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EFFECTS OF COMBINED EXERCISE ON PSYCHOLOGICAL AND PHYSIOLOGICAL VARIABLES IN CANCER PATIENTS: A PILOT STUDY

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ABSTRACT

Purpose: *The aim of this study was to investigate the effect of a short-term combined exercise intervention program on perceived self-efficacy, fatigue, lower back flexibility, balance and task specific functional mobility in cancer patients.*

Materials and Methods: *Fifteen patients met all the eligibility criteria and were assigned to a single training group (range age, 22-75 years) that performed an 8-week intervention program (~60min, 2d·wk^{-1}). Each session included a progressive training of cardiorespiratory, resistance, flexibility and postural education exercises. Measures pre-intervention and post-intervention included psychological and physiological measurements. Adherence to training was high (92.3±5.2%) and no major health problem were noted in the participants over the 8-week period.*

Results: *Measures of fatigue have significantly decreased (p<0.001; -27.7%) and perceived capability to regulate negative affect (p<0.001; +18.2%) and to express positive emotions (p = 0.003; +11.8%) improved between the pre and post-study measurements. Highly significant increases were observed in the trunk lateral flexibility test (L: p<0.001; -13.2%; R: p<0.001; -12.8%), stork balance stand test (L: p<0.001, +30.1%; R: p<0.001, +66.7%), and in the number of standing up and sitting down from a chair within 30 seconds (p<0.001; +20.4%).*

Conclusion: *Results suggest that a short-term combined exercise program may improve the physical fitness, functional capacity, capability to manage emotional life and reduce levels of perceived fatigue in cancer patients providing an important support to deal the physiological and psychological side effects. Specialists in Adapted Physical Education need to be involved in the biomedical staff because they are the only ones able to manipulate the training variables for the health and well-being benefit of the special populations.*

Keywords: *Physical fitness, special population, functional capacity, self-efficacy, cancer-related fatigue.*

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Introduction

Cancer is a major public health concern worldwide. Physical activity has been demonstrated to play a preventive role in terms of the risk of developing cancer (e.g., breast, colon, prostate, lung, endometrial)[1, 2]. Physical activity is also emerging as a major tool to improve the quality of life and survival of patients with cancer[3]. Data show that higher levels of physical activity are associated with lower overall cancer mortality[4, 5]. In a report from the American Cancer Society, both physical activity and dietary interventions were identified as strategies to successfully reduce the overall incidence, morbidity, and mortality from certain kinds of cancer[6]. In fact, for the non-smoker, dietary and physical activity interventions are the most important modifiable determinants of cancer risk. Cancer patients and survivors, however, bring with them physiological and psychological side effects including muscular atrophy, weight changes, lowered aerobic capacity, decreased strength and flexibility, nausea, fatigue, depression, and an overall decrease in the quality of life[7, 8, 9]. Cancer-related fatigue is the most common side effect of cancer and cancer treatment. It differs from the normal fatigue of everyday living activities and affects up to 70% of cancer patients during chemo- and radiotherapy and after surgery[10, 9]. Moreover, the sedentary habits usually recommended by the biomedical staff and the family to protect the patient may lead to the development of the self-perpetuating fatigue cycle[9], which results in a higher and higher level of catabolic processes at all levels (i.e., physical, emotional, social). Rest does not improve cancer-related fatigue because inactivity promotes muscular catabolism, and extended periods of rest may lead to chronic fatigue[9, 10]. In severe cases, patients may develop muscle-wasting disease[9]. Physical training breaks this downward cycle and diminishes cancer-related fatigue[9]. For this reason, the specialists in Adapted Physical Education need to be involved in team including the physicians, nurses, social workers, physical therapists, nutritionists, and psychologists.

Exercise both during and after treatment is an effective tool to improve functional capacity, strength, postural control[11] and improving balance, compared to the standard reference values of the healthy population[12], will lower the risk of falls and fracturesfatigue, psychological well-being[13] (i.e., reducing the risk of anxiety and depression), and health-related quality of life in cancer patients and survivors[14-18]. Some authors have even reported that exercise can improve the survival rate after diagnosis of breast cance [19, 20] and prostate cancer[21, 22]. The explanation for all this could be improved oxygen transport to the muscles, cardiac dynamics, and muscle function (i.e., increased mitochondrial density, improved muscle fiber vascularization, cardiac ejection fraction, muscular efficiency)[9]. However, the benefits of physical training may vary according to the type of cancer and treatment; the stage of disease; the mode, intensity, and duration of the exercise program; and the current lifestyle of the patient[23]. There is still, however, much research needed in this area.

Some studies have assessed the benefits of resistance training and combined aerobic and resistance training in cancer patients and survivors, reporting improvements in many areas including functional mobility[24, 25], flexibility[26, 27], fatigue [28, 29,50] and psychological well-being[26, 30], which were also analysed in present study. However, determining a relationship between physical activity and cancer risk is complex because the mechanism(s) through which exercise acts to lower cancer risk is not well understood. It is not known whether risk reduction occurs through the effect of specific training variables (i.e., volume, intensity or load, duration of rest periods, frequency of training, and training velocity) on training outcomes, so more research is needed to address these issues. Moreover, studies on the effects of exercise training on the physical capacity of cancer patients/survivors have used both short (≤ 10 weeks)[31-34], or longer term (≥3-4 months) programs[35]. However, short-term studies have a practical advantage, as cancer sufferers must enter in training programs as soon as possible. The finding that even a few weeks of regular exercise might be sufficient to start helping patients and survivors cope with the anti-cancer treatment and its long lasting, deleterious side effects is a promising one for this subpopulation.

Accordingly, the purpose of this pilot study was to investigate the effect of a relatively brief (8 weeks) combined (cardiorespiratory, resistance and postural) exercise intervention program on perceived self-efficacy, fatigue, lower back flexibility, balance and task specific functional mobility in cancer patients. We hypothesized that psychological and physiological measures and functional performance would enhance with physical exercise.

Materials and methods

Participants

This pilot study utilized a quasi-experimental one-group pretest–posttest research design, in order to collect data before and again following the eight-week treatment and compare the difference between pretest and posttest data.

Before entering the study, informed consent was obtained from each participant. This study did not involve human individuals from a clinical or therapeutic point of view. A human sample was used, without medical contraindications, to examine only the influence of physical exercise as an educational means to improve lifestyles and self-efficacy.

The procedures followed were in accordance with the ethical standards of the responsible institutional committee on human experimentation and with the Helsinki Declaration of 1975, as revised in 2008. A preliminary screening for patient selection was performed in the medical database of the Oncology Department, "Haematology Unit". Patients were contacted by telephone (July 2018) and a preliminary medical examination and the completion of a lifestyle history questionnaire were performed prior to the star of the study (September 2018). After the corresponding oncologist provided consent, participants were deemed eligible for the study if they did not present the following contraindications to physical exercise for patients with cancer:

- Hemoglobin <10.0 g · dL-1;
- White blood cells <3000/mL;
- Neutrophil count <0.5 · 109 · mL-1;
- Platelet count <50 · 109 · mL-1;
- Fever >38 °C;
- Unsteady gait (ataxia);
- Cachexia or loss of >35% of premorbid weight;
- Limiting dyspnea with exertion;
- Bone pain;
- Severe nausea;
- Extensive skeletal metastases.

Fifteen participants (4 males and 11 females) among those who have been contacted met all the above-mentioned eligibility criteria and were assigned to a single training group (range age, 22-75 years; mean age, 56.6±16.6 years; body mass, 67.1±13.4 kg; height, 1.63±0.08 m; and BMI, 25.2±5.0 kg $\cdot m^{-2}$). Among the cancer diseases diagnosed are included: breast cancer (n = 3), Hodgkin's lymphoma (n = 4), Non-Hodgkin's lymphoma (n = 5), multiple myeloma (n = 1), colon cancer (n = 1), and polycythemia vera (n = 1). Eleven patients were on therapy and four were not. Nine patients followed a food plan and six did not. The study was carried out between the months of October and November 2018. All participants completed the study.

Testing procedures

Assessments were made at baseline (pre-test) and repeated after 8 weeks (post-test).

The following psychological and physiological measures were collected:

- Perceived self-efficacy (RESE scale);
- Cancer-related fatigue (0-10 subjective rating scale);
- Lower back flexibility (trunk lateral flexibility test);
- Static balance (stork balance stand test);
- Functional performance (30-second chair stand test).

All participants were tested in a gym located inside the oncological institute. One week before pre-test, two familiarizations sessions were held. Initial and final test measurements were made at the same time of day and under the same experimental conditions. All measurements were performed and supervised by the same exercise professionals, that is Adapted Physical Education Specialists.

Regulatory emotional self-efficacy (RESE) scale

Self-efficacy beliefs influence self-regulative standards adopted by people, whether they think in an enabling or a debilitating manner, the amount of effort they invest, how much they persevere in the face of difficulties, and their vulnerability to stress and depression. On the basis of this reasoning, we administered to cancer patients an instrument to assess self-efficacy in regard to emotional regulation and, in particular, perceived self-efficacy in managing negative affect in response to adversities or frustrating events and in expressing or managing positive emotions such as joy, enthusiasm, and pride[36, 37]. Participants rated (ranging from 1 [not well at all] to 5 [very well]) their capability to manage their emotional life with the RESE scale. This scale included items on perceived capability to regulate negative affect (NEG: 8 items) and to express positive affect (POS: 7 items). A Cronbach's alpha of 0.85 and 0.72 was reported for the NEG and POS items, respectively.

Cancer-related fatigue subjective rating

Fatigue is a symptom affected by multiple biological and psychosocial factors. When assessing cancer-related fatigue, therefore, we need to include both subjective and objective data.

To assess cancer-related fatigue, the participants were asked two questions[38] to help assess the severity of fatigue and its effect over time:

- Are you experiencing any fatigue?
- If so, how severe has it been, on average, during the past week? (If fatigue is present a simple 0-10 rating scale can be used, that is, 0-3 is mild fatigue, 4-6 moderate, and 7-10 severe).

All patients had been familiarized with this scale prior to the commencement of the study and followed standardized instructions for rating perceived exertion. Scores was collected and recorded before and after the eight-week intervention period.

Trunk lateral flexibility test

Each participant was measured for trunk lateral range of motion using a tape measure. The same tape measurement procedure has been reported previously and has high levels of reliability with repeated measures (ICC = 0.98)[39]. Participants first underwent a 15-second static stretch in the lateral trunk motion and then were tested. Participants stood on the floor with arms in the neutral position, heels together, knees and back straight. Then they bent toward the right/left with elbow and fingers straight and attached hand on their lateral side of leg. The distance (cm) between the tip of third finger and the floor was measured three times and the lower measure was used in the analyses. The test-retest reliability reported a high reliability for this test (ICC = 0.99).

Stork balance stand test

This test evaluates postural static balance[40]. Participants were tested on the dominant and non-dominant leg. The participants were instructed to lift and hold the contralateral leg against the medial side of the knee of the stance leg while keeping his hands on the iliac crests. The trial ended when the heel of the involved leg touched the floor, the hands came off the hips, or the opposite foot was removed from the stance leg. This test was conducted with eyes opened only. The participants performed three attempts and the best time (sec.) was recorded for analysis. High test-retest reliability has been reported for this test with an intraclass correlation coefficient (ICC) of 0.94.

30-second chair stand test

This test is one of the most important functional evaluation clinical tests because it measures lower body strength and relates it to the most demanding daily life activities (e.g., climbing stairs, getting out of a chair or bath tub or rising from a horizontal position)[41]. It is also able to assess functional fitness levels[42] and the fatigue effect caused by the number of sit-to-stand repetitions. It consists of standing up and sitting down from a chair as many times as possible (n) within 30 seconds. A standard chair (with a seat height of 40 cm) without a backrest but with armrests was used. Initially, patients were seated on the chair with their back in an upright position. They were instructed to look straight forward and to rise after the "1, 2, 3, go" command at their own preferred speed with their arms folded across their chest. All trials were performed using the same chair and with similar ambient conditions.

Intervention program

Currently there is no evidence supporting a different training response to exercise in the patient with cancer from that in the general adult population. Accordingly, in present study the American College of Sports Medicine (ACSM) guidelines for cancer survivors were followed(43). All sessions were conducted in small groups of five participants under direct supervision of exercise professionals, specialists in Adapted Physical Education, to ensure safety, proper intensity, and appropriate exercise technique. Additionally, the mode, frequency, intensity, duration, and progression in an individual exercise log were recorded to ensure adequate training. The 8-week study period followed the initial data collection, with the single training group that performed an intervention program consisting of twice-per-week exercise sessions lasting 60 minutes each. Every single exercise session was divided into a 10-min warm-up (i.e., postural education exercises and stretching of all major muscle groups), a 40-min main exercise period (i.e., aerobic exercise, resistance training), and a 10-min cooldown period (i.e., stretching again and/or postural education exercises).

During the main exercise period, *cardiorespiratory training* consisted of progressive 30-min of walking and stationary bike at an intensity that ranged from 40% to 85% of heart rate reserve. Heart rate was monitored by the participants and the exercise professionals during training using a Polar heart rate monitor (Target model, Kempele, Finland). The duration of the aerobic exercise was initially 16 min and was divided equally among the two exercise modalities in a rotational order. Based on the recommendations in the literature(3, 43), the aerobic-exercise period was increased by 2 min a week, such that it was 30 min during week 8. However, ≥150 min/week of moderate intensity or ≥75 min/week of vigorous intensity were recommended by ACSM (43) . Unfortunately, in this study it was not possible to follow these indications for organizational reasons. But if the results should be promising we could humbly provide new indications on training loads for cancer patients.

Resistance training consisted of 10-min of exercises with free weights and/or resistance bands, at an intensity ranging from 50% to 70% of 1RM for lifts involving the lower body and from 40% to 70% of 1RM for lifts involving the upper body. 8-10 exercises for major muscle groups, 1 or 2 sets of 8 to 12 reps, and a rest 1-3 min between exercises and sets, were performed with a gradual increase in resistance (1-2 kg) following two consecutive symptom-free sessions.

Flexibility was trained before and after main period by stretching exercises performed maximally on all major muscle groups (1-3 sets per muscle group) but avoiding pain, especially in joints.

Duration was gradual from 10 to 30 s per stretch, repeating one to three times for a total of 60 s per stretch. Following approval from surgeon, special attention was given to shoulder mobility stretches in breast cancer survivors.

Postural education exercises were carried out both in the warm-up and cooldown period, and consisted of breathing, proprioception and balance exercises. In some sessions a Pilates mat workout has also been integrated.

Finally, the exercise program focused on physical activities that use large muscle groups rather than small groups, since most daily living tasks depend on these large muscle groups. Session design and exercises were modified according to the acute or chronic treatment effects of surgery, chemo-therapy, or radiotherapy.

Statistical analysis

Normality of all parametric variables was tested using Shapiro-Wilk test procedure. A paired sample t-test was used to determine whether the changes from pre- to post-test for the physiological dependent variables were statistically significant. Nonparametric statistics (Wilcoxon signed-rank test) were used to identify the significant changes for the psychological dependent variables after 8-weeks of training. Nonparametric statistic was also used in the stork balance stand test since the data were not normally distributed.

The effect size (ES) was identified to provide a more qualitative interpretation of the extent to which changes observed were meaningful. For parametric data, Cohen's d was calculated as post-training mean minus pre-training mean divided by pooled SD before and after training and interpreted as small, moderate and large effects defined as 0.20, 0.50, and 0.80, respectively. For nonparametric data, r was determined by dividing the z value by the square root of N and interpreted as small, moderate and large effects defined as 0.10, 0.30, and 0.50, respectively[44].

The reliabilities of the physiological measures were assessed using the intraclass correlation coefficients; scores from 0.8 to 0.9 were considered as good, while values above >0.9 were considered as high[45]. To assess the internal consistency of the psychological measures was used the Cronbach's alpha; scores from 0.70 to 0.79 were considered as reliable, from 0.80 to 0.90 as highly reliable and >0.90 as very highly reliable(46). Percentage changes were calculated as [(posttraining value - pretraining value)/pretraining value] x 100. All analyses were conducted with SAS JMP® Statistics (Version <14.1>, SAS Institute Inc., Cary, NC, USA, 2018) and the parametric data are presented as group mean values and standard deviations, and the categorical data as median and minimum and maximum. An alpha level of $p<0.05$ was considered statistically significant.

Results

Adherence to training and possible adverse effects

Adherence to training averaged 92.3±5.2%. No major adverse effect and no major health problem were noted in the participants over the 8-week period. Although no follow-up was conducted in the study participants, the patients were satisfied with the results of the study and reported their intention to continue the training program on their own, at least twice per week.

Overview

In terms of emotional life management, perceived fatigue, physical capacity and functional performance, a majority of patients improved during the 8-week program. However, one patient has worsened both in the perceived capability to regulate negative affect and to express positive affect. Changes and statistical data in the psychological and physiological values over 8-week intervention program are reported in Table 1.

Variables	Improved	Worsened	Unchanged	*p (ES)*	Baseline	Week 8	Difference	
Categorical							Absolute	%
RESE scale NEG	13	1	1	0.0004 (0.90)	26 (16-35)	32 (20-35)	4.7	18.2
RESE scale POS	10	1	3	0.0034 (0.95)	28 (22-35)	33 (27-35)	3.4	11.8
Fatigue rating scale	14	0	1	<0.0001 (1.12)	4 (1-6)	3 (1-4)	-1.2	-27.7
Parametric								
Trunk flexibility L (cm)	15	0	0	<0.001 (0.52)	13.6 (3.5)	11.8 (3.3)	-1.8	-13.2
Trunk flexibility R (cm)	15	0	0	<0.001 (0.48)	14 (3.9)	12.2 (3.7)	-1.8	-12.8
Stork balance L (s)*	15	0	0	<0.001 (0.15)	35.2 (60.1)	45.8 (75.0)	10.6	30.1
Stork balance R (s)*	15	0	0	<0.001 (0.32)	27.6 (42.9)	46.0 (64.0)	18.4	66.7
30-s chair (n)	15	0	0	<0.001 (0.82)	13.7 (3.4)	16.5 (4.0)	2.8	20.4

Table 1: Pre and post values for variables tested in the single training group (n = 15). Parametric data are shown as mean (SD), whereas categorical data (RESE and fatigue scale) are shown as median (minimum-maximum). **Statistical analyses were made with the Wilcoxon signed rank test since data were not normally distributed. Absolute and percentages differences were calculated using the group's mean values. L=left; R=right.*

Psychological measures

Statistical analysis revealed that measures of fatigue significantly decreased ($p<0.001$; $r = 1.12$, large effect size) in the single training group between the pre and post-study measurements. Instead, their capability to manage their emotional life has improved both in the perceived capability to regulate negative affect ($p = 0.0004$; $r = 0.90$, large effect size) and to express positive emotions ($p = 0.003$; $r = 0.95$, large effect size).

Physiological measures

Over the 8 weeks of treatment, highly significant increases in physical and functional fitness measures were observed. Paired sample t-tests indicated a significant decrease in the distance between the tip of third finger and the floor in trunk lateral flexibility test (L: $t(14) = -6.22$, $p<0.001$, $d = 0.52$, moderate effect size; R: $t(14) = -5.44$, $p<0.001$, $d = 0.48$, small effect size), and a significant increase in the number of standing up and sitting down from a chair within 30 seconds ($t(14) = 12.58$, $p<0.001$; $d = 0.82$, large effect size). A Wilcoxon signed rank test revealed statistically significant gains in seconds in the stork balance stand test (L: $p<0.001$, $r = 0.15$, small effect size; R: $p<0.001$, $r = 0.32$, moderate effect size).

Discussion

In keeping with recent trends in exercise prescription to encourage even modest levels of physical activity for health benefits, this study evaluated the effect of combined aerobic, resistance and postural exercises. It has been found that 8-week of a physical exercise intervention program significantly improved the perceived self-efficacy and cancer-related fatigue, lower back flexibility, static balance and task specific functional mobility in cancer patients. This is in agree with several other studies that have shown the benefits of combined aerobic and resistance training in cancer patients and survivors, reporting improvements in functional fitness levels and psychological well-being[24, 26, 29, 28, 25, 27, 30].

There is a growing body of research demonstrating that physical exercise performed both during and after treatment is an effective tool to achieve health benefits in terms of functional performance, fatigue, psychological well-being, and health-related quality of life in cancer patients and survivors[47, 14, 15, 31, 16, 17, 48, 18]. However, the benefits of physical training may vary according to the type of cancer and treatment, and the current lifestyle of the patient[23]. In the present study, participants were affected by different forms of cancer (breast cancer, Hodgkin's lymphoma, non-Hodgkin's lymphoma, multiple myeloma, colon cancer, and polycythemia vera) and not everyone was following a food plan, nevertheless all showed significant improvements in physiological measures. Improvements ranged from 12.8% to 66.7% demonstrating the effectiveness of the exercise intervention program on lower back flexibility, static balance, lower body strength and fatigue resistance. Improving balance, patients will have a lower risk of falls and fractures, and with greater strength in the legs they will be able to carry out the activities of daily life more easily without being overwhelmed by fatigue.

Cancer-related fatigue is the most common side effect of cancer treatment, and the sedentary habits usually recommended by the biomedical staff and the family to protect the patient may lead to higher level of catabolic processes at all levels (i.e., physical, emotional, social)[9, 10]. Our combined exercise program, made by exercise professionals, not only allowed to increase the functional and physical fitness levels of all cancer patients, increasing the fatigue resistance, but also reduced the subjective perception of perceived exertion (-27.7%). However, the combined results of increased lower body strength and endurance showed by the 30-second chair stand test could partially explain the reduced levels of perceived fatigue observed in the present study and in other study[34]. In any case, we have given cancer patients the opportunity to improve their quality of life, as also shown by previous studies[49, 16, 15, 17, 18], and we confirmed the physical exercise as a major prevention tool.

A novel finding that can be attributed to our study is the increased capability, on the part of cancer patients, to manage their emotional life[36, 37]. In particular, they have enhanced the emotional perceived self-efficacy in managing negative affect (+18.2%) in response to adversities or frustrating events and in expressing positive emotions (+11.8) such as joy, enthusiasm, and pride. This is another notable result of our study because cancer patients and survivors bring with them physiological and psychological side effects including, inter alia, vulnerability to stress and depression[26, 7, 8].

Effectiveness of our combined exercise intervention program is also demonstrated by no major adverse effect and no major health problem in the participants over the 8-week period. Furthermore, the participants were satisfied with the results of the study and reported their intention to continue the training program on their own. So, our research confirms that a few weeks of regular exercise might be sufficient to start helping patients and survivors cope with the anti-cancer treatment and its long lasting, deleterious side effects. However, most of these results could be the consequence of the high level of deconditioning of cancer patients, such that any small stimulus such as a short exercise program (i.e., eight weeks) may lead to the partial recovery of the patient's normal physiological and psychological characteristics. So, more work is needed to elucidate the long-term beneficial effects of combined exercise training in cancer patients.

Our study presents several limitations must be known. The small number of patients (n=15) and the absence of a control group mean that the study lacked statistical strength, and thus did not allow valid conclusions to be reached on the basis of the results obtained. The standardized regulatory emotional self-efficacy scale and a simple 0-10 rating scale to assess cancer-related fatigue were selected for their ability to predict changes in one or more classifiable phenomena in the specific population. In pilot studies with small populations, these methods were insufficiently sensitive to detect changes resulting from a specific intervention. Accordingly, use of more rigorous research designs with larger sample sizes, control groups including healthy controls and attentional controls as appropriate, and greater standardisation of interventions to facilitate replication and increase internal validity are needed. It must be said, however, that we assessed fatigue (our main topic) by both subjective and objective data. In fact, the 30-second chair stand test, in addition to measure the lower body strength and relates it to the most demanding daily life activities, is also able to assess functional fitness levels and the fatigue effect caused by the number of sit-to-stand repetitions.

This study may be the first investigation to attempt to identify the effect of combined aerobic, resistance and postural exercises on both physiological and psychological functioning in cancer patients. In particular, this study demonstrated the effectiveness of exercise on perceived cancer-related fatigue, confirming the physical exercise as a major prevention tool but also capable of improving the emotional perceived self-efficacy in managing negative affect and in expressing positive emotions. Furthermore, physical fitness and functional capacity were enhanced, providing an important support to cancer patients undergoing treatment. In this way, it may actually be possible to prevent and minimize physical inactivity, fatigue, muscle wasting, and loss of energy. For this reason, exercise professionals, specialists in Adapted Physical Education, need to be involved in the biomedical staff because they are the only ones able to manipulate the training variables like volume, intensity or load, duration of rest periods, frequency of training, and training velocity for the health and well-being benefit of the special populations.

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