but only among one subgroup (e.g., girls but not boys) or only for one of the outcome measured (e.g., BMI improved but not waist circumference). This method has been previously used to assess parental impact on intervention results (17). As the studies varied in outcome measures, the results were ordered into broader categories including diet, PA, fitness, anthropometric, and metabolic outcomes.

No Parental Involvement

Eleven studies had no parental involvement (21–34). Parents were only mentioned in these studies for consenting purposes or to serve as proxies for self-reporting behavior data. Of these papers, none positively impacted anthropometric or metabolic outcomes (Table 2). However, 85% of the studies that collected fitness data reported positive outcomes and 71% of studies that collected PA data reported positive outcomes. Only one study included a diet measure in the form of a behavior questionnaire (33,34) and reported mixed outcomes, i.e., a significant reduction of junk food consumption in the intervention group with no other significant dietary improvements reported (34).

Indirect Parental Involvement

Eleven studies used indirect methods to engage parents in the interventions by sending materials home to parents, inviting parents to attend sessions with their children, enrolling parental support, and/or providing assignments to parents that required a response (parent satisfaction questionnaires) or action (active parent observation of home interventions) (35–47). Of the three indirect parental involvement studies that gathered diet data, one showed mixed outcomes, with improvements in total calorie and carbohydrate intake, but only among older participants (>14 y old) (39). Of the indirect studies that used anthropometric measures, the majority (57%) showed no impact, 14% had mixed results and 28% demonstrated positive impact. Of the indirect studies that measured fitness, 67% showed positive impact. Fifty percent of indirect studies that used PA measures showed improvements in outcomes.

Direct Parental Involvement

Only three studies used direct strategies to engage parents (48–51). One study included 75 cancer survivors aged between 11–21, with 38 randomized to the intervention group and 37 to a wait-listed control. In this study design (50,51), parents were shown a 20-min video explaining the program and were given the same study materials as their children to discuss in a group setting (allowing the parents to connect with each other as well as fully understanding the intervention). Parents were engaged in the development of the program by offering their opinions in preliminary focus groups. This study focused on bone health through healthy eating habits and found participants that attended the half-day workshop reported higher calcium intake than the control (51).

In the other two studies, parents were directly targeted for parent-only activities, though these were not necessarily

Table 1. Summary of study characteristics

	Study type (Reference)	Number of studies
Level of parental involvement reported		
None; Parents provided consent/proxy reports only	Exercise:(21–32); Multi:(33,34)	11
Indirect; Provision of information/invitations to parents that did not require a response and/or use of parents for observational or satisfaction data collection (surveys).	Exercise:(35–38,40,43–47); Multi:(39,41,42)	11
Direct; Parent attendance requested at intervention sessions or parent-specific training sessions and/or parents active in program development.	Exercise:(48,49); Multi:(50,51)	3
Primary setting		
Clinic/hospital	Exercise:(21,27–29,31,32,40,43–45); Multi:(33,34,42)	11
Community	Exercise:(22,37,38,46): Multi:(50,51)	4
Home	Exercise:(23,24,47): Multi:(41)	4
Combination clinic/hospital and home	Exercise:(30,35,36,49)	4
Other	Exercise:(25,26); Multi:(39)	2
Program length		
<1 wk	Exercise:(25,26); Multi:(33,34,50,51)	3
3–8 wk	Exercise:(21,22,29,43,48)	5
3–6 mo	Exercise:(23,24,28,30,31,35–38,44–47,49); Multi:(39)	12
1 y or more	Exercise:(27,40); Multi:(41,42)	4
Sample size		
<20	Exercise:(21–24,28,30,35,37,38,43–47); Multi:(41)	13
20–50	Exercise:(27,29,32,36,48,49); Multi:(39,42)	8
>50	Exercise:(25,26,40); Multi:(33,34,50,51)	4
Age range		
Under 12	Exercise:(44,45,47,49); Multi:(41)	4
Under age 18	Exercise:(21,22,25–29,31,32,35,36,40,43,46,48); Multi:(33,34,39,42)	17
Beyond 18 (starting target age <16 up to 30)	Exercise:(23,24,30,37,38); Multi:(50,51)	4
Stage of treatment		
Active	Exercise:(22,32,35,37)	4
Maintenance	Exercise:(28,36,44,45,47,48); Multi:(41)	6
Survivor	Exercise:(23–38,49); Multi:(39,50,51)	8
Mixed or other	Exercise:(21,29,40,43,46); Multi:(42)	6
Diagnosis		
Leukemia (ALL)	Exercise:(23,24,28,35,36,40,43–49); Multi:(39,41)	13
Tumor	Exercise:(27,32); Multi:(42)	3
Mixed	Exercise:(21,22,25,26,29–31,37,38); Multi:(33,34,50,51)	9
Behavioral theory		
None specified	Exercise:(21–24,27–32,35,36,40,43–47); Multi:(41,42)	18
Health behavior theory used	Exercise:(25,26,48) (Multiple) (37,38); (Theory of Planned Behavior); Multi:(50,51) (Multiple) (33,34); (Health Behavior Model) (39); (Social Cognitive Theory)	6
Outcome measures		
Anthropometric (height, weight, BMI, BMI Z-score, body composition, and % ideal body weight)	Exercise:(21,23,24,30,31,40,43,46,47); Multi:(39,41,42)	11
PA/exercise (PAI MET hours/week, LSI, PA psychosocial Qn, PA/Exercise behavior Qn, CUHK-PARCY, SOC-PA, accelerometer, and PDPAR)	Exercise:(22–27,30,32,37,38,48); Multi:(33,34,39,41,42)	13
Fitness (VO_{2PEAK}, VO_2, Maximal work load, strength tests, flexibility tests, TUDS, TUG tests, GMFM, passive AD, motor performance tests, knee extension strength, 6/9 min walk/run test, ergometer (duration/intensity), dynamometer (manual force), OMNI walk/run scale, and BOT-2) PACER laps	Exercise:(21–24,28–31,35,36,40,41,43–49)	17
Diet (behavior questionnaires, FFQ, 24 h recall, and 3-d food record)	Multi:(33,34,39,41,42,50,51)	5
Metabolic (fasting plasma insulin, HOMA-IR, BP, blood glucose, lipids, IGF, IGFBP, GH, and Hemoglobin A1c)	Exercise:(23,24,30,44,45,49); Multi:(39,42)	6
Study design characteristics		
Randomized controlled trial	Exercise:(25,26,36,40,49); Multi:(33,34,39,41,50,51)	8
Case–control/nonrandom control group	Exercise: (21,27,29,31,32,43,48)	7
Pre–post (no control group)	Exercise:(22–24,28,30,35,37,38,44–47); Multi:(42)	10
Feasibility study	Exercise:(22,29,35,46–48)	6

This table shows the main characteristics of each study included. The key characteristics are divided into major subheadings including level of parental involvement, primary setting, program length, sample size, age range, stage of treatment, diagnosis, behavioral theory, outcome measures, and study design. The sub headings within the second column separate the studies into exercise only and multi-component studies. Multi-component studies are those that include diet and/or exercise as well as other health behavior targets. Exercise studies only include exercise and physical activity.

AD, ankle dorsiflexion; BP, Blood pressure; BOT-2, Bruininks-Oseretsky test of motor proficiency version 2; BQn, behavior questionnaire; CUHK-PARCY, Chinese University of Hong Kong-Physical activity rating for children and youth; DF ROM, ankle dorsiflexion range of motion; FFQ, food frequency questionnaire; GH, growth hormone; GMFM, gross motor function measure; HOMA-IR, homeostasis model assessment - insulin resistance; IGF (BP) insulin growth factors (binding proteins); LSI, leisure score index; MET, metabolic equivalent of task; PACER, Progressive Aerobic Cardiovascular Endurance Run; PA-SE, physical activity self efficacy; PDPAR, previous day physical activity recall; PAI, physical activity index; SOC, stages of change; TUDS, timed up and down stairs test; TUG, timed up and go test.

Table 2. Summary of relevant results by level of parental involvement

First Author	Age (yo)	N	Dx	Survivor or active	Intervention	Ctl	Setting	Length	Outcome measure	Positive results	Mixed results	Effect size
No parent involvement												
Chamorro-Vina (21)	4–16	20	Mixed	Active	Aerobic and resistance training	Standard care	Hospital	3 wk	Anthrop[a], fitness[c]	Resting heart rate, Strength tests	—	N/A
Wurz (22)	5–17	8	Mixed	Mixed	Group yoga classes	N/A	Comm	12 wk	Fitness, PA[e]	Functional mobility and flexibility	Time spent in PA and mild PA not total PA	N/A
Jarvela (23,24)	16–30	17	ALL	Survivor	Illustrated home muscle-training program, pedometers and biweekly counseling calls	N/A	Home	16 wk	Anthrop, fitness, metabolic[d], and PA	Strength tests, VO2peak, and maximal work load	Waist circumference, waist-to-hip ratio, and fat % not BMI; fasting plasma insulin, HOMA-IR, and SDBP only	N/A
Li (25) Chung (26)	9–16	71	N/A	Survivor	Adventure-based training and health education program	Standard care + non PA leisure activity	Outdoor Activity Center	6 mo + 12/18 mo follow up	PA	—	—	Large
Muller (27)	8–18	21	Osteosarcoma / Ewing's sarcoma	Active	Balance, flexibility and resistance training	Standard care	Hospital	Appx 88 d + 12 mo follow up	PA	PA	—	Large
Perondi (28)	5–16	6	ALL	Active	Resistance, aerobic and stretching training	N/A	Hospital	12 wk	Fitness	PA	—	Med
Rosenhagen (29)	12–18	13	Mixed	Active	Endurance and strength training	Standard care	Hospital	Appx 34 d	Fitness	PA Dynamometer	—	N/A
Sharkey (30)	16–22	12	Mixed	Survivor	Aerobic training	No control	Hospital	12 wk	Anthrop, fitness, PA	Strength tests	Peak oxygen uptake and VAT only	N/A
Shore (31)	13–14	6	Mixed (mainly ALL)	Survivor	Stretching and aerobic training	Noncancer children	Hospital	12 wk	Anthrop, fitness	—	—	N/A
Winter (32)	8–18	31	Bone tumors	Active	Games, strength, endurance, flexibility and relaxation training	Standard care	Hospital	6 mo +12/18 mo follow up	PA	PA	—	N/A
Hudson (33) Cox (34)	12–18	266	Mixed	Mixed	Health behavior workshop and telephone follow ups	Standard care	Hospital	6 mo +12 mo follow up	Anthrop, diet[b], PA	Ergometer	Junk food consumption not macro nutrients	Small
Indirect parent involvement												
Gohar (35)	2–14	9	ALL	Active	Home exercise plan (stretching, strengthening, and aerobic) and in-hospital PT	No control	Home and hospital	6–7 mo	Fitness	Motor function	—	N/A
Marchese (36)	4–18	28	ALL	Active	Stretching, strengthening and aerobic training, and home exercise program	Consult session after study period	Home and hospital	12 wk	Fitness, and metabolic	—	—	N/A
Keats (37,38)	14–19	10	Mixed	Survivor	Education materials and aerobic, core strength and flexibility training	No control	Comm	16 wk + 3/12 mo follow up	Fitness and PA	Strength tests, flexibility, and PA	—	N/A

Table 2. Continued on next page

Table 2. Continued

First Author	Age (yo)	N	Dx	Survivor or active	Intervention	Ctl	Setting	Length	Outcome measure	Positive results	Mixed results	Effect size
Huang (39)	8–18	38	ALL	Survivor	Web, phone and sms weight management program tailored for CCS	Untailored program	Mobile	4 mo	Anthrop, diet, metabolic, and PA	—	Weight maintenance Dietary intakePA (Participants >14 only)	N/A
Hartman (40)	1 –18	51	ALL	Active	Motor function, stretching, aerobic training, and education	Standard care	Hospital	2 y	Anthrop and fitness	—	—	N/A
Moyer-Mileur (41)	4–10	13	ALL	Active	Nutrition education and home exercise program (strength, flexibility, aerobic)	Standard care	Home	1 y	Anthrop, diet, fitness, and PA	PA, cardiovascular fitness	—	N/A
Rakhshani (42)	4–18	39	Brain/ CNS tumors	Mixed	Comprehensive care clinic attendance, including access to a dietitian and exercise consultant	Standard care	Hospital	1 y	Anthrop, Metabolic, and PA	% Weight gain	HDL cholesterol only	N/A
San Juan (43)	8–16	16	ALL post-BMT	Active	Resistance and aerobic training	Noncancer children	Hospital	8 wk	Anthropand Fitness	Strength tests and VO2Peak	—	N/A
San Juan (44), Ruiz (45)	4–7	7	ALL	Active	Stretching strength and aerobic training	No control	Hospital	16 wk (20 wk detraining)	Metabolic, anthrop, and Fitness	Strength tests, and VO2Peak	Insulin growth factor IGFBP-1 only	N/A
Takken (46)	6–18	9	ALL	Mixed	Strength, aerobic, and interval training	No control	Comm	12 wk	Anthrop and fitness	—	—	N/A
Esbenshade (47)	5–10	17	ALL	Active	Home exercise program (stretching, strengthening, and aerobic) and follow up calls	No control	Home	6 mo	Anthrop and fitness	Flexibility, strength tests, cardiopulmonary fitness, and BMI classification	—	N/A
Esbenshade (47)	5–10	17 | N/A	ALL	—	Written and video stretching, strengthening, and aerobic training program plus weekly follow up calls	No control	Home	6 mo	Anthrop and fitness	—	—	N/A
Direct parent involvement												
Yeh (48)	> 18	22	ALL	Active	Home exercise program (aerobic)	Standard care	Home	6 wk	PA, fitness	PA	—	N/A
Tanir (49)	8–12	40	ALL	Survivor	Inhospital exercise training, home exercise program, education, and phone calls	Standard care	Hospital and home	3 mo	Fitness and metabolic	Endurance, strength tests, hemoglobin, hematocritc	—	N/A
Donze (50), Mays (51)	11–21	75	Mixed	Survivor	Interactive workshop–risk reduction and health promotion and gift bags (focus on bone health/calcium intake)	Standard care—wait list	Group	1/2 d workshop	Diet	Calcium intake	—	Large

Study measures are displayed by level of parent involvement. Age is presented in years, diagnosis, active treatment or survivorship, key program elements, measures, and results are also presented. Outcome measures are displayed as broad categories. Only results categorized as positive or mixed are reported. Positive results indicate that changes occurred in the desired direction. Mixed results indicate that there were some positive changes, but only for one subgroup or only for one part of the outcome measure.

Parent involvement levels: None (Parents provided consent/proxy reports only), Indirect (Provision of information/invitations to parents that did not require a response and/or use of parents for observational or satisfaction data collection surveys), Direct (Parent attendance requested at intervention sessions or parent-specific training sessions and/or parents active in program development). Dx: Acute lymphocytic/lymphoblastic leukemia (ALL), Central Nervous System (CNS), Bone marrow transplant (BMT). Assessment tools: (i) Anthropometric: height, weight, BMI, BMI Z-score, body composition, % ideal body weight, waist circumference. (ii) Diet: Behavioral questionnaires (various), Food frequency questionnaire, 24 h recall, 3 d food record. (iii) Fitness: VO_{2PEAK}, VO_2, Maximal work load, Ventilatory anaerobic threshold (VAT), strength tests, flexibility tests, Timed up and down stairs test (TUDS), Timed up and go test (TUG), 9 min walk/run test, ergometer (duration/intensity), dynamometer (manual force), OMNI walk/run scale, Knee Extension (KE), Progressive Aerobic Cardiovascular Endurance Run (PACER) laps. (iv) Metabolic: Fasting plasma insulin, HOMA-IR, BP, blood glucose, lipids, insulin growth factors (IGF), IGFBP (binding proteins), growth hormone, Hemoglobin A1c, flow mediated dilation (FMD), supine diastolic blood pressure (SDBP). (v) PA: Physical Activity Index (PAI), leisure score index (LSI), Physical activity psychosocial questionnaire, Physical activity /Exercise behavior Questionnaire, Chinese University of Hong Kong: Physical Activity Rating for Children and Youth (CUHK-PARCY), Stages of change- physical activity (SOC-PA), accelerometer, Previous Day Physical Activity Recall (PDPAR), Gait Cycles (GC). Note on Results: Positive results indicate that changes occurred in the desired direction. Mixed results indicate that there were some positive changes, but only for one subgroup or only for one part of the outcome measure.

related to specific parenting style advice (48,49). These studies focused on exercise training both at home and in the hospital. They engaged parents not only by having them complete surveys and serve as proxies for their children, but also requiring at least one parent to physically attend exercise sessions with their children (48,49).

One exercise study included children under 18 on active treatment for ALL (48). This nonrandomized pilot study had a standard care control group of 10 children and an intervention group of 12 children that received a home based exercise training course. While the main outcome of interest was fatigue, researchers also measured PA stage of change after the 6-wk intervention and found participants changed their intent to practice PA from the "contemplation" and "preparation" stages to "action" and "maintenance" stages, although these effects lessened at the 1 mo follow up. This study also included a measure of perceived exertion (OMNI walk-run scale) but did not report results (48).

Tanir and Kuguoglu (49) used direct parent involvement in an intervention for ALL survivors aged 8–12. Nineteen children were randomized to an intervention group receiving both hospital based and home based exercise sessions as well as educational pamphlets and biweekly phone calls with research staff. Twenty-one children were randomized to a standard care control. The main outcome of this 3-mo study was quality of life, but researchers also examined fitness and metabolic measures. Participants showed significant improvements in hemoglobin and hematocrit at postintervention and improved physical fitness as indicated by the 9 min walk run test, timed up and go (TUG) and timed up and down stairs (TUDS) tests and dynamometer (strength test) (49).

DISCUSSION

This is the first review to examine parental involvement in diet and PA studies in CCS. Of 25 diet and/or PA interventions targeting child and adolescent CCS, 11 studies did not report parental involvement in the intervention, 11 studies reported indirect parental involvement and three studies reported direct parental involvement. Studies with no or indirect parental involvement had similar amounts of success, both lower than direct parental involvement, which reported improvements in all study measures. However, only three studies directly engaged parents, and they had relatively small sample sizes, did not include anthropometric measures, and were not all randomized controlled trials, which limits our ability to draw firm conclusions about the role of directly engaging parents in lifestyle interventions for pediatric CCS.

In general, studies focusing on promoting change in lifestyle behaviors in the CCS population were limited. Of the 11 studies that included anthropometric measures, only three demonstrated any positive change and each had a very different approach. The majority of eligible studies focused on exercise interventions and demonstrated moderate success with regard to fitness and PA behavior outcomes, but were likely underpowered given their small sample sizes and variable study designs. Studies showing fitness improvements included organized aerobic training sessions at least once a week over several weeks. Similarly, studies that demonstrated improved PA behavior included organized PA sessions either through formal training classes, games, sports or other physical leisure activities.

Despite the limited number of evaluation studies targeting lifestyle changes, CCS interest in healthy eating and PA interventions has been demonstrated in several survey studies on mixed diagnoses groups of survivors (5,11,52). Two studies found CCS were interested in participating in these programs with a parent (5,52). Such findings highlight the potential benefit of parental involvement during interventions and may assist with recruitment of participants in health behavior interventions.

Published CCS lifestyle interventions took place in a variety of settings including the participants' homes, at community locations and also in hospitals/care facilities. Some hospital-based exercise studies, though small, measured successful outcomes (43,44) but long-term hospital-based interventions present a set of challenges to providers, as most hospitals are not equipped with full gyms and trained staff. Also, CCS may not be able to or not interested in returning to a hospital setting for this type of intervention. Therefore, transition into community or home-based activities focused on long-term fitness goals and lifestyle change is a practical evolution for hospital-based interventions. However, at-home lifestyle behavior change programs need to be carefully developed in conjunction with input from the end users, CCS and parents, to ensure parents have the tools to promote the continued progress of study subjects (53). The home component of one exercise program was described as "boring" by participants and thus, subjects could not be motivated to finish the intervention (46); another home-based study found declining levels of PA after the formal intervention ended (38). Parents may be an avenue for promoting sustained behavior change and motivation to complete home-based interventions.

Adding a parental involvement component may improve health promotion interventions for CCS. One review noted an increase in emotional closeness over time for many families and a perceived deepening bond between parents and the sick child (54). No relationship between parental involvement and participant age range, stage of treatment or diagnosis could be determined given the limited number of studies. Furthermore, some research has shown that parents may remain involved in the healthcare of CCS even into adulthood (55). Therefore, as CCS continue to experience increased health risks, including obesity, parental involvement should not be overlooked in lifestyle interventions during later treatment that target children or adolescents.

The few studies that used direct parent involvement in this review may offer strategies to effectively engage parents in interventions. These strategies include using parent focus groups to develop interventions, discussing intervention materials and structure with parents in a group setting, and creating parent-specific activities (48–51).

Parents of CCS face unique psychological challenges when they want to influence their child's diet and PA behaviors. A systematic review found recurring themes of overindulgence, and spoiling of children on and off active treatment across a range of diagnoses, with parents perceiving their sick child as vulnerable and disadvantaged (54). A study of parents of children being treated specifically for ALL, one of the most common pediatric cancers, showed that these trends of increased overprotection, emotional feeding, and varying amounts of discipline were associated with increased junk food consumption and decreased fruit and vegetable consumption (56). CCS parents are also more likely to be overprotective and at times employed a monitoring and a restrictive parenting style (4). Higher levels of parent overprotection and perceived child vulnerability were associated with lower CCS quality of life (57). Parents being over protective may also lead to restricting children from participating in physical activities that these parents deem as risky (58). One exercise study suggested parental overprotectiveness needed to be addressed in future program design given the negative short-term effects of increasing exercise (i.e., fatigue and muscle soreness) to prevent subject dropouts (46).

CCS parents experience psychosocial issues related to their child's cancer and treatment, in addition to the everyday stresses of parenthood (58–60). Parenting stress has been associated with poor social and behavioral adjustment in CCS (61–63). Thus, CCS parents may benefit from training in effective parenting practices to minimize overprotection and stress, while being cognizant of unique household dynamics in CCS families.

Limitations of this review include the fact that this is a developing field of research with few studies addressing the research question. Several identified articles were feasibility studies with small numbers of participants, limited control groups and limited evaluation measurements. These structural issues limited attempts to grade the quality of this literature. Varying outcome measures across studies also made comparison of results difficult. Overall, while parental involvement is important in obesity interventions of children without cancer, it has not been adequately studied in CCS interventions. This review identifies the need to evaluate whether parental inclusion in diet and exercise interventions for CCS would help reduce obesity risk in this vulnerable population, with the preliminary studies suggesting it might.

METHODS

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses checklist was followed to present study findings (**Supplementary Table S1** online) (64). The literature review was conducted in July 2015 using electronic databases: Scopus, Medline (Ovid), PsycINFO (Ovid), and Web of Science to identify articles reporting diet and PA change interventions that targeted child and adolescent CCS. Key search terms included: infant, child, adolescent, pediatric, patient, survivor, intervention, neoplasms, health behavior, physical activity, nutrition therapy/surveys, diet, feeding behaviors, and eating. Articles were restricted to those published in peer-reviewed journals in English. As no protocol currently exists, a librarian experienced in conducting systematic and scientific reviews evaluated and verified the search strategy.

Publications from the initial search were reviewed for inclusion first based on title and abstract. Remaining full text articles were reviewed and citations from relevant articles were searched for further studies that met the inclusion criteria. This process was repeated by a second reviewer with a random sample of 25% of the originally sourced articles. The articles selected for inclusion were 100% concordant across the two reviewers. No human subject's research was conducted as part of this review article so institutional review board approval was not necessary.

Inclusion criteria were (i) intervention or feasibility studies targeting diet, PA (PA behavior in general or fitness through exercise classes) or both; (ii) included CCS on or off treatment into young adulthood up to age 30 (study inclusion age starting <18); and (iii) measured changes in fitness, PA, diet, anthropometric or metabolic measures. Anthropometric measures included: weight, BMI, BMI-z scores, waist circumference, and/or body composition. Metabolic measures included: cholesterol, triglycerides, blood pressure, hemoglobin A1C, and insulin measures. Exclusion criteria were studies that (i) targeted only adult survivors of childhood cancer (study inclusion age starting at ≥18) or (ii) did not report on diet, PA, anthropometric or metabolic outcomes.

Components for each type of intervention were examined (i.e., exercise classes only or multicomponent interventions) and level of parental involvement assessed for the selected study. Based on published studies (17,18), we initially grouped parental involvement into the following categories with slight modifications: none (no parental involvement at all or parents were only consented or used as proxies for self-report measures), indirect 1 (provision of information to parents that did not require a response), indirect 2 (invitations to parents and children to attend activities sponsored by the intervention such as family days), indirect 3 (assignments given to parents including active parent observation or parent satisfaction assessments), direct 1 (parent attendance requested/required at intervention sessions and/or parents active in program development), and direct 2 (parent participation requested/required for specific parenting activities or training) (17). There were insufficient studies to warrant using all of these categories, so categories used were: no, indirect, and direct parental involvement. Other individual components included study design, primary setting, program length, sample size, target age, stage of cancer treatment, cancer diagnosis, behavioral theories used in program development, and outcome measures. Few studies reported effect sizes and summary measures varied widely across studies, so results were kept general. Risk of bias was assessed by documenting methodological quality parameters for included studies (**Supplementary Table S2** online) (65).

SUPPLEMENTARY MATERIAL

Supplementary material is linked to the online version of the paper at http://www.nature.com/pr

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