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Physical Activity Guidelines for Children During and After Cancer Treatment

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Physical Activity Guidelines for Children During and After Cancer Treatment

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Introduction

Childhood is a time where rapid changes are occurring in the body (5, 18). These changes include skeletal, muscular, social, and emotional growth (5). If, during this time, a child is also battling cancer and the necessary treatment, it can also be a time of endless fatigue, muscle atrophy, delayed growth, nausea, loneliness, and depression (2, 5, 10, 14). The side effects of cancer treatment are often considered more unbearable than the cancer itself (5).

Common short-term side effects include nausea, fatigue, anxiety, loss of appetite, shortness of breath, sleep disturbances, and decreased mood (5, 10, 14). While children, adults, and older adults receiving cancer treatment experience these side effects, children seem to be less affected than their older counterparts (18). Yet, nausea and fatigue are two of the most debilitating side effects observed in children (5, 10). Adults and older adults have also reported other side effects even after cancer treatment has ended (1, 5). These include a decrease in motor skills, aerobic capacity, social and cognitive function, muscular strength, lean body mass, flexibility, self-esteem and overall quality of life (1, 3, 10, 14). Fat mass, facture risk, and rates of depression often increase in adults and older adults who have previously received cancer treatment (12, 19). Depression and loneliness are other detrimental effects associated with cancer. While often overlooked, these psychological issues can be just as devastating to a child's development as the physiological effects (17). Precautions should be taken during this time to reduce the detrimental long-term effects of cancer treatment as well as alleviate the short- term side effects.

One precaution that seems plausible for alleviating the short and long term side effects is an exercise intervention. Exercise is known to decrease fatigue, increase muscle strength, and promote strong bones (10, 12, 19). Oftentimes the general population is skeptical, or even

nervous, when individuals who are ill are told to exercise. However, the American College of Sports Medicine (ACSM) released a position stand stating that exercise is not harmful to individuals receiving cancer treatment, and is, in fact, beneficial and safe for this population, if approved by their physicians and oncologists (21). In addition to the physiological benefits, exercise is proven to release endorphins (10), the "feel good" neurotransmitter, responsible for creating a sense of euphoria and subsequently decreasing depression (10).

One way to ensure that children reap the benefits of exercise during their stay at the hospital would be to create an entire hospital based treatment and rehabilitation program. This program would be modeled on a set of physical activity guidelines created specifically for children going through cancer treatment. Within the program children would steadily increase their activity level until they can successfully follow ACSM's Physical Activity Guidelines for Children and Adolescents (21). Not only would this program allow the children to gradually increase their physical activity in a way that is safe and effective for them, it would also create a social environment in which they could interact and connect with children who are also going through cancer treatment and rehabilitation. The hospital program would incorporate three phases, with each phase following the child's path to recovery. Each phase has its own set of physical activity guidelines to allow for easier individualization of any exercise prescription. An example exercise prescription has been attached to this thesis, in order to visualize the guidelines as well as further explain the hospital program.

Purpose

The purpose of part one of this thesis was to synthesize previous research and information about cancer, children and cancer, exercise and cancer, and the long and short-term effects of cancer. After synthesizing previous research, the second part of this thesis was to integrate that research and create a set of safe and effective physical activity guidelines for children during and after cancer treatment. Lastly, a sample exercise prescription was created. This prescription was tailored for a fictional young child in a pediatric cancer rehabilitation program. The design of the pediatric cancer rehabilitation program was based on meeting the needs of a child, physically, emotionally, and socially.

Methods

Many previous studies have been done on cancer and cancer treatment. However, due to the recent advancements of cancer treatments, there may be some unidentified long-term effects. This is especially true in children, where survival rates have increased dramatically in the past few years (4, 15, 20). There are ongoing studies that follow children after they have received cancer treatment and as they transition into their adult lives to see if and how the treatments affect them after remission. For the purpose of this thesis, only completed studies were used when compiling research.

Studies investigating the ways in which cancer affects adults and older adults were used in lieu of the incomplete child-related studies in conjunction with the relatively few studies that were available on children. Although the studies on adults and older adults cannot be directly used when attempting to hypothesize exactly which long-term side effects children will encounter, they do provide many insights into the possible effects that *may* occur. Until the

current research in progress is finalized, there can be no definite list of detrimental long-term effects that children may encounter years after they have finished cancer treatment. For the time being, and with the current research on adults and older adults, this thesis attempts to hypothesize what possible long-term side effects children may encounter later in life as well as propose a plausible solution.

Literature on exercise and its interactions with the side effects of cancer treatment are abundant. Unfortunately, most studies are cancer type-specific and performed with adults. Due to these specifications, it is difficult to synthesize the information to create a set of physical activity guidelines that would be broad enough to effectively decrease the side effects of treatment for children with all different types of cancer. The research available on adults and lack of research available on children is yet another hindrance encountered. However, with the available research and knowledge of exercise, cancer, and cancer treatment, a set of guidelines was created.

When creating the example exercise prescription, it became clear that to fully implement the guidelines, a complete hospital program would have to be developed. Research was done on the development of similar programs and then used to construct the skeleton of a new program. This program was broken up into three phases and was designed based on guidelines created in a later section of this thesis. This thesis was completed once the research, guidelines, example exercise prescription, and hospital program were created.

Results

This study resulted in the creation of guidelines for children during and after cancer treatment (Tables 1-3). Along with these guidelines came an entire hospital program that supported the guidelines and made the following example exercise prescription possible. The

exercise prescription (Appendix B) is six months in duration and includes a two-month Phase One, “In-Patient Phase”, program, three-month Phase Two, “Out-Patient Phase”, program and one-month Phase Three, “Maintenance Phase”, program.

The “In-Patient” phase was created to be followed during the in-patient segment of a child’s treatment for cancer. During this time a child may feel physically and mentally exhausted, contributing to increased sedentary behavior. To combat this, the guidelines created for this thesis suggest to “avoid inactivity.” This portion of the guidelines focuses on initiating light activities during the child’s stay at the hospital. Examples includes taking a walk around with the hospital staff or decorating their room with pictures. Additionally, the administration of cancer treatment is taken into consideration. It is understandable that immediately following treatment a child will be more lethargic and, hence, more inactive than on other days. However, it is still important that the child move periodically throughout the day to break up sedentary periods. Also stressed is the notion that a child should try to increase their physical activity, even during their stay at the hospital and while receiving treatment.

Phase Two, the out-patient portion of the guidelines created for this thesis, start to focus on the specific aspects of physical fitness such as the aerobic and anaerobic systems as well as the neuromuscular system. The aerobic guidelines suggest 60 minutes or more of moderate to vigorous activity at least five days per week. The 60 minutes may be broken up into bouts of ten minutes; however, the child should strive to be physically active for longer periods throughout their participation in Phase Two. As stated in the “Considerations” section of the guidelines, rests and breaks should be given to the child as necessary. Exhausting any child physically could be dangerous, but this is especially true for those children recovering from cancer and cancer treatment (10).

During the “Out-Patient” Phase of the guidelines anaerobic activity is also introduced and includes structured and unstructured activities. Structured anaerobic activities include resistane training using weights, resistance bands and bodyweight training. This type of training should be done at least twice a week. Unstructured anaerobic activities include weight bearing activities such as jumping, running, climbing, or playing games with a weighted ball. These sorts of activities should be incorporated into the 60 or more minutes of aerobic physical activities by playing games.

Neuromuscular or balance training is also introduced in this phase. These activities can be incorporated into either the aerobic or anaerobic activities. Neuromuscular activities are extremely important and include core strengthening exercises. Other exercises such as standing on one leg and playing catch are also appropriate forms of balance training for children. Functional exercises such as reaching up high and down low are also to be implemented to improve balance, flexibility, and range of motion.

The last phase of the guidelines, the “Maintenance” Phase, is applied to the child’s exercise prescription after the child has surpassed the guidelines for Phase Two. The guidelines for this phase come from ACSM’s Physical Activity Guidelines for Children and Adolescents. It is the hope that after progressing through the first two stages, the children will be able to meet the physical activity requirements that other children their age are expected to meet. The ACSM guidelines incorporate the same features of aerobic and anaerobic exercises as the guidelines created for this thesis; however, they encourage even more physical activity than the Phase One and Phase Two guidelines. The bone strengthening segment is stressed more during Phase Three, whereas it was simply incorporated into the 60 minutes of aerobic activity in the first two phases. At this stage in the child’s recovery they should be able to meet the ACSM’s Physical Activity

Guidelines for Children and Adolecents until they reach the age where they are encouraged to meet ACSM's Physical Activity Guidelines for Adults.

Hospitals can often be a scary place for children. It is the hope that through participating in the proposed hospital program these children will begin to see the hospital as a place where they get to have fun and play games with their friends while increasing their muscle mass, aerobic capabilities, flexibility, balance and range of motion. During the "In-Patient" Phase, the children are receiving treatment and are therefore in a state of decreased immune response (2, 10). Due to this it would not be in their best interest to interact with children who are in other phases of the program. Therefore, this phase is the least socially interactive for the children. However, they will interact with their parents, nurses, doctors, staff, and other children that are also receiving treatment. Children in this phase have the opportunity to participate in "Group Play Time." This is a time where the children are given the chance to play games, color, and interact with others who are going through the same process as them while being supervised by staff. Weight-bearing activities such as standing, walking and jumping are encouraged during "Group Play Time". Also during this phase are periods of time where the children practice sport skills such as kicking a soccer ball or throwing a baseball. Simple gymnastics is also introduced in this phase. A weekly "Dance Party" is the last showcased item of Phase One. This Dance Party is another way for the children to have fun while being physically active. During the times where the child is not in a structured session, parents are encouraged to motivate their child to stand up and move around occasionally, to interrupt prolonged periods of sedentary behavior.

Phase Two of the hospital program is one of the two out-patient portions. After Phase One, the children arrive at the hospital to participate in one hour of structured activities, six days a week. The different aspects of Phase Two work on aerobic capabilities, anaerobic strength and

balance training. There are three different types of activities that the children will participate in: one-on-one sessions, small group sessions, and Group Play Time. The one-on-one sessions are run by exercise physiologists, physical therapists, occupational therapists, and recreation therapists. These sessions focus on balance, core strength, and functional training as needed. Functional training can include exercises such as going up and down stairs, walking on uneven surfaces, or any other activity of daily living that may be harder for these children due to the side effects of cancer and cancer treatment.

Small group sessions focus on anaerobic training. This includes both structured and unstructured muscular training. In the small groups, the children will be led through exercises that increase their muscle mass. These exercises can be disguised as games while incorporating bodyweight, resistance band, and weight lifting exercises. Activities such as climbing rope, jumping on a trampoline and playing tug-of-war are examples of exercises that build muscle but are also developmentally appropriate and entertaining. As the child continues their participation in Phase Two, the muscular training will become increasingly more difficult to promote the continuation of hypertrophy.

Group Play Time was introduced during Phase One; however, now in Phase Two it is mostly structured. During this session, the children of Phase Two will learn the basics of different youth sports such as basketball, baseball, gymnastics, soccer, tennis and karate. On certain days the children can pick between two sports. Other times during the week Group Play Time has “Gym Fun Day!” when the children can pick one of the sports they have learned about, or play games run by hospital staff. This time is supervised and children are encouraged to play during the whole time.

Phase Two is offered six days a week, yet the children should aim to be physically active on all seven days of the week. Therefore, parents and children are encouraged to be physically active together on the one day off. Example of activities that can be enjoyed by both the parents and children are going for a walk, going to the playground, roller skating, and going on a hike.

The final phase of the program is Phase Three: Maintenance. This is the phase in which children can participate for as long as they wish after they have finished Phase Two. The program is offered at the hospital three days a week for one hour each day. Each day offers a different sport that the children learned together in Phase Two. During the hour that the program is offered the children will participate in 45 minutes of the sport and 15 minutes of muscle conditioning and balance training. All children who have completed Phase Two are invited to participate in Phase Three. On the days that the program is not offered, it is recommended that the children and parents participate in at least 60 minutes of physical activity at home. During Phase Three, it is stressed that the children should be aiming to meet the ACSM's Physical Activity Guidelines for Children and Adolescents. Actively encouraging children and parents to stay active at home is critical to continue the child's success and progress.

Discussion

Unfortunately, many children have been and will be affected by cancer and cancer treatment. In 2014, the number of children affected by cancer neared 16,000 in the United States alone (20). Fortunately, the majority of these children survive cancer, thanks to their bodies' abilities to recover and to the advancements in cancer treatment (20). The mortality rate from most types of childhood cancer have decreased dramatically, especially in the last few years (4, 20). These decreases in mortality and increases in 5-year survival rates are proof that science and

technology has made large strides recently. However, the increasing number of childhood cancer survivors leads scientists to a new question: How will these children be affected in the future?

From preliminary research and research previously done on adults and older adults, it can be hypothesized that these children will also be affected by cancer and cancer treatment. The question of *how* the children will be affected is still in the process of being determined. Once the long-term side effects are recognized, specific precautions can be put in place to alleviate these effects. Until these studies are completed, a more general solution should be put in place to help the children currently receiving treatment. Both the guidelines and hospital program contained in this thesis are proposals for that intermediate general solution. The guidelines created for this thesis integrate precautions for the long-term effects we have seen in adults and older adults, the estimated ability of children going through cancer treatment, and ACSM's Physical Activity Guidelines for Children and Adolescents. Furthermore, the program integrates these guidelines with the social and emotional needs of a child during these times.

The side effects of cancer and cancer treatment span physiological, social, and emotional states. It is obvious that one proposition cannot be the solution to any and all side effects. There are too many systems affected by cancer and cancer treatment for a "one for all" solution. This is especially true when one investigates the causes behind these side effects. Some of the effects come from the body's attempt at battling the cancer itself, while other side effects come from the chemicals uses to combat the cancer (18). Other, non-physiological, side effects come from sitting in a hospital room, uninformed, and uncertain of the end outcome (12). It is impossible, and potentially irresponsible, to only acknowledge the physical and physiological side effects of cancer and cancer treatment. Although cancer is an illness that wreaks havoc on an individual's body, the psychological effects due to the isolation and constant worrying can be as detrimental

as the physical effects (5, 10). Therefore, not only one solution should be applied when trying to alleviate some of the short and long-term suffering these patients have to endure.

The long-term effects of cancer and cancer treatment on children have not been clearly determined. It is possible to apply the research that is available on how cancer treatment affects the human body and the long term effects found in adults and older adults to create a hypothesis as to what children may face in the future. Research has found, however, the existence of cardiovascular disease in individuals who have survived childhood cancer. The study, published in early 2016, found that a larger percentage of cancer survivors had evidence of heart disease when compared to individuals of the same age and sex who never had cancer (9). In fact, during the study five percent of the cancer survivors that were under the age of thirty had evidence of cardiovascular disease (9). Most of the subjects were asymptomatic, however their work capacity was significantly decreased while performing the 6-minute walk test (9). Another study, published in 2010, also found that individuals who had survived cancer (but not necessarily childhood cancer) had a decreased work capacity when compared to a control group (6). This study used a volume of oxygen consumption (VO_2) maximal cycle ergometer protocol to test the subject's cardiovascular function (6).

Blunted cardiovascular capabilities are not the only long-term side effect that children may face. An article published in 2002 looked at the effects of common cancer treatments such as chemotherapy, irradiation and corticosteroids on bones and bone growth in children (18). The research shows that depending on the type of treatment received, children may or may not reach their mid-parental height. The differences lie in how the treatments affect the chondrocytes and osteoblasts, or bone cells (18). Cancer spreads through rapidly-dividing cells. Therefore, cancer treatment targets these rapidly-dividing cells. However, during growth spurts, osteoblasts are

also rapidly dividing. This leads to the cancer treatment (irradiation, chemotherapy) accidentally affecting the osteoblasts as well as the cancer cells (18). The damaging of these dividing bone cells can permanently affect the length of the long bones in an individual. The study found differences in the types of treatments and how they affect bone growth. Irradiation is shown to hinder the growth of children; however, the exact causes are not known. Some types of chemotherapy such as the DNA-damaging category cause irreversible damage to the proliferating chondrocytes (18). Other types of chemotherapy such as the purine salvage inhibitors did not cause irreversible damage, instead they only acted to slow down the proliferation of the chondrocytes (18). Corticosteroids, however, act on the matrix of the bone and local growth factors, as well as on the growth plate (18). All these treatments have the potential to limit bone growth, and not all of them can be corrected with the use of growth hormone (18).

Another possible long-term side effect for children is neuromuscular deficits. This includes decreased stability and coordination, along with an increased fall risk. A case-study published in 2010 followed an older woman two and a half years after her cancer treatment was completed (3). Prior to treatment, the woman was described as someone who showed few signs of neuromuscular impairments. However, after three rounds of chemotherapy, the woman had difficulty with her activities of daily living (ADL's) as well as activities that she used to participate in. These impairments continued and worsened over the two and a half years that she was observed (3). This is a clear example that the side effects of cancer treatment do not stop after the treatment is halted. The possibility of a child acquiring neuromuscular impairments may depend on the type and dose of treatment the child receives. There was no research found on the neuromuscular abilities of children post- cancer treatment, yet this does not mean that the

children are not or will not be affected. Neuromuscular deficits seem to be a plausible long-term side effect for children, especially if they are receiving high-dose treatments for a long period of time. A research study published in 2006 supports this dose-dependent relationship (5). The study found a strong, positive correlation between treatment time and number of side effects (5). An individual receiving cancer treatment for an extended period of time is at a higher risk for an increased number of side effects.

Along with neuromuscular deficits, comes mobility limitations. If these children cannot get up and play with others their age, more social and emotional effects may arise. Depression, anxiety and decreased social development can all stem from a lack of interaction with others their age (16, 17). If a child starts to realize that they are not able to physically play with their friends, then depression may develop. Once this happens, it may be hard to convince the child to find the much needed social interaction for them to develop as expected.

Fatigue is another significant side effect that occurs both during and after treatment (2, 5, 10, 13, 19). Anemia is one major contributor to this debilitating fatigue. Cancer treatment often affects bone marrow, which is largely where red blood cells are produced. With a lack of red blood cells, oxygen cannot be circulated as needed, hence the feeling of fatigue (2). Over half of cancer patients are affected by anemia (2). Anemia can last well beyond the completion of treatment, if not properly alleviated (2). If the anemia continues, so does the fatigue. With an increased sense of fatigue comes a decreased feeling of motivation and decreased social functioning ability (1, 2, 16, 17). Anxiety and sleep disturbances can also be signs of anemia (2). This is a long-term side effect that can easily be alleviated, yet is often misdiagnosed (2). In fact, anemia can be treated by increasing red blood cells (2), potentially via pharmacological treatment.

Fortunately, anemia is not the only side effect that can be alleviated. Other issues negatively impacted by cancer and cancer treatment including aerobic capability, social and cognitive function, flexibility, mood, muscular strength, body esteem, lean body mass, and sleep quality (2, 5, 10, 14) can also all be partially or completely alleviated. In reality, the solution to alleviating these issues is multifactorial and is not currently universally prescribed during cancer treatment. Yet if it were to be, perhaps some of the long-term side effects would not be seen in the future. This seemingly simple, yet complex solution is physical activity. A study completed in 2009 looked at the use of exercise on cancer survivors and how exercise impacted their long-term side effects and quality of life (10). The study looked at aerobic, resistance, and mindfulness exercises and the different impact the exercise had on side effects and quality of life. The results support the use of exercise as an effective management tool for the side effects of cancer and cancer treatment. More specifically, aerobic exercise was shown to reduce chronic fatigue, nausea, anxiety, sleep disturbances and depression. Aerobic exercise was also shown to increase aerobic capacity (10). Progressive resistance training also improved long-term side effects relating to cancer and cancer treatment such as decreasing chronic fatigue, increasing cognitive function, muscular strength and overall quality of life as well as decreasing body fat and increasing self-esteem (10). This study also found that individuals who participated in exercise decreased their risk of reoccurrence (10).

The study supports the guidelines set forth in this thesis. The guidelines incorporate aerobic and anaerobic training in order to alleviate some of the side effects of treatment. The short-term side effects such as sleep disturbances, anxiety and nausea may significantly improve with exercise. Exercise can improve anemia by naturally increasing the number of red blood cells produced through an increase in the hormone erythropoietin. Aerobic exercise for example

has been shown to be especially helpful in increasing the production of erythropoietin and red blood cells, which can improve anemia in children with cancer (2, 10). With an increase in red blood cells and a decrease in anemia, some of the chronic fatigue may decrease as well. This decrease in fatigue could lead to an increase in mood and motivation, further helping the child post cancer treatment. Similarly, depression, another long-term effect of cancer, will also improve with exercise (10, 12, 19). The manifestation of depression may not even occur if exercise is prescribed early on during the cancer treatment. Yet if it does occur, it will most likely not be to the same extent as if the individual was not participating in exercise. The benefits seen with resistance training are important as well, such as increasing cognitive function, muscular strength and quality of life (12, 19). The purpose of resistance training at this point is not to specifically hypertrophy, yet rather to help the individuals achieve independence with their activities of daily living, improve strength and endurance, to better allow them to keep up with their peers.

The concept of exercise benefiting cancer survivors is not novel. The earliest mention of using exercise for this population was in 1986, when Winningham et al. called exercise a "promising restorative technique" (22). However, a standard of prescribing and using exercise concurrently with cancer treatment has yet to be reached. A study published in 2012 observed men receiving androgen deprivation therapy for prostate cancer. Exercise was prescribed to them and increases in lean mass and balance were found along with decreases in bone loss and fat mass – all of which are affected by androgen deprivation therapy (12). One of the major findings from the report was that weight bearing exercises were crucial to preventing bone loss during treatment (12). This finding supports the emphasis on weight bearing activities in the following guidelines. Bone loss associated with cancer could be especially detrimental during childhood

while the bones are still forming. Weight bearing activities may also alleviate some of the damage done to the chondrocytes and osteoblasts during cancer treatment.

Many research studies have found significant decreases in muscular strength post cancer treatment (3, 5, 10, 12, 19). The reason behind this muscle atrophy has two factors. First, the individuals are often more sedentary than their healthy peers (5, 6, 9, 10, 12, 19). Second, the cancer treatment itself may interfere with the muscle hypertrophy process (12, 19). If an individual were to stay physically active during treatment they would be able to decrease the amount of muscle atrophy, hopefully retaining the muscle mass they had before treatment. Phase One of the guidelines encourages the children to avoid inactivity, even during treatment. Later, during Phase Two, the children begin to engage in structured and unstructured resistance training, to help rebuild muscle that was lost during treatment and potentially increase their muscle mass. Phase Three of the hospital program further focuses on resistance training by incorporating it into functional activities such as sports and sport-specific muscle conditioning.

When integrating resistance training into a young individual's exercise prescription, it is prudent to be aware of the capabilities, needs, and wants of that child. Structured resistance training such as using weights and resistance bands require correct form and technique to be safe and effective. If the child is unable to perform the exercises with correct form and technique, for either physical or mental reasons, then these types of exercises are not appropriate. Young children may not understand that they should focus on being safe while lifting weights, and therefore even if they are physically able to perform the exercise, they still should not. If the child is both physically and mentally capable of lifting weights or using resistance bands, then this type of training can be extremely beneficial. Body weight exercises are a good structured

exercise to introduce to young children instead of weights. By excluding external weights, the child only has to focus on learning correct form and has less of a potential to hurt themselves.

Structured resistance training is paired with unstructured resistance training. Both types of training are integrated into the guidelines, as both are beneficial and produce muscle hypertrophy. Unstructured resistance training is often not seen as "training" by the children. This type of training is usually more fun and entertaining, which will usually lead to the children participating in it more willingly or even without being instructed to do so. Teaching children ways to exercise that are fun and developmentally appropriate strengthen the positive relationship they will form with exercise. This positive relationship has the potential to remain for their entire life, making them more likely to participate in physical activity even after the completion of Phase Three.

Neuromuscular training was also included in the proposed guidelines due to the many research articles and studies that found balance deficits following cancer treatment (3, 5, 7, 10, 12, 17). An impaired neuromuscular system during childhood may lead to even more impairments during adulthood. In an attempt to decrease the amount of damage done to the neuromuscular system, training it is necessary. Phase One guidelines do not specifically mention neuromuscular training, however it is assumed that through normal play with the nurses and staff as well as during "Group Play Time," the neuromuscular system will be activated and used in such a way that slows down or prevents severe neuromuscular deficits. The addition of neuromuscular training occurs in Phase Two and continues through Phase Three. With the increased risk of poor bone density (5, 10, 12), balance and neuromuscular training becomes even imperative. Minimizing fall risk is crucial to limit the number of bone fractures and breaks

in this population, as the majority of these children will be on immunosuppressants, which often lead to poor healing of any break or fracture that does occur.

In order to attain the maximal benefits and adaptations from the aerobic, anaerobic, and neuromuscular training, progression must be emphasized. During the first phase, progression entails increasing the duration the child spends out of bed – either total volume or extending the length of the sessions, but decreasing the frequency. The goal of this phase is to eventually attain at least 30 minutes of physical activity on at least three days per week. Progression may be slow, and during treatment days there may be no progression at all. However, a general increase in time spent out of bed is necessary. Ideally, the child should be increasing their physical activity by 30 minutes per week.

During the second phase, progression has to be made in all three categories of physical activity. In this phase, progression in the aerobic sessions should be seen by increasing the length of the sessions by about five minutes per week. This will help the child's stamina, or ability to engage in physical activity for extended periods of time. Anaerobically, progression should be made once the child can perform all exercises with correct form and technique. The number of repetitions can also be increased to intensify the workload. Progression in neuromuscular training is not specified in the guidelines; however, the difficulty of the balance and core-strength exercises should increase as the aerobic and resistance exercises increase and as tolerated by the child. For example, if gymnastics is incorporated into the exercise prescription, a child can use the balance beam as a neuromuscular exercise. As the child becomes comfortable walking across the beam normally, with one foot in front of the other, the difficulty can be increased by asking the child to walk while plantar flexing (on their "tippy-toes").

During the Maintenance Phase, progression should be made as per the ACSM Guidelines for Children and Adolescents (21). Once the child has reached the third phase, it is assumed that they are capable of achieving the amount of physical activity recommended by ACSM. Progression at this point can be in duration, frequency, intensity or functional difficulty. Phase Three allows the children to continue advancing their skills in the sports and activities that they have learned during the previous phases, as well as continue to engage in social activities with their friends and others who have gone through the program.

Group Play Time and small group sessions encourage a very social aspect during the hospital program while the one-on-one sessions allow each child to receive individual attention. In a study done in 2006 on cardiac rehabilitation patients, it was found that those who were placed in a group that integrated the patients' families into their exercise regimen participated in more post- cardiac rehabilitation physical activity (8) than the patients not placed in the experimental group. Two separate studies published in 2012 also researched the effectiveness of group-based exercise programs. One study observed children who were also burn victims (16). Immediately after discharge from the Intensive Care Unit, the children were recruited into the study. Two groups were made, a control or "Standard of Care" group and an experimental "Wellness and Exercise" group (16). The individuals in the Wellness and Exercise group participated in physical activity, physical therapy, occupational therapy as well as psychotherapy. The experiment ran a total of 12 weeks and was offered to any child with severe burns (16). The results of the study found that children who participated in the Wellness and Exercise group had a significantly improved quality of life over the children who were placed in the Standard of Care group (16). The second study published in 2012 by Naumann et al., researched the effectiveness of a group-based exercise program for breast cancer survivors (11). This study

compared two groups, an individual-based exercise group and a group-based exercise group. The findings were that both the individual based exercise group and the group-based exercise group gained significant increases in their quality of life after nine weeks (11). The authors suggest trying a combined individual and group based exercise program to increase the benefits even more. The results of the study found that children who participated in the Wellness and Exercise group had a significantly improved quality of life over the children who were placed in the Standard of Care group (16). These findings support the idea that a social support system is an integral part of the rehabilitative process. Through participation in the hospital program put forth in this thesis, children will be able to create bonds with other children in the same phase. These children will continue on through the three phases with the same friends, creating a social support system amongst themselves.

Conclusion

Through study and synthesis of previous research experiments on cancer, cancer treatment, and their effects on adults, older adults and children, a partial overview of the existing literature was produced. From this research, along with existing knowledge and using a format mimicking previous ACSM recommendations, a set of safe, effective guidelines was created. Through discussion, the guidelines were explained and rationalized using findings from the mentioned research studies to support the specific types (aerobic, anaerobic, neuromuscular) of physical activity prescribed. The numbers used in the guidelines are not scientifically supported; however, with experimentation a set of more specific guidelines could be produced. The numbers in this set of guidelines are adapted from the ACSM Guidelines for Children and Adolescents, chosen based on the hypothetical tolerance of children receiving and recovering

from cancer treatment. Further studies should be done to produce a set of scientifically-backed guidelines for children of this population. Even before a set of specific guidelines are created, guidelines such as these along with a whole hospital based treatment and rehabilitative program should be implemented as soon as possible. Medical supervision should be required at all time for these children as they engage in physical activity, especially during the first two phases. Physical activity has been proven beneficial to every age, weight, gender, ethnic group and special population tested (21), and as long as there are no absolute contraindications, the benefits far outweigh the risks (21).

Appendix A

Table 1

Phase One: In-Patient

FITT	Recommendation
Frequency	• At least 3 days per week, preferably more
Intensity	• Light (RPE of 9-11) to moderate (RPE of 12-13)
Time	• ≥ 30 minutes • Can be continuous if tolerate by child, or broken up into multiple 10 minute sessions
Type	• Enjoyable and developmentally appropriate aerobic *weight-bearing* physical activities, including walking, brisk walking, playing with a ball, and other tolerated physical activities.
Progression	• Child should try to increase the frequency by one day per week, with the goal being daily physical activity
Considerations	• Avoid inactivity • Any tolerable physical activity is beneficial • Physical activities should be those that encourage child to move around and break up extended sedentary periods • 30 minutes can be split into multiple sessions • Physical activity should be enjoyable for the child; for example, playing games instead of walking a hallway

Table 2

Phase Two: Out-Patient

FITT-VP	Aerobic Recommendation
Frequency	• At least 5 days of the week
Intensity	• Moderate (RPE of 12-13) to vigorous (RPE of 14-17) • Vigorous at least 1 day per week
Time	• ≥ 60 minutes per day
Type	• Enjoyable and developmentally appropriate aerobic *weight-bearing* physical activities, including running, brisk walking, dancing, sports and other tolerated physical activities
Volume	• 1,250-1,600 MET/minutes/week
Progression	• As tolerated by child, with a general inclination towards longer sessions of physical activity • Example: If the child can only tolerate 10 minute bouts of exercise, during the second week of exercise try to increase the sessions by an extra 5 minutes
Considerations	• Physical activity can be split into multiple sessions if necessary • When necessary, allow time for the child to rest and recover • Youth sports can provide an excellent social environment as well as physical activity • Physical activity should be enjoyable for the child; for example, playing games instead of walking a hallway

FITT-VP	Anaerobic/Resistance Training Recommendation
Frequency	• Unstructured: During physical activity session • Structured: ≥2 days per week
Intensity	• Unstructured: Light to moderate (RPE of 9-13) • Structured: Moderate to vigorous (RPE of 12-17)
Time	• Unstructured: as part of daily physical activity • Structured: 10-15 reps, light to moderate intensity, 2-4 sets OR 8-10 reps, moderate to vigorous intensity, 2-4 sets
Type	• Unstructured: Includes weight-bearing aerobic exercises, medicine ball games, tug-of-war, and jumping. • Structured: Includes body weight exercises, using resistance bands and lifting weights
Pattern	• Rest intervals of 2-3 minutes between sets
Progression	• 40%-50% 1RM = very light to light • 50%-60% 1RM = light to moderate • 60%-70% 1RM = moderate to vigorous • Resistance or repetitions should be increased when child is able to perform eight to 15 repetitions with good form, or as tolerated by child
Considerations	• Unstructured resistance training should be incorporated into the child's daily physical activities by including many weight-bearing exercises. • Games such as tug-of-war and throwing a medicine ball are examples of unstructured resistance training • Proper form should always be stressed for structured resistance and child should be supervised at all times • Progression should not be made unless child can perform the movement at least eight to 15 times with *correct mechanical form.* • Multi-joint exercises should be the main focus of structured resistance training • Allow full recovery of muscle tissue to occur between structured training days (at least 48 hours)

FITT	Neuromuscular/Balance Recommendation
Frequency	• During physical activity sessions
Intensity	• Light to moderate (RPE of 9-13)
Time	• 2-4 sets, or as tolerated by child • 10-15 repetitions
Type	• Enjoyable and developmentally appropriate neuromuscular, balance and core-strengthening activities including those using a BOSU ball, physioball, catching a ball while standing on one foot and other functional activities
Considerations	• Any tolerable physical activity is beneficial • Physical activity should be enjoyable for the child; for example, playing games instead of doing abdominal crunches

Table 3

Phase Three: Maintenance- ACSM Physical Activity Guidelines for Children and Adolescents

FITT	Aerobic Recommendation
Frequency	• Daily
Intensity	• Moderate to vigorous (12-17) • Vigorous ≥ 3 days per week
Time	• ≥ 60 minutes per day
Type	• Enjoyable and developmentally appropriate aerobic physical activities, including running, biking, brisk walking, swimming, and dancing.

FITT	Muscle Strengthening Recommendation
Frequency	• ≥ 3 days per week
Time	• As part of their 60 minutes or more per day of exercise
Type	• Muscle strengthening physical activities can be unstructured (e.g., playing on playground equipment, climbing trees, tug-of-war) or structured (e.g. lifting weights, working with resistance bands).

FITT	Bone Strengthening Recommendation
Frequency	• ≥ 3 days per week
Time	• As part of their 60 minutes or more per day of exercise
Type	• Bone strengthening activities include running, jumping rope, basketball, tennis, resistance training, and hopscotch.

(21)

Appendix B

Phase One: In Patient

Weeks 1-2

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Frequency (Times/day)	6	N/A	6	N/A	N/A	6	N/A
Intensity (RPE)	Light (9-11)	Light (9-11)	Light (9-11)	Light (9-11)	Light (9-11)	Light (9-11)	Light (9-11)
Time (minutes)	10	N/A	10	N/A	N/A	10	N/A
Type	• Take a walking tour of the pediatric unit • Decorate room • Introduce herself to the nurses • Play catch with a ball while standing • Mini golf • Play with therapy dog	• Activities of daily living (ADLs) • Example: Getting dressed, taking a bath and/or shower	• Introduce herself to other patients • Play catch with a ball while standing • Take a walking tour of exercise room/gym • Play hide-and-seek with staff • Play dress-up • Have a "dance party"	• Activities of daily living (ADLs) • Example: Getting dressed, taking a bath and/or shower	• Activities of daily living (ADLs) • Example: Getting dressed, taking a bath and/or shower	• Kick a soccer ball with staff • Look for hidden toys around the gym area • Join in "Group Play Time" with other pediatric patients • Help clean room • "Help" make dinner (play pretend with fake kitchen set) • Walk to gym to find a book to have read before bedtime	• Activities of daily living (ADLs) • Example: Getting dressed, taking a bath and/or shower
Volume (Minutes)	60	N/A	60	N/A	N/A	60	N/A

Weeks 3-4

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Frequency (Times/day)	6	N/A	4	N/A	6	4	N/A
Intensity (RPE)	Light (9-11)	Light (9-11)	Light (9-11)	Light (9-11)	Light (9-11)	Moderate (12-13)	Light (9-11)
Time (minutes)	10	N/A	15	N/A	10	15	N/A
Type	• Join in "Group Play Time" with other pediatric patients • Kick a ball with staff • Play hide-and-seek with nurses • Play dress-up • Look for hidden toys around the gym • Play with therapy dog	• Activities of daily living (ADLs) • Example: Getting dressed, taking a bath and/or shower	• "Help" make breakfast • Join in "Group Play Time" with other pediatric patients • Play catch with a ball while standing • Visit friends in the unit	• Activities of daily living (ADLs) • Example: Getting dressed, taking a bath and/or shower	• Join in "Group Play Time" with other pediatric patients • Act out a scene from favorite book • Play catch • Mini golf • "Help" make dinner • Find a book in the gym to be read before bed	• Practice gymnastics • Help clean room • Join in "Group Play Time" with other pediatric patients • Have a "Dance Party" with other pediatric patients	• Activities of daily living (ADLs) • Example: Getting dressed, taking a bath and/or shower
Volume (Minutes)	60	N/A	60	N/A	60	60	N/A

Weeks 5-6

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Frequency (Times/day)	4	4	4	N/A	4	2	N/A
Intensity (RPE)	Light (9-11)	Moderate (12-13)	Light (9-11)	Light (9-11)	Light (9-11)	Moderate (12-13)	Light (9-11)
Time (minutes)	15	15	15	N/A	15	30	N/A
Type	• Join in "Group Play Time" with other pediatric patients • Play mini golf • Find toys hidden in gym area • Play with therapy dog	• Practice gymnastics • Join in "Group Play Time" with other pediatric patients • Put on a dance show for parents • Kick a ball with staff	• Play catch with a pay while standing • Surprise visit with friends from home • Join in "Group Play Time" with other pediatric patients • Play dress-up	• Activities of daily living (ADLs) • Example: Getting dressed, taking a bath and/or shower	• Kick a ball with staff • Join in "Group Play Time" with other pediatric patients • "Help" make lunch • Help clean room	• Join in "Group Play Time" with other pediatric patients • Practice gymnastics	• Activities of daily living (ADLs) • Example: Getting dressed, taking a bath and/or shower
Volume (Minutes)	60	60	60	N/A	60	60	N/A

Weeks 7-8

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Frequency (Times/day)	4	4	4	2	4	2	N/A
Intensity (RPE)	Light (9-11)	Moderate (12-13)	Light (9-11)	Moderate (12-13)	Light (9-11)	Moderate (12-13)	Light (9-11)
Time (minutes)	15	15	15	30	15	30	N/A
Type	• Join in "Group Play Time" with other pediatric patients • Practice kicking a ball/soccer • Learn a gymnastics routine • Play with therapy dog	• Play hopscotch • Join in "Group Play Time" with other pediatric patients • Play hide-and-seek with nurses • Practice gymnastics routine	• Play dress-up • Practice gymnastics routine • Join in "Group Play Time" with other pediatric patients • "Help" make dinner	• Practice gymnastics routine • Join in "Group Play Time" with other pediatric patients	• Practice gymnastics routine • Help clean room • Act out a scene from her favorite book • Join in "Group Play Time" with other pediatric patients	• Join in "Group Play Time" with other pediatric patients • Perform gymnastics routine for parents	• Activities of daily living (ADLs) • Example: Getting dressed, taking a bath and/or shower
Volume (Minutes)	60	60	60	60	60	60	N/A

Phase 2: Out-Patient **Weeks 1-4**

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Frequency (Times/day)	2	2	3	2	2	3	N/A
Intensity (RPE)	Moderate (12-13)	Moderate (12-13)	Vigorous (14-17)	Moderate (12-13)	Moderate (12-13)	Vigorous (14-17)	Moderate (12-13)
Time (minutes)	30	30	20	30	30	20	N/A
Type	Session 1: Group Play Time "Let's Learn Karate!" -All pediatric patients in Phase 2 Program engage in learning karate together Session 2: One-on-one -Focus on balance and core strength by standing on one leg, walking a balance beam, etc.…	Session 1: Group Play Time "Let's Learn Gymnastics!" -All pediatric patients in Phase 2 Program engage in learning gymnastics together Session 2: One-on-one -Focus on balance and core strength	Session 1: Group Play Time "Gym Fun Day!" -All pediatric patients engage in supervised games of their choice Session 2: One-on-one - Focus on balance and core strength by standing on one leg, walking a balance beam, etc.… Session 3: Small Group -Work on muscle strength by climbing ropes, playing tug-of-war, jumping on a trampoline, etc.…	Session 1: Group Play Time "Let's Learn Karate!" -All pediatric patients in Phase 2 Program engage in learning karate together Session 2: One-on-one - Focus on balance and core strength by standing on one leg, walking a balance beam, etc.…	Session 1: Group Play Time "Let's Learn Gymnastics!" -All pediatric patients in Phase 2 Program engage in learning gymnastics together Session 2: One-on-one - Focus on balance and core strength by standing on one leg, walking a balance beam, etc.…	Session 1: Group Play Time "Gym Fun Day!" -All pediatric patients engage in supervised games of their choice Session 2: One-on-one - Focus on balance and core strength by standing on one leg, walking a balance beam, etc.… Session 3: Small Group -Work on muscle strength by climbing ropes, playing tug-of-war, jumping on a trampoline, etc.…	Children and parents are encouraged to engage in at least 60 minutes of physical activities at home
Volume (Minutes)	60	60	60	60	60	60	≥60

Weeks 5-8

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Frequency (Times/day)	3	2	3	2	3	2	N/A
Intensity (RPE)	Vigorous (14-17)	Moderate (12-13)	Vigorous (14-17)	Moderate (12-13)	Vigorous (14-17)	Moderate (12-13)	Moderate (12-13)
Time (minutes)	20	30	20	30	20	30	N/A
Type	Session 1: One-on-one - Focus on balance and core strength by standing on one leg, walking a balance beam, etc.… Session 2: Small Group -Focus on building muscle strength by climbing ropes, playing tug-of-war, jumping on a trampoline etc.… Session 3: Group Play Time "Gym Fun Day!"	Session 1: Group Play Time "Let's Learn Tennis!" -All pediatric patients in Phase 2 Program engage in learning tennis together Session 2: One-on-one -Focus on balance and core strength by standing on one leg, walking a balance beam, etc.…	Session 1: One-on-one - Focus on balance and core strength by standing on one leg, walking a balance beam, etc.… Session 2: Small Group -Focus on building muscle strength by climbing ropes, playing tug-of-war, jumping on a trampoline etc.… Session 3: Group Play Time "Gym Fun Day!"	Session 1: Group Play Time "Let's Learn Baseball!" -All pediatric patients in Phase 2 Program engage in learning baseball together Session 2: One-on-one -Focus on balance and core strength by standing on one leg, walking a balance beam, etc.…	Session 1: One-on-one - Focus on balance and core strength by standing on one leg, walking a balance beam, etc.… Session 2: Small Group -Focus on building muscle strength by climbing ropes, playing tug-of-war, jumping on a trampoline etc.… Session 3: Group Play Time "Gym Fun Day!"	Session 1: Group Play Time "Children's Pick!" -All pediatric patients in Phase 2 Program pick to either play tennis or baseball Session 2: One-on-one -Focus on balance and core strength by standing on one leg, walking a balance beam, etc.…	Children and parents are encouraged to engage in at least 60 minutes of physical activities at home
Volume (Minutes)	60	60	60	60	60	60	≥60

Weeks 9-12

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Frequency (Times/day)	3	2	3	2	3	2	N/A
Intensity (RPE)	Vigorous (14-17)	Moderate (12-13)	Vigorous (14-17)	Moderate (12-13)	Vigorous (14-17)	Moderate (12-13)	Moderate (12-13)
Time (minutes)	20	30	20	30	20	30	N/A
Type	Session 1: Small Group -Focus on building muscle strength by climbing ropes, playing tug-of-war, jumping on a trampoline etc.… Session 2: Group Play Time "Gym Fun Day!" Session 3: One-on-one - Focus on balance and core strength by standing on one leg, walking a balance beam, etc.…	Session 1: Group Play Time "Let's Learn Soccer!" -All pediatric patients in Phase 2 Program engage in learning soccer together Session 2: One-on-one -Focus on balance and core strength by standing on one leg, walking a balance beam, etc.…	Session 1: Small Group -Focus on building muscle strength by climbing ropes, playing tug-of-war, jumping on a trampoline etc.… Session 2: Group Play Time "Gym Fun Day!" Session 3: One-on-one - Focus on balance and core strength by standing on one leg, walking a balance beam, etc.…	Session 1: Group Play Time "Let's Learn Basketball!" -All pediatric patients in Phase 2 Program engage in learning basketball together Session 2: One-on-one -Focus on balance and core strength by standing on one leg, walking a balance beam, etc.…	Session 1: Small Group -Focus on building muscle strength by climbing ropes, playing tug-of-war, jumping on a trampoline etc.… Session 2: Group Play Time "Gym Fun Day!" Session 3: One-on-one - Focus on balance and core strength by standing on one leg, walking a balance beam, etc.…	Session 1: Group Play Time "Children's Pick!" -All pediatric patients in Phase 2 Program pick to either play soccer or basketball Session 2: One-on-one -Focus on balance and core strength by standing on one leg, walking a balance beam, etc.…	Children and parents are encouraged to engage in at least 60 minutes of physical activities at home
Volume (Minutes)	60	60	60	60	60	60	≥60

Phase Three: Maintenance

Weeks 1-4

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Frequency (Times/day)	1	N/A	1	N/A	1	N/A	N/A
Intensity (RPE)	Vigorous (14-17)	Moderate (12-13)	Vigorous (14-17)	Moderate (12-13)	Vigorous (14-17)	Moderate (12-13)	Moderate (12-13)
Time (minutes)	60	N/A	60	N/A	60	N/A	N/A
Type	Phase 3 Program: "Let's Play Soccer!" All children in the Phase 3 Program are invited to come and play soccer together. The program includes about 45 minutes of soccer and 15 minutes of muscle and balance strengthening exercises	Children and parents are encouraged to engage in at least 60 minutes of physical activities at home	Phase 3 Program: "Let's Do Gymnastics!" All children in the Phase 3 Program are invited to come and do gymnastics together. The program includes about 45 minutes of gymnastics and 15 minutes of muscle and balance strengthening exercises	Children and parents are encouraged to engage in at least 60 minutes of physical activities at home	Phase 3 Program: "Let's Play Baseball!" All children in the Phase 3 Program are invited to come and play baseball together. The program includes about 45 minutes of baseball and 15 minutes of muscle and balance strengthening exercises	Children and parents are encouraged to engage in at least 60 minutes of physical activities at home	Children and parents are encouraged to engage in at least 60 minutes of physical activities at home
Volume (Minutes)	60	≥60	60	≥60	60	≥60	≥60

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