

Whole body vibration exercise in the management of cancer therapy-related morbidities: A systematic review

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Summary

The purpose of this systematic review was to investigate the effects of whole body vibration (WBV) exercise in the management of cancer therapy-related morbidities. The PubMed and PEDro databases were used to access publications published in English about the use of whole body vibration (WBV) exercises in cancer patients until February 22nd 2017. The studies included were classified according to the level of evidence (LE) by the National Health and Medical Research Council Hierarchy of evidence and the methodological quality (MQ) by the PEDro scale. The four included studies (2 of them with "high" LE-II and MQ) were performed in patients with different types of cancer (*i.e.* breast, lung, prostate, solid or hematological), treated with WBV exercise to counteract the cancer therapy-related morbidities. The variables evaluated were muscle activity, subjective rate of perceived exertion, exercise capacity, muscle strength, quality of life, resting urinary incontinence and severity of peripheral neuropathy. Although WBV exercise appears to be a potential treatment procedure of cancer therapy-related morbidities, further additional studies are required to determine specific and tailored protocols to be used in the different stages of the disease.

Keywords: Whole body vibration, cancer, oncology, rehabilitation, exercise

1. Introduction

Cancer is a group of diseases that causes the growth of abnormal cells, which exceed their usual limits and can

invade adjacent parts of the body and/or spread to other organs (1). Although it actually represents one of the main causes of morbidity and mortality worldwide, with approximately 14 million new cases in 2012, the amount of cancer survivors is progressively increasing due to advances in early detection and treatment (2,3).

Cancer development and its treatment are usually associated with fatigue (4) pain (5), anxiety or depression (6), and sleep disturbances (7) which determine a decrease of physical and psychological functions and negatively affect the patients' quality of life (QoL) (8).

One way to promote health, to diminish the

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physiologic and psychological effects of cancer and its treatment, to achieve the maximum possible physical, social and vocational well-being is to acquire or maintain a healthy lifestyle, entailing physical activity as a component of cancer rehabilitation (9-11). Physical activity is any movement of the body that involves the muscles action with energy expenditure above rest and the exercise is this physical activity with planning (12). According to the American Cancer Society, cancer survivors should exercise at least 150 minutes per week, including strength training exercises at least 2 days per week (2). The exercise can be beneficial to counteract cancer-related fatigue (10,13-15), improve overall quality of life, as well as relief of symptoms and side effects (10) of the disease and/or of the treatment. In this respect, recent studies have shown the positive effect of physical activity on breast (16,17), prostate (18), ovarian (19) and lung cancer (20).

Among the different exercise modalities, whole body vibration (WBV) exercise (21) has gained progressive popularity, being safe and well accepted by the patients. WBV exercises are generated by mechanical vibrations produced in oscillating/vibratory platforms (OVP) and can be transmitted to the body of the individual when is in contact with the OVP (22-24).

Several authors have already demonstrated the effects of WBV exercise with different protocols in improving muscle strength (25,26), bone formation (25,27), balance (28), flexibility (29,30), function ability (26,27), relief of pain (31) and fatigue (32). Moreover, investigations have shown the WBV exercise benefits in the rehabilitation programs of patients with chronic diseases, such as metabolic syndrome (24), chronic obstructive pulmonary disease (33-35), fibromyalgia syndrome (36), multiple sclerosis (32,37), rheumatoid arthritis (27) and cancer therapy-related morbidities (39).

Due to the importance of the exercise in several clinical conditions, the aim of this systematic review was to investigate the effects of WBV exercise in the management of morbidities related to the cancer therapy. This is the first systematic review to assess whether WBV exercises are safe and beneficial in the management of morbidities for cancer patients.

2. Materials and Methods

2.1. Search strategy used to find the publications

Two databases were accessed in the *Universidade do Estado do Rio de Janeiro* on February 22nd 2017 and two searches were performed. The keywords "whole body vibration" and "cancer", and "whole body vibration" and "oncology" were searched in the PubMed and PEDro databases for three reviewers independently. This systematic review adheres to the Preferred Reporting Items for Systematic Reviews and

Meta-Analysis (PRISMA) Statement (39).

2.2. Criteria to select the publications

All the publications were screened following inclusion and exclusion criteria.

Inclusion criteria: In the search, all the publications found in the databases (PubMed and PEDro) were preliminarily considered to be included in this current review. To be included in this review, all studies had to investigate effects of WBV on cancer patients. A flowchart (Figure 1), based in the PRISMA analysis, was done to show the steps in the selection of the full papers analyzed in this review (39).

Exclusion criteria: Exclusion criteria allowed the elimination of unnecessary publications. Papers were excluded if they were: (i) published in a language other than English; and (ii) findings not related to cancer.

2.3. Levels of evidence (LE) of the selected papers

The National Health and Medical Research Council Hierarchy of evidence (NHMRC, 2003-2007) (40) were used to classify the included studies in this systematic review (Figure 2). Each article was assigned to one reviewer and cross-checked by a second reviewer and where there was disagreement a third party was consulted and the issue discussed until consensus was reached. Moreover, the methodological quality of these studies was determined by the PEDRo scale (41). In the PEDRo scale, each publication was evaluated according to: (a) eligibility criteria, (b) subjects were randomly allocated to groups, (c) concealed allocation, (d) the groups with baseline similarity, (e) blinding of the patients, (f) blinding of the therapists, (g) blinding of all assessors, (h) measures obtained from more than 85% of the subjects, (i) all subjects received the treatment or control condition or, at least one key outcome was analyzed by "intention to treat", (j) results of the groups with statistical comparisons and (h) point measures and measures of variability of outcome. Those publications with a score of seven or greater in the PEDro scale were considered of 'high' methodological quality, those with a score of five to six would be of 'fair' quality and a score of four or below were classified as 'poor' quality (42).

3. Results

The steps to select the full papers analyzed in this systematic review are shown in the flowchart (Figure 1). Of the twelve papers firstly screened, only four have reached the inclusion criteria.

The characteristics of the participants, the protocols used, the aims of the studies, the tools for evaluation and the outcomes of the selected articles and the level of evidence of the selected papers and the methodological quality are shown in the Table 1.

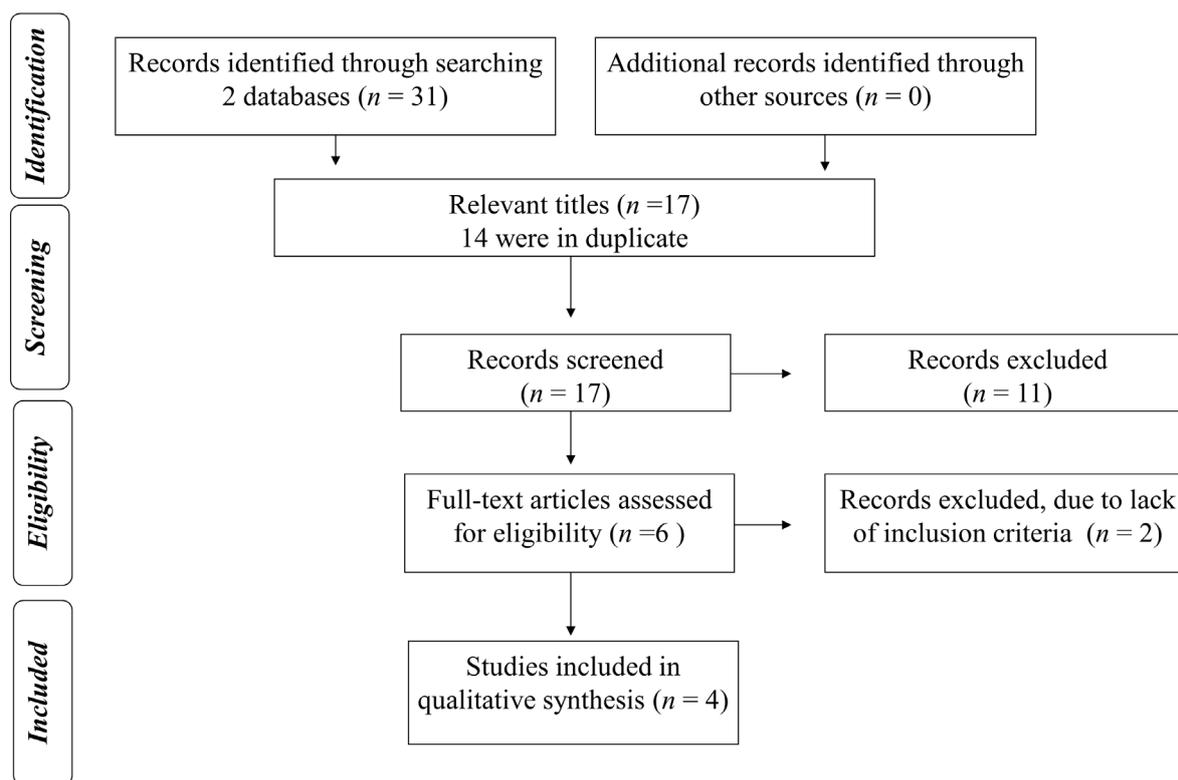
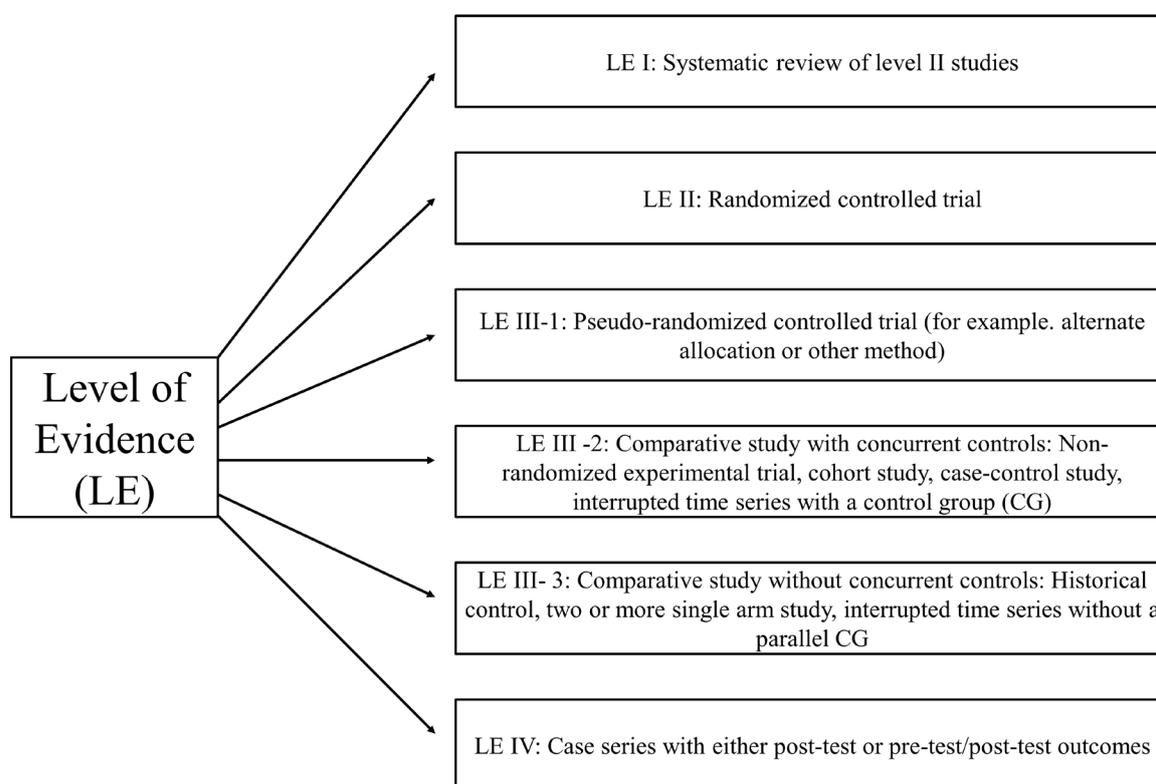


Figure 1. Flowchart indicating the steps to select the full papers analyzed in this review. A flowchart based in the PRISMA analysis, was done to show the steps in the selection of the full papers analyzed in this review.



CG – control group, LE – level of evidence

* Adapted from National Health and Medical Research Council (NHMRC), Q5 2003-2007.

Figure 2. Designation of levels of evidence according to the intervention research question. The National Health and Medical Research Council Hierarchy of evidence (NHMRC, 2003-2007) were used to classify the included studies in this systematic review.

Table 1. Characteristics of the participants, protocols used, aims of the studies, tools for evaluation, outcomes of the selected articles, level of evidence of the selected papers and methodological quality

Study	Type of cancer/ Treatment performed/ number of individuals	Morbidities of the treatment	WBV Intervention	Aim	Tools for evaluation	Outcome (s)	Level of evidence/ methodological quality
Van Ruymbeke <i>et al.</i> , 2014	Breast cancer survivors/ all type of treatment. Breast cancer survivors (<i>n</i> = 20) and Control group- healthy woman (<i>n</i> = 20)	No comorbidity was reported	Two groups were undergoing vibration, the women were standing on a synchronous vibrating platform with a knee joint angle of 55°. Each condition: nonvibration condition (0Hz) and vibration condition at 20-30-40-50Hz vibration frequencies (amplitude, 4mm) lasting for 30 s with 2-min rest between conditions.	To analyze muscle activity and subjectively rate of perceived exertion	Surface EMG analysis of the RF, VM, VL, TA and GT muscles. The level of subjectively perceived exertion was rating on a combination of a VAS and revised Borg.	The muscle activation did not differ between breast cancer survivors and healthy controls. There was a significant frequency × muscle interaction effect. For the VAS scores no significant group × frequency interaction was found and no significant main effect for the factor group, in contrast the factor frequency was significant. The values of perceived exertion in both groups increased with increasing frequency.	III-1/ Fair
Salhi <i>et al.</i> , 2015	Stages I-III lung cancer or mesothelioma/radical resection with or without a chemotherapy or radiotherapy CON group (<i>n</i> = 21), CRT group (<i>n</i> = 20), WBV group (<i>n</i> = 17)	Post-treatment QF was either equal or less than 70% of the predicted normal value or showed a decrease of at least 10% from the baseline value	CON group - patients were discouraged to improve their exercise tolerance. CRT group - 20 min of aerobic training on the bicycle and treadmill at 70% of the respective Wmax and speed plus resistance training on multigym equipment starting with three sets of eight repetitions for each exercise at 50% IRM. WBV group - 20 min of aerobic training on the bicycle and treadmill at 70% of the respective Wmax and speed plus performed exercises on the synchronous vibration platform, three sets of 30 s for each exercise at 27 Hz. Patients trained three times a week for 12 weeks.	To assess the potential beneficial effect of rehabilitation	Exercise capacity with 6MWD and Wmax, muscle strength by the QF with isometric handheld dynamometer, and QoL with EORTC QLQ-C30	6MWD not increased in CON and in WBV group, and increased in CRT group. Wmax was significantly increased in both CRT and WBV group. QF significantly increased only in CRT group. For none of the groups, the score of EORTC QLQ-C30 Global changed significantly.	II/ High

Electromyography = EMG; Rectus Femoris = RF; Vastus medial = VM, Biceps femoris BF, Tibialis anterior = TA; Gastrocnemius = GT; Visual analogue scale = VAS; Control = CON; Conventional resistance training = CRT; Whole Body Vibration = WBV; Quadriceps force = QF; One-repetition-maximum = 1RM; Maximal workload (Wmax); 6-min walking distance = 6MWD; Quality of life = QoL; European Organisation for Research and Treatment of Cancer Quality of Life Cancer Questionnaire = EORTC QLQ-C30; Chemotherapy-induced polyneuropathy = CIPN; Functional Assessment of Cancer Therapy/ Gynecologic Oncology Group neurotoxicity subscale = FACT/GOG-NTX; Warm detection threshold = WDT.

Table 1. Characteristics of the participants, protocols used, aims of the studies, tools for evaluation, outcomes of the selected articles, level of evidence of the selected papers and methodological quality (continued)

Study	Type of cancer/ Treatment performed/ number of individuals	Morbidities of the treatment	WBV Intervention	Aim	Tools for evaluation	Outcome (s)	Level of evidence/ methodological quality
Crevenna <i>et al.</i> , 2016	Prostate cancer/radical prostatectomy/Case report	Urinary incontinence	WBV- 20-26 Hz, synchronous platform plus performing pelvic floor exercises, supine position on the device, 2 times a week for a period of 6 weeks	To treat the disabling and isolating symptom incontinence	Number pads/day	After intervention, the number of pads decreased from 5 pads/day to 1 safety pad/day.	IV/ Poor
Schönsteiner <i>et al.</i> , 2017	Cancer patients- solid or hematological neoplasms /Chemotherapy/ Experimental group (n = 44), Standard group (n = 50)	CIPN grade II-III according to National Cancer Institute Common Toxicity Criteria	All patients received massage and passive mobilization in posture and transport layers for 30 min per side. Experimental group - training with WBV 9 Hz- 23Hz, alternate platform for 18 minutes alternating positions and frequencies. Standard group - Alternating training exercises with a focus on training of posture and transport movements were initiated including 21 separate exercises. patients were invited to practice the exercises at home on a daily basis and asked to document their efforts. In addition, all patients were motivated to walk as frequently and long as possible.	To evaluate the potential benefits of WBV to patients with CIPN	Severity of peripheral neuropathy was evaluated with chair- rising test, FACT/GOG- NTX, quality of life questionnaire (EORTC QLQ-C30), patellar tendon reflex and Achilles tendon reflex, quantitative evaluation of pallesthesia by using a Rydel-Seiffer tuning fork (C64), and the quantitative sensory testing followed a standardized protocol.	The time needed for the chair-rising test decreased significantly over time and that patients treated in experimental arm had a significantly higher reduction in the time needed for the chair-rising test compared to those treated in standard arm. FACT/ GOG-NTX categories "tingling" as well as "discomfort" in the feet were significantly EORTC QLQ C30 improved over time but again without differences between the study groups. The neurological reflex, Achilles and patellar tendon reflexes, the difference did not reach statistical significance. Quantitative sensory testing before the intervention and after completion of the program revealed a significant reduction in the WDT in the experimental arm compared to the standard group.	II/ High

Electromyography = EMG; Rectus Femoris = RF; Vastus medial = VM, Biceps femoris BF, Tibialis anterior = TA; Gastrocnemius = GT; Visual analogue scale = VAS; Control = CON; Conventional resistance training = CRT; Whole Body Vibration = WBV; Quadriceps force = QF; One-repetition-maximum = 1RM; Maximal workload (Wmax); 6-min walking distance = 6MWD; Quality of life = QoL; European Organisation for Research and Treatment of Cancer Quality of Life Cancer Questionnaire = EORTC QLQ-C30; Chemotherapy-induced polyneuropathy = CIPN; Functional Assessment of Cancer Therapy/ Gynecologic Oncology Group neurotoxicity subscale = FACT/GOG-NTX; Warm detection threshold = WDT.

Table 2. Quality evaluation of the studies according to the PEDro scale

Author/year	Van Ruymbeke <i>et al.</i> , 2014	Salhi <i>et al.</i> , 2015	Crevenna <i>et al.</i> , 2016	Schönsteiner <i>et al.</i> , 2017
Eligibility criteria were specified*	No	Yes	No	Yes
Subjects were randomly allocated to groups	Yes	Yes	No	Yes
Allocation was concealed	No	Yes	No	Yes
The groups were similar at baseline regarding the most important prognostic indicators	Yes	Yes	No	Yes
There was blinding of all subjects	No	Yes	No	No
There was blinding of all therapists who administered the therapy	No	No	No	No
There was blinding of all assessors who measured at least one key outcome	No	No	No	Yes
Measures of at least one key outcome were obtained from more than 85 % of the subjects initially allocated to groups	Yes	Yes	Yes	Yes
All subjects for whom outcome measures were available received the treatment or control condition as allocated or data for at least one key outcome was analyzed by "intention to treat"	Yes	Yes	Yes	Yes
The results of between-group statistical comparisons are reported for at least one key outcome	Yes	Yes	No	Yes
The study provides both point measures and measures of variability for at least one key outcome	Yes	Yes	No	Yes
Total PEDro Scale	06	08	02	08

*It is not scored in the total score.

The level of evidence (NHMRC, 2003-2007) (40) of the two studies included in the current review (38,43) were considered LE II, one study (44) was considered LE III-1 and one study (45) was considered LE IV.

As far as the methodological quality evaluated following the PEDro scale (Table 2) is concerned, two studies (38,43) were considered of "high" quality, one study (44) was considered of "fair" quality and one study (45) was considered of "poor" quality.

Individuals with different types of cancer, such as breast cancer (44) lung cancer or mesothelioma (43), prostate cancer (45) and solid or hematological neoplasms (38) were evaluated in these studies. The ages of the participants ranged from 18 up to 80 years old. Although different variables were investigated, the common aim of all the selected papers was to evaluate the effects of the WBV exercise on cancer therapy-related morbidities.

Van Ruymbeke *et al.*, 2014 (44) analyzed the muscle activity and subjectively rate of perceived exertion in breast cancer survivors and healthy women. The authors demonstrated that the muscle interaction effect and the values of perceived exertion significantly increased, being comparable in the two groups.

Salhi *et al.*, 2015 (43) evaluated the effects of whole body vibration on exercise capacity, muscle strength and QoL in patients with stages I-III lung cancer or mesothelioma undergone to radical treatment. Although 6-min walking distance (6MWD), muscle strength and QoL did not significantly increase, maximal workload (Wmax) significantly increased ($p = 0.002$).

Crevenna *et al.*, 2016 (45), have studied a patient suffering from severe urinary incontinence after radical prostatectomy due to prostate cancer. After whole body vibration therapy the patient regained continence, the urine loss almost stopped completely, the ability to work and to attend social and private activities

increased.

Schönsteiner *et al.*, 2017 (38) have evaluated the benefits of whole body vibration in chemotherapy-induced polyneuropathy. The authors reported a reduction of the time needed to complete the chair-rising test (CRT) in the individuals of the WBV group compared with individuals of a group with an intervention with other training exercises. In addition, a significant reduction in the quantitative sensory testing warm detection threshold (WDT) was found in the WBV group, and the categories "tingling" as well as "discomfort" in the feet of the program Functional Assessment of Cancer Therapy/ Gynecologic Oncology Group neurotoxicity subscale (FACT/GOG-NTX) were also significantly lower ($p < 0.001$, $p < 0.001$) in the WBV group. However, in the global status, functional, symptoms score and overall QoL, there was a significant improvement over time but no difference between the two groups.

The treated morbidities of the studies included on this review were functional exercise capacity reduction, fatigue, weakness, urinary incontinence and peripheral neuropathy. The WBV exercise frequencies ranged from 9 to 50 Hz, only one study was performed in one session, the others ranged from 12 to 36 sessions. The authors report no side effects during the interventions and among the studies that reported compliance, this ranged from 67 to 80%.

4. Discussion

The exercises have been used as one of the possibilities to rehabilitation for the morbidities caused for the treatment of the cancer survivors (46,47). This systematic review included articles in which WBV exercise was used to manage morbidities due to cancer treatment.

The WBV loads a mild cardiovascular exertion and its neural as well as muscular mechanisms may play a

role of fatigue (48,49). The frequency of mechanical vibration used to generate WBV exercise affects parts of the body through of which it is transmitted (50). The enhancement in muscle strength and power after vibration can be attributed to the increased muscle activity as a result of interaction of the mechanical vibration.

Authors have investigated the effects of frequency on the muscle activity (51,52). Herrero *et al.*, 2011 (51) verified an increase of the electromyography (EMG) activity of the vastus lateral (VL) and vastus medial (VM) muscles in patients with spinal cord injury (SCI) exposed to WBV. Liao *et al.*, 2016 (52) have also reported an increase of the vastus lateral and gastrocnemius (GS) muscle activity in patients with chronic stroke exposed to WBV. Similarly, to these findings, Van Ruymbeke *et al.*, 2014 (44) showed a muscle interaction effect with frequency of the mechanical vibration with an increase of the muscle activation in individuals with breast cancer after therapy.

Salhi *et al.*, 2015 (43) evaluated treated stages I-III lung cancer or mesothelioma performing aerobic training plus performed exercises on the synchronous vibration platform and found increase in maximal workload (Wmax) in these patients. In a study developed in the early phase after lung transplantation in which the patients remained in a static position on the platform and were exposed to WBV exercise, also revealed a significant improvement of the Wmax (53). It is relevant to consider that the Wmax might be a parameter to detect changes in aerobic endurance capacity (54) and it is suggested in this current revision that WBV exercise should be an important, safe and feasible intervention to improve aerobic capacity in individuals after cancer treatment.

The urinary incontinence is other morbidity that has been found after radical prostatectomy in prostate cancer patients (55). This dysfunction has noninvasive modalities considered first-line treatment during the first 6-12 months following prostatectomy and conservative modalities include pelvic floor muscle training (56). Pelvic muscle exercises are important to active retention strength of the striated muscles improving coordination of the contraction and relaxation process for better control and quality of muscle contraction (57). Crevenna *et al.*, 2016 (45) showed a benefit of the additional use of high-intensity whole body vibration therapy in a patient suffering from severe post radical prostatectomy urinary incontinence. WBV exercise also showed the beneficial effects in patients without cancer as women with stress urinary incontinence (58).

The neuropathic disease is common in cancer survivors and may result from the infiltration of nerve tissue by the tumor, radiation treatment, chemotherapy, or cancer-related surgery, leading to symptoms such as pain and functional impairment (59). Schönsteiner

et al., 2017 (38) have demonstrated the beneficial impact (symptoms relieve, physical fitness and sensory function) on chemotherapy-induced polyneuropathy (CIPN) of a program including massage, mobilization as well as physical exercises and WBV. Moreover, other studies have shown the positive effects (reduction of pain (60), enhanced muscles strength and balance (61,62) of WBV exercise on peripheral neuropathy in diabetic patients.

Several limitations of this review should be recognized. A relevant limitation is that we could not draw certain conclusions because there is still limited knowledge about WBV exercise on cancer patients. Moreover, it is difficult to prove the effects of whole body vibration on outcomes, because differences exist in multiple WBV parameters and morbidities among the studies. In addition, relevant studies published in other languages other than English may be missed; and there may be publication bias, due to the greater possibility of publication of studies with favorable intervention results.

Despite the limitations, it is important to consider that, in our knowledge, this is the first review about the use of suitable, non-invasive and simple procedure. Moreover, relevant findings are presented and demonstrated that the WBV exercise must be more understood and known to be used in the management of morbidities due to the cancer therapy.

In conclusion, the WBV exercise might be one modality of treatment to morbidities due cancer treatment for the benefits demonstrated, however other studies should be performed to determine the parameters and specific protocols that will be used to each morbidity.

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