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REVIEW ARTICLE

Clinical exercise interventions in prostate cancer patients—a systematic review of randomized controlled trials

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Abstract
Introduction Urinary incontinence, erectile dysfunction, fatigue as well as fears and depression rank among the most common complaints in patients with prostate cancer, resulting in a reduced participation in daily life and social isolation. Consequently, the quality of life of prostate cancer patients is strongly affected in a negative way. Numerous studies focusing on physical exercise interventions in prostate cancers patients demonstrate positive physiological and psychological effects. Our objective was to evaluate the evidence of randomized controlled studies which examined exercise during medical treatment and in the aftercare of a prostate cancer disease.
Methods Twenty-five randomized controlled trials regarding physical activities in patients with prostate cancer were obtained by systematic literature research (Medpilot). Twenty-one studies examined clinical exercise interventions during the phase of medical treatment (irradiation, pre- and/or post-op, androgen deprivation therapy) and four studies during the aftercare. In order to evaluate the evidence of the included studies, the evaluation system of the Oxford Centre for Evidence-Based Medicine was used. Within this systematic review, we differentiated between "supervised clinical exercise" and "non-supervised clinical exercise."
Results and discussion Current data suggest that incontinence, fitness, fatigue, body constitution, and also quality of life can be improved by clinical exercise in patients during and after prostate cancer. Studies were mostly ranked evidence level "2b." Only four studies, all conducted during medical treatment, reached the level "1b." It seems to be that "supervised exercise" is more effective than "non-supervised exercise." For future research, further randomized controlled trials with high methodological quality need to be conducted in order to establish evidence-based recommendations particularly for prostate cancer patients.

Keywords Prostate cancer · Clinical exercise · Cancer · Rehabilitation · Physical activity

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Purpose

The incidence rate of prostate cancer in Germany is currently 60.120 per year. According to data published by the Tumor Register Munich and the Robert Koch Institute, the incidence rate increased by approximately 50% within the past 8 years [1, 2]. Accounting for approximately 25% of all newly diagnosed cancer diseases, the prostate carcinoma is the most common malignant tumor in men. Despite improved treatment regimes, the therapy of prostate cancer is accompanied by numerous side effects. Urinary incontinence is one of the most common complications caused by radical prostate resection [3, 4]. Depending on the tumor stadium, BMI, comorbidity, surgical technique, operative experience of the urologist, assessment method, and definition of incontinence, 5–74% of the operated patients are affected, and unfortunately, some patients will have to live with an irreversible incontinence [5, 6]. The androgen deprivation therapy (ADT), often applied in patients with advanced prostate cancer, can also affect healthy organs, especially those that depend on sex hormones. Since androgens affect the psyche, skin, bones, muscles, and sexual function, most side effects are related to

these organ systems [7]. The most common side effects caused by an ADT include missing libido, hot flushes, erectile dysfunction, anemia, and an increase in percent body fat. However, complaints may vary according to the extent of androgen deprivation [7–9]. Muscular strength decreases during and after an androgen deprivation therapy [10, 11]. Studies have also shown that a long-term ADT could increase the risk of a metabolic syndrome [12, 13]. Further side effects of a cancer disease and its medical treatment can be observed on the psychological and psychosocial level. Cancer patients often suffer from anxiety, depression, and sleep disorders [14]. Possible long-term effects of the disease and therapy weaken patients' self-esteem. Furthermore, motivational and cognitive restrictions like hopelessness, pessimism, reduced mental capacity, and lack of concentration may arise [15], which lead to a reduced participation in activities and social life, difficulties in maintaining relationships and activities with the family, and a reduced earning capacity [15]. Taken together, these aspects bring about a social withdrawal of many cancer patients leading to a negative overall quality of life [16].

Clinical exercise in cancer patients

During the past few years, physical activities or exercise have shown to be safe, feasible, and effective in cancer patients [17, 18]. They can maintain and improve muscle mass and strength, cardiorespiratory fitness, body function, physical activity levels, flexibility, function of the immune system, body image, self-esteem, and mood [18, 19]. In addition, they contribute to less intense and less frequent symptoms and side effects (e.g., nausea, fatigue, pain), shorter duration of hospitalization, less psychological and emotional distress, depression, and anxiety [18, 19]. A positive influence of these aspects will improve quality of life and facilitate daily activities. Additionally, the metabolic and cardiorespiratory effects of exercise are of great importance in the prevention of subsequent diseases such as type 2 diabetes or cardiovascular diseases [19]. Latest investigations with breast, prostate, and bowel cancer patients suggest that mortality and probability of a relapse can be reduced by physical activity [20–22]. First evidence-based exercise recommendations for cancer patients have already been published; however, special recommendations particularly for prostate cancer patients are still missing [18, 23].

Methods

In the following review, we used the term "clinical exercise" and differentiated between "supervised clinical exercise" and "non-supervised clinical exercise" interventions. "Supervised clinical exercise" studies include movement interventions that pursue rehabilitative and curative aims and are always supervised by a therapist/physiologist. Studies with "non-supervised clinical exercise" also involve movement interventions with rehabilitative and curative aims; however, a therapist is not permanently present and in charge, e.g., home-based programs.

Within the following systematic review, our aim was to compile the data currently available on the effects of "supervised clinical exercise" and "non-supervised clinical exercise" (pelvic floor/sphincter training, resistance training, aerobic endurance training) during medical treatment (inpatient post-op, chemotherapy, irradiation, and ADT) as well as during the aftercare of a prostate cancer disease, in order to then evaluate the evidence of these studies:

How profound is the evidence of "supervised and non-supervised clinical exercise" studies in patients with prostate cancer? Through December 2010, literature was acquired using the Medpilot database. Medpilot is a medical information portal that enables the search of literature in different databases (e.g., Medline, CC MED, Cochrane Database of Systematic Reviews, Cochrane Database of Abstracts of Reviews of Effectiveness) with only one query. It is a service of the German National Library of Medicine and the German Institute of Medical Documentation and Information. German and English search terms involving physical activity and prostate cancer were entered in different combinations (prostate cancer or prostatectomy in combination with physical activity, physical exercise, exercise, moving therapy, sports therapy, sports, endurance, aerobic training, resistance training, pelvic floor and pelvic floor exercise). Table 1 contains the inclusion and exclusion criteria for the systematic literature research.

Table 1 Inclusion and exclusion criteria for systematic research

Inclusion criteria	Exclusion criteria
Physical activities interventions	Studies regarding physical activities behavior or motivation
Exercise intervention	Studies with additional interventions (psychotherapy, nutritional consultation)
Supervised and non-supervised interventions	Studies with patients with benign prostate hyperplasia
Participants: prostate cancer patients only (or separate diagrams for every tumor entity)	
Randomized trial	
Controlled trial	
Number of participants >20	
Published in English or German	

In order to evaluate the evidence of the included studies, we used the evaluation system of the Oxford Centre for Evidence-Based Medicine (OCEBM) since it is commonly used in this context [24, 25]. The evaluation is primarily based on the study's study design; however, the quality of the study and its results are considered likewise. Usually, the ten evaluation levels are comprised to four levels of recommendation. However, in order to establish reliable levels of recommendation, treatment costs and possible benefits and risks for the patients have to be considered [26]. Since valid data have hardly ever been published or do not yet exist, the levels of recommendation were not included in this review.

The literature research was carried out by two independent researchers. Full-text articles of relevant abstracts were viewed in consideration of the inclusion and exclusion criteria. Finally, 25 studies were included in the following systematic review. Twenty-one randomized controlled trials started during medical treatment, and four randomized controlled trials were performed during the aftercare of prostate cancer (Fig. 1). The identified studies all examined one of the following aims: improving physical fitness (strength, endurance), incontinence, quality of life, fatigue, psychological parameters, and medical side effects. The involved exercising methods included endurance training, resistance training, combined endurance and resistance training, and pelvic floor/sphincter training.

Results

"Supervised clinical exercise" and "non-supervised clinical exercise" studies during medical treatment

Of the 21 included studies involving "supervised clinical exercise" and "non-supervised clinical exercise" interventions during the medical treatment of prostate cancer, 4 studies were conducted during irradiation, 3 during ADT, and 14 with inpatients prior to and/or shortly after surgery (pre- and/or post-op; Table 2). The duration of the interventions and the number of subjects in each study varied strongly. Primarily, physiological and psychological parameters were assessed (see "Methods" Section). While the studies that observed patients during irradiation or ADT chose an aerobic endurance and/or resistance training program [27–33], the remaining 14 studies examined the effects of a pelvic floor and sphincter training in inpatients pre- and/or post-op [34–47].

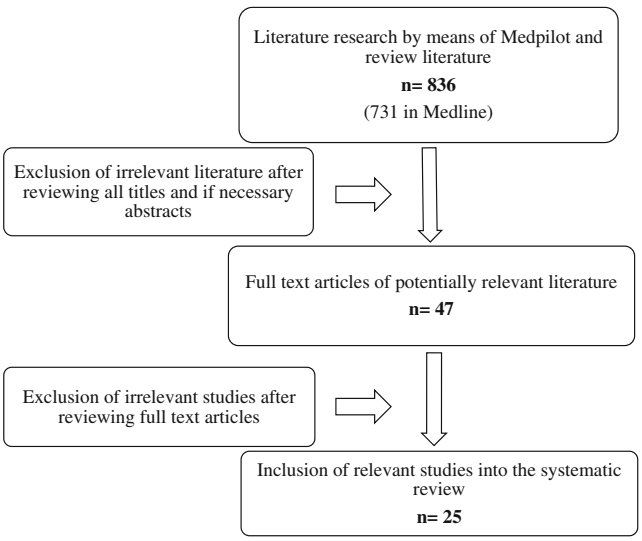

Fig. 1 Course of literature research and study selection

Resistance training during irradiation showed significant improvement in fatigue, aerobic fitness, muscle strength, and quality of life [27]. Similar results could be observed in prostate cancer patients performing aerobic endurance training during irradiation [27–29]. In addition to that, toxicity scores decreased [30]. However, resistance training brings about more positive effects than endurance training [27]. Quality of life and well-being scores increased [28].

A combination of endurance and resistance training might have positive effects on the exercise behavior of prostate cancer patients during ADT [31]. Blood pressure can be lowered, and an increase in waist and cervical girth can be prevented [32]. Yet, significant improvements in quality of life, fatigue, and fitness seem to only be accomplished by isolated resistance training during ADT [33].

Pelvic floor/sphincter training programs significantly reduce the duration of incontinence [35, 39, 41] and increase the quality of life in patients with prostate cancer [35]. A positive trend concerning the timing of the training can also be observed. Pelvic floor/sphincter training seems to be more effective the earlier it is initiated [38]. Even training sessions prior to surgery are possible and have shown positive effects [36, 37, 41, 45]. Finally, a supervised pelvic floor/sphincter training is assumingly more effective than home-based programs [34].

The current study results regarding the application of biofeedback or electrostimulation techniques to accelerate recovery from incontinence are controversial. Few studies have shown that patients who performed a biofeedback-enhanced pelvic floor/sphincter training had a shorter duration of incontinence than those who did not receive the technical support [36, 44]. However, other studies could not observe a significant effect [46]. Therefore, there seem to be no differences between a biofeedback-enhanced and a "pure" pelvic floor/sphincter training [14, 37, 43]. The application of electrostimulation or magnetic innervation during continence training is controversial as well. While some studies showed a reduced duration of incontinence in patients with prostate cancer due to one of these techniques [40], others could not confirm such an effect [42].

In two of the four studies conducted during irradiation, the interventions were supervised and therefore defined as

Table 2 Evidence levels of supervised and non-supervised clinical exercise studies during medical treatment based on the evidence levels of the Oxford Centre for Evidence-Based Medicine

Authors	Design[a]	Form of therapy	Intervention	Measuring point	Significant results	Level of evidence
Interventions during radiation						
Kapur et al. 2010 [30]	*N*=66 (65); TG, 33; CG, 33 Duration, 4 weeks	Non-supervised clinical exercise	TG: at least 3×/week 30 min home-based walking program at 60–70% HRmax	t1: before radiation/ intervention, t2: 2 weeks, t3: 3 weeks, t4: 4 weeks after t1, t5: 4 weeks posttreatment	Mean rectal toxicity score: TG vs. CG ↓ from t1–t4 Bladder toxicity score: TG vs. CG ↓ t5	1b
Segal et al. 2009 [27]	*N*=121; TG (R), 40; TG (E), 40; CG, 41 Duration, 24 weeks	Supervised clinical exercise	TG (resistance): 3×/week supervised resistance training with 2 sets of 8–12 repetitions each at 60–70% 1-RM for 10 full-body exercises TG (endurance): 3×/week 15–45 min. supervised ergometer training at 50–75% VO_2max	t1: before radiation/ intervention, t2: after 12 weeks, t3: after 24 weeks/intervention	Fatigue: TG vs. CG ↓ from t1–t2; QoL: TG (R) vs. CG ↑ from t1–t3; Aerobic fitness: TG(R) vs. CG ↑ from t1–t3, TG (E) vs. CG nearly sign. ↑; upper body strength: TG vs. CG ↑ from t1–t3; leg strength: TG vs. CG ↑ from t1–t3;% body fat: TG vs. CG nearly sign ↓ from t1–t3; testosterone: CG und TG (E) ↓ from t1–t3; PSA reduction: TG(R) vs. CG ↓ from t1–t2; Hemoglobin: TG und CG ↓ from t1–t3; Triglycerides: TG (R) vs. CG ↓ from t1–t3.	1b
Monga et al. 2007 [28]	*N*=21; TG, 11; CG, 10 Duration, 8 weeks	Supervised clinical exercise	TG: 3×/week 30 min. supervised endurance training on a treadmill (THR=0.65×(HRmax rest HR)+rest HR)	t1: before radiation, t2: after radiation	Cardiovascular fitness: TG vs. CG ↑ from t1–t2; Fatigue: TG vs. CG ↓ from t1–t2; QoL: TG vs. CG ↑ from t1–t2; Physical well-being: TG vs. CG ↑ from t1–t2; Functional well-being: TG vs. CG ↑ from t1–t2; Social well-being: TG vs. CG ↑ from t1–t2; Flexibility: TG vs. CG ↑ from t1–t2; Leg strength: TG vs. CG ↑ from t1–t2	2b
Windsor et al. 2004 [29]	*N*=66 (65); TG, 33; CG, 33	Non-supervised clinical	TG: at least 3×/week 30 min home-based	t1: before radiation, t2: 1 week, t3:	Fatigue: CG ↑ from t1–t5; Walking	1b

Table 2 (continued)

Authors	Design[a]	Form of therapy	Intervention	Measuring point	Significant results	Level of evidence
	Duration, 4 weeks	exercise	walking program at 60–70% HRmax with constant speed	2 weeks, t4: 3 weeks, t5: 4 weeks after t1 (after radiation), t6: 8 weeks after t1	distance: TG vs. CG ↑ from t1 to t5	
Interventions pre- and/or post-op						
Centemero et al. 2010 [47]	*N*=143 (118); TG1, 59; TG2, 59	Non-supervised clinical exercise	TG1: pre- and post-op: 2×/week 30 min. supervised PFST+30 min./day home-based PFST	t1: 4 weeks pre-op	Continence rate: TG1 vs. TG2 ↑ t2; TG1 vs. TG2 ↑ t3	1b/2b
	Intervention pre- and post-op Duration, 3–4 months		TG2: post-op: 2×/week 30 min supervised+ 30 min/day home-based PFST	t2: 1 month, t3: 3 months post-op		
Overgard et al. 2008 [34]	*N*=85 (80), TG: 42, CG: 43	Non-supervised clinical exercise	TG+CG: 3×/day 10 contractions as home-based PFST	t1: pre-op, t2: 6 weeks, t3: 3 months, t4: 6 months, t5: 12 months post-op	Continence: TG vs. CG ↑ t5; Perceived bladder dysfunction: TG vs. CG ↓ t3; Training frequency: TG vs. CG ↑ t3 and t4; Contractions/day: TG vs. CG ↑ t2, t3 and t4	1b
	Intervention post-op Duration, 1 year or until continent		TG: additional 1×/week 45 min supervised PFST			
Manassero et al. 2007 [35]	*N*=107 (94); TG, 54; CG, 53 Intervention post-op	Non-supervised clinical exercise	TG: 3×/day 15–30 contractions as home-based PFST	t1: 7 days, t2: 1 month, t3: 3 months, t4: 6 months, t5: 12 months after catheter removal	Duration of incontinence: TG vs. CG ↓ t2,t3,t4 and t5; VAS: TG vs. CG ↓ t5; QoL**:** TG vs. CG ↑ t5	2b
	Duration, 1 year or until continent					
Burgio et al. 2006 [36]	*N*=125 (112); TG, 63; CG, 62	Non-supervised clinical exercise	TG: pre-op: 1× supervised PFST with biofeedback+3×/day 15 contractions as home-based PFST	t1: pre-op, t2: 6 weeks, t3: 3 months, t4: 6 months post-op	Duration of incontinence: TG vs. CG ↓ t4; Severity of incontinence: TG vs. CG ↓ t4; Dry days: TG vs. CG ↑ t4; Pad use: TG vs. CG ↓ t4; Symptoms of stress incontinence: TG vs. CG ↓ t4	2b
	Intervention pre- and post-op Duration, 6 months		Post-op: resumption of home-based PFST			
Lilli et al. 2006 [37]	*N*=90 (90); TG, 45; CG, 45 Intervention pre- and post-op	Non-supervised clinical exercise	TG: pre-op: 20 min/day PFST with biofeedback Post-op: 4×/day25 contractions as home-based PFST	t1: pre-op, t2: 1 month, t3: 3 months, t4: 6 months post-op	No significant results between the cohorts (continence in TG 71.1% and in CG 66.6%)	2b
	Duration, 6 months		CG: pre- and post-op: 4×/day 25 contractions			

Table 2 (continued)

Authors	Design[a]	Form of therapy	Intervention	Measuring point	Significant results	Level of evidence
			as home-based PFST			
Pannek 2005 [38]	*N*=132 (132); CG, 46; TG, 96; TG(2), 28; TG(3), 27 Intervention post-op Duration, unclear	Supervised clinical exercise	TG(1): early-onset PFST: 3 sessions at 30 min. each TG(2): verbal instructions and late-onset PFST at rehabilitation clinic TG(3): early- and late-onset PFST CG: only verbal instructions for PFST	t1: pre-op, t2: 2–3 days, t3: 1 year post-op	Duration of incontinence, continence rate and Pad use: positive trend towards early-onset PFST	2b
Filocamo et al. 2005 [39]	*N*=300 (298); TG, 150; CG, 150 Intervention post-op Duration, at least 6 months	Non-supervised clinical exercise	TG: 3 group session+3×/day 10 contractions as home-based PFST	t1: 1 month, t2: 3 months, t3: 6 months, t4: 12 months post-op	Continence: TG vs. CG ↑ t1,t2 and t3	2b
Yokoyama et al. 2004 [40]	*N*=36; TG(1), 12; TG(2), 12; CG, 12 Intervention post-op Duration, TG (1): 1 month, TG (2): 2 months, KG: N/A	Non-supervised clinical exercise	TG(1): 2×/day 15 min. home-based functional electrostimulation TG(2): 2×/week 20 min. extracorporeal magnetic innervation CG: verbal and written instructions for home-based PFST	t1: before intervention, t2: 1 week, t3: 2 weeks, t4: 4 weeks, t5: 2 months, t6: 3 months, t7: 4 months, t8: 5 months, t9: 6 months after t1	Incontinence: TG(1) vs. CG ↓ t4; TG(2) vs. CG ↓ t5	2b
Parekh et al. 2003 [41]	*N*=38 (36), TG: 19, CG: 19 Intervention pre- and post-op Duration, at least 6 months	Non-supervised clinical exercise	TG: pre-op: 2 supervised PFST sessions (different methods; different positions); post-op: every 3 weeks for 3 months supervised PFST+2×/day home-based PFST	t1: pre-op, t2: after catheter removal, t3: 6 weeks, t4: 12 weeks, t5: 16 weeks, t6: 20 weeks, t7: 28 weeks, t8: 52 weeks after t2	Duration of incontinence: TG vs. CG ↓ post-op; Continence rate: TG vs. CG ↑ t4	2b
Wille et al. 2003 [42]	*N*=139 (129), CG: 47, TG (1): 46, TG (2): 46 Intervention post-op Duration, 3 months	Non-supervised clinical exercise	TG(1): 2×/day 15 min. home-based PFST with electrostimulationTG(2): 2×/day 15 min. home-based PFST with electrostimulation and biofeedback CG: 2×/day home-based PFST	t1: before intervention, t2: 3 months, t3: 12 months post-op	No significant results between the cohorts (continence rate in TG and CG 83% t3)	2b
Floratos et al. 2002 [43]	*N*=42 (42), TG: 28, CG: 14	Non-supervised clinical exercise	TG: 3×/week for 5 weeks 30 min. supervised PFST	t1: before intervention, t2: 1 month, t3:	No significant results between the cohorts	2b

Table 2 (continued)

Authors	Design[a]	Form of therapy	Intervention	Measuring point	Significant results	Level of evidence
			with biofeedback+50–100 contractions/day as home-based PFST CG: 1 supervised PFST session with verbal instructions+4x/day 20–25 contractions as home-based PFST	2 months, t4: 3 months, t5: 6 months after t1	(continence rate in TG and CG 91% (Pad test) and 95% (questionnaire) respectively t4)	
	Intervention post-op Duration, 6 months					
Van Kampen et al. 2000 [44]	*N*=102 (98); TG, 50; CG, 52	Non-supervised clinical exercise	TG: 1×/week supervised PFST with biofeedback+90 contractions/day as home-based PFST CG: 1×/week placebo electrostimulation	t1: pre-op, t2: 1 month, t3: 3 months, t4: 6 months, t5: 12 months post-op	Continence rate: TG vs. CG ↑ t3; Duration of incontinence: TG vs. CG ↓ post-op; Level of incontinence: TG vs. CG ↓ t5; VAS: TG vs. CG ↑ t2	1b
	Intervention post-op Duration, 1 year or until continent					
Bales et al. 2000 [45]	*N*=100 (97); TG, 50; CG, 50	Non-supervised clinical exercise	TG+CG: pre- and post-op: 4×/day 10–15 contractions as home-based PFST TG: pre-op: additionally 1×45 min supervised PFST with biofeedback	t1: 1 month, t2: 2 months, t3: 3 months, t4: 4 months, t5: 6 months post-op	No significant results between the cohorts (continence rate in TG 94% and in CG 96% t5)	2b
	Intervention pre- and post-op Duration: 6 months					
Mathewson-Chapman et al. 1997 [46]	*N*=53 (51); TG, 27; CG, 24 Intervention post-op Duration, 12 weeks	Non-supervised clinical exercise	TG: 3×/week 15–35 contractions as home-based PFST with biofeedback	t1: 2 weeks, t2: 5 weeks, t3: 9 weeks, t4: 12 weeks after catheter removal	No significant results between the cohorts (duration of incontinence in TG~51 days and in CG~56 days)	2b
Interventions during ADT						
Galvao et al. 2010 [31]	*N*=97 (57); TG, 29; CG, 28 Duration, 12 weeks	Supervised clinical exercise	TG: 2×/week supervised resistance and aerobic training. Progressive resistance training with 2–4 sets each from 12–6 RM, for 8 full-body exercises+aerobic training with 15–20 min. of cardiovascular exercise at 65–80% HRmax	t1: before intervention, t2: after 12 weeks	Lean mass: TG vs. CG ↑: t2; Muscle strength: TG vs. CG ↑: t2; Walking time: TG vs. CG ↑: t2; Quality of life: TG vs. CG ↑: t2; Fatigue: TG vs. CG ↓: t2	1b
Culos-Reed et al. 2009 [32]	*N*=100 (66); TG, 53; CG, 47 Duration, 16 weeks	Non-supervised clinical exercise	TG: 3–5×/week home-based exercise program with moderate intensity (walking, stretching, light resistance training)+1×/week 90 min group session	t1: before intervention, t2: after intervention	PA behavior: TG vs. CG ↑; Blood pressure: TG und CG ↓; Waist and neck girth: CG vs. TG ↑	2b
Segal et al. 2003 [33]	*N*=155 (135); TG, 82; CG,	Supervised clinical	TG: 3×/week supervised	t1: before intervention, t2:	Fatigue: TG vs. CG ↓; QoL:	2b

Table 2 (continued)

Authors	Design[a]	Form of therapy	Intervention	Measuring point	Significant results	Level of evidence
	73 Duration, 12 weeks	exercise	resistance training program with 2 sets of 8–12 repetitions each at 60–70% 1-RM for 9 full-body exercises	after intervention	TG vs. CG ↑; Muscular fitness: TG vs. CG ↑	

Example for presentation of results: TG vs. CG ↑: significantly higher in TG compared to CG

↑ significantly longer, higher, more; ↓ significantly shorter, lower, less; *PFST* pelvic floor/sphincter training, *HR* heart rate, *HRmax* maximum heart rate, *CG* control group, *Pad test* incontinence test, *post-op* after surgery, *pre-op* prior to surgery, *PSA* prostate-specific antigen, *QoL* quality of life, *RM* repetition maximum, *rest HR* resting heart rate, *TG* training group, *TG vs. CG* comparison between cohorts, *THR* training heart rate, *VAS* visual analog scale, VO_2max maximal oxygen uptake, *R* resistance training group, *E* endurance training group, *ADT* androgen deprivation therapy

[a] Number of participants after subtraction of dropouts on the last measuring point, time point of intervention, and duration

"supervised clinical exercise" [27, 28]. Of the three studies that examined patients undergoing ADT also two interventions were classified as "supervised clinical exercise" [31, 33]. In 13 of 14 studies that examined the effects of pelvic floor/sphincter training, focusing on the incontinence of prostate cancer patients, at least parts of the training sessions were conducted home-based. The interventions of these 13 studies were classified as "non-supervised clinical exercise." In one study, the exercise intervention of the training group was completely supervised and the intervention therefore defined as "supervised clinical exercise" [38].

The evaluated evidence levels of the studies which were performed during medical treatment of prostate cancer are shown in Table 2. Of the 21 identified studies, only five studies calculated or published the confidence intervals for their primary endpoints. Therefore, these studies were rated evidence level "1b" [27, 29, 31, 34, 44]. The remaining 16 studies lack this information and therefore had to be downgraded to the level "2b" [28, 30, 32, 33, 35–43, 45–47].

"Supervised clinical exercise" and "non-supervised clinical exercise" studies during aftercare

Four randomized controlled studies involving clinical exercise during the aftercare of a prostate cancer disease were identified (Table 3). All studies examined the effects of a pelvic floor/sphincter training on the incontinence of prostate cancer patients in the aftercare of the disease.

Pelvic floor/sphincter training programs during aftercare significantly reduce incontinence in patients with prostate cancer [48–50]. Similar to the study results mentioned above, a biofeedback-enhanced pelvic floor/sphincter training or the application of electrostimulation does not seem to have significant benefits regarding incontinence or quality of life when compared to a "pure" pelvic floor/sphincter training [48–51].

In all four studies, at least parts of the training sessions were conducted home-based. The interventions were therefore defined as "non-supervised clinical exercise" [48–51].

According to the levels of evidence of the OCEBM, all four identified studies regarding clinical exercise in patients with prostate cancer during aftercare were classified as level "2b" studies. In three studies, the reason for the ranking was based on the missing confidence intervals for the primary endpoints [48–50], while in the fourth study, a low follow-up rate (<80%), and therefore a weak methodological quality, was the decisive factor [51].

Discussion

The current data suggest that clinical exercise in patients with prostate cancer improves incontinence, fatigue, muscle

Table 3 Evidence levels of supervised and non-supervised clinical exercise studies during aftercare based on the evidence levels of the Oxford Centre for Evidence-Based Medicine

Authors	Design[a]	Form of therapy	Intervention	Measuring point	Significant results	Level of evidence
Moore et al. 2008 [50]	*N*=205 (166); TG, 106; CG, 99 Intervention ~ 4 weeks post-op Duration, 24 weeks (or until continent)	Non-supervised clinical exercise	TG and CG: 3×/day 12–20 contractions as home-based PFST TG: additional 1×/week 30 min supervised PFST with biofeedback	t1: pre-op, t2: 4 weeks, t3: 8 weeks, t4: 12 weeks, t5: 16 weeks, t6: 28 weeks, t7: 52 weeks post-op	Urinary symptoms and their impact: TG and CG ↓ fromt1–t4	2b
Hoffmann et al. 2005 [49]	*N*=180 (154); TG (P), 60; TG (A), 60; CG, 60 Intervention during and after inpatient rehabilitation Duration, 12 weeks (or until continent)	Non-supervised clinical exercise	TG and CG: 1×/day 30 min. group physical therapy+3×/week 30 min individual physical therapy+3×/day independent PFST (home-based after rehab) TG(P): PFST + perineal electrostimulation TG(A): PFST + anal electrostimulation CG: PFST only	t1: admission, t2: 4 weeks after t1 (discharge), t3: 3 months after t1	Number of pads/day: CG, TG(A) and TG(P) ↓ from t1–t2; Number of pads/night: CG, TG(A) and TG(P) ↓ from t1–t2; micturition frequency at night: CG, TG(A) and TG(P) ↓ from t1–t2; maximum and mean urinary flow: CG, TG(A) and TG(P) ↓ from t1–t2; QoL: CG, TG(A) and TG(P) ↑ from t1–t2	2b
Franke et al. 2000 [51]	*N*=24 (15); TG, 13; CG, 11 Intervention 6 weeks post-op Duration, 18 weeks	Non-supervised clinical exercise	TG: 5×45 min supervised PFST + biofeedback +3×/day 20 contractions as home-based PFST	t1:6 weeks, t2:12 weeks, t3: 24 weeks post-op	No significant results between the cohorts (continence rate in TG 86% and 88% in CG)	2b
Moore et al. 1999 [48]	*N*=63 (58); TG (PFST), 21; TG (ES), 21; CG, 21 Intervention at least 8 weeks post-op Duration, 12 weeks	Non-supervised clinical exercise	TG(PFST): 2×/week 30 min. supervised PFST+5×/week 3×/day home-based PFST TG (ES): 2×/week 30 min. supervised PFST altered with electrostimulation+ 5×/week 3x/day home-based PFST CG: common instructions for PFST	t1: before intervention, t2: 12 weeks, t3: 16 weeks, t4: 24 weeks after t1	No significant results between the cohorts (continence rate ↑ in all groups)	2b

Example for presentation of results: TG and CG ↑: significant higher in TG and CG

↑ significantly longer, higher, more; ↓ significantly shorter, lower, less; *A* anal, *ES* electrostimulation, *CG* control group, *P* perineal, *PA* physical activity, *PFST* pelvic floor/sphincter training; *post-op* after surgery, *QoL* quality of life, *RM* repetition maximum, *TG* training group

[a] Number of participants after subtraction of dropouts on the last measuring point, intervention point, and duration

strength, aerobic fitness, flexibility, quality of life, body constitution, blood lipids, and well-being. These positive effects in patients with prostate cancer were observed with regard to resistance and endurance training programs. In a review by Schmitz et al. [23], exercise intervention studies with prostate cancer patients were ranked between category A and B which underlines that exercise is safe during and after treatment. The authors used for categorization the *Evidence Levels of the National Heart, Lung, and Blood Institute*. Studies with breast cancer patients demonstrate similar positive results [52–54]. The current study situation also confirms that a pelvic floor/sphincter training can shorten the duration of incontinence after prostate resection [35, 36, 39, 41, 44]. Possibly, an additional pelvic floor/sphincter training prior to surgery is more effective than a post-op training alone [47]. In this context, however, study designs differ considerably. The additional application of biofeedback-enhanced techniques or electrostimulation rather than "pure" pelvic floor/sphincter training is still controversial [37, 40, 42, 43, 45]. These results support the

data presented in past reviews [55–57] and underline the lack of good evidence. Further studies with high methodological quality are therefore necessary in this field of research [55].

In summary, the evidence for clinical exercise in patients with prostate cancer is rated evidence level "2." However, it must be considered that the ranking of the studies according to the Oxford Levels of Evidence-Based Medicine was hampered due to missing confidence intervals in most of the studies. Consequently, studies might be under- or overrated. Furthermore, certain subjectivity could not be excluded since many items are described imprecisely and a standardized scheme of weighing these items does not exist. However, all evaluation systems are associated with shortcomings and restrictions [25, 57]. Schmitz et al. [23] used the categories outlined by the National Heart, Lung, and Blood Institute in order to evaluate the evidence of the studies in their review. However, the authors acknowledge that the rating criteria do not involve data about the effect size.

In literature, special recommendations particularly for prostate cancer patients are still missing. First evidence-based exercise recommendations for cancer patients have been published; yet, precise training guidelines including repetitions, duration, frequency etc. cannot be found [62, 63]. The large heterogeneity of the included studies makes it very difficult to define evidence-based recommendations. It is challenging to compare the clinical exercise programs of the single studies because, at least partly, they differ substantially in terms of intervention, duration, dosage, exercise choice, in- and exclusion criteria, outcomes or also patient supervision, an aspect that also influences the clinical effects. Home-based programs of pelvic floor/sphincter exercises, for example, show smaller effects than supervised programs [34, 36, 38, 41]. Interestingly, these effects were primarily found in studies that were published after 2003. Possibly, the method, duration, frequency, etc. of pelvic floor/sphincter training programs changed over the past few years because no significant differences between home-based and supervised pelvic floor/sphincter training programs could be determined in the studies published before 2003 [43, 45, 46, 48].

The frequently quoted sentence "sport is healthy" has to be qualified given that "exercise therapy" should not be mistaken with "sport." We considered this aspect in our systematic review by differentiating between "supervised

Table 4 Recommendations for clinical exercising with prostate cancer patients

Exercise	Pelvic floor/sphincter training (PFST)	Endurance training	Resistance training
Aims	Improving incontinence, QoL	Reduce fatigue and medicaments side effects	Reduce fatigue and medicaments side effects
		Improving physical fitness, QoL	Improving physical fitness, QoL
Begin	4 weeks pre-op	Pre-op	Pre-op
	During radiation and ADT	During radiation and ADT	During radiation and ADT
	48 h after removal of the catheter	48 h post-op: low intensities	48 h post-op: low intensities
		6 weeks post-op: intensive and extensive training possible; however, intensity depends on the degree of incontinence	6 weeks post-op: intensive and extensive training possible; however, intensity depends on the degree of incontinence
Duration	Approx. 12 weeks, if the patient is continent after removal of the catheter	Lifelong	Lifelong
	6 to12 months, if the patient is not continent after removal of the catheter		At least 12 weeks to achieve an effect
Sessions	3–4 sessions per day	2–3 sessions per week	2–3 sessions per week
Intensity		60–80% of the HRmax 50–75% of the VO_2max	60–85% of the 1-RM
Length, sets, repetitions	10–15 contractions per session, no more than 90 contractions per day	15 min with 75–80% of the max. performance	7–8 full-body exercises
	Time of contraction, 5–10 s	30–45 min with 60–70% of the max. performance	2–4 sets
	Time of relaxation, 10–20 s		6–12 repetitions
			3–4 sets with 10–12 repetitions at 60–70% of the 1-RM
			2–3 sets with 6–8 repetitions at 75–85% of the 1-RM

HRmax maximum heart rate, *PFST* pelvic floor/sphincter training, *pre-op* prior to surgery, *post-op* after surgery, *1-RM* one repetition maximum, *VO_2max* maximal oxygen uptake, *QoL* quality of life, *ADT* androgen deprivation therapy

clinical exercise" and "non-supervised clinical exercise" (see "Methods" Section) and actually found that "supervised clinical exercise" could be more effective. To date, not much is known about what kind of exercise should be chosen, when clinical exercise should begin, or how long or intensive a patient should exercise [58]. We know that clinical exercise can effectively help prostate cancer patients; however, precise recommendations are still missing. Future research should pay more attention to therapeutic contents and concepts.

Based on the findings of our systematic review, we defined, possibly for the first time, special recommendations for exercising with prostate cancer patients (Table 4). We differentiated between PFST and endurance training and resistance training. However, these recommendations cannot be considered as evidence-based because further studies are necessary.

In this review, not only the clinical exercise interventions of the different studies are heterogeneous but also the applied assessment methods that generate the observed effects and impacts. An overall evaluation of the clinical exercise studies is therefore limited. Both the calculation of total effects as well as the realization of a meta-analysis would not be meaningful. A further unavoidable limitation of this review is the literature research. Despite the fact that a comprehensive research was performed, certainly not all relevant studies were found. Moreover, the evidence-based evaluation was challenging because the determined results may vary considerably depending on the applied evaluation system [25, 59, 60].

Nevertheless, this review—as well as similar reviews in this context—provides evidence that clinical exercises such as pelvic floor/sphincter exercises and endurance or resistance training programs are seemingly important for the health status and rehabilitation of patients with prostate cancer [11, 55–57, 61, 62]. Due to the various types of interventions, different assessment methods and endpoints of the currently published studies, fundamental and comprehensive clinical exercise recommendations cannot yet be defined.

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