Title: Sustaining a hemodialysis exercise program: A review

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Abstract:

This article reviews the literature addressing exercise programs for dialysis patients in order to identify elements necessary for sustaining exercise programs in this population.

Literature searches for publications (January 1980 to February 2009) in Medline (OVID), PubMed, CINAHL (EBSCO), EBSCOhost EJS, ProQuest Central, Web of Science, Cochrane Library, Google Scholar, ScienceDirect, SpringerLink (Kluwer) and Wiley Interscience (Blackwell) were performed. Reference lists from relevant articles were hand searched for further publications. Criteria for inclusion included full-text primary research and review articles focused on exercise for adult hemodialysis patients. One hundred and seventy one publications were found with a primary focus on exercise in hemodialysis. Of these, 28 primary research and 14 review articles addressed one or more aspects of sustainability of hemodialysis exercise programs. Factors contributing to sustainable exercise programs included: dedicated exercise professionals; encouragement to exercise intradialytically; dialysis and medical staff commitment; adequate physical requirements of equipment and space; interesting and stimulating; cost implications need to be addressed; exercise is not for everyone; requires individual prescription, and there is no age barrier to exercise on hemodialysis.

Background

People living with end stage kidney disease (ESKD) on dialysis have significantly higher mortality rates (1, 2) and significantly lower rates of exercise (2-22) when compared to healthy individuals. Dialysis exercise programs have been shown to improve cardiovascular risk (5, 23-33), quality of life (34-51), physical function (6, 34, 46, 47, 49, 52-83), muscle condition (84-93), dialysis efficacy (35, 36, 61, 77, 94-102) and can decrease indicators of depression (41, 103-108), inflammatory markers (56, 86, 109, 110) and mortality (111, 112) in this population. Although the benefits of exercise have been frequently reported there are challenges for dialysis providers to incorporate exercise in their routine treatment (113-126) with many well-designed exercise interventions, showing great efficacy, but with limited value in real world settings (127).

Recent comprehensive reviews have summarized the clear benefits of exercise for people receiving dialysis (111, 113, 114, 128-139). These reviews have presented the advantages of exercise and physical activity for dialysis patients, recommending the incorporation of exercise into routine dialysis prescription and strongly question why exercise is not a part of the standard dialysis prescription. However, sustaining exercise and activity may be a greater challenge.

Exercise sustainability

The concept of sustainability as it relates to dialysis exercise programs has not been clearly defined in the literature. We propose that sustainability implies the notion that exercise is included in routine care (126, 130, 138, 140) and/or considered a normal part of a person's life (113), whether the exercise is performed on or off dialysis. Thus, sustainable exercise should be an ongoing, routine priority in the life of a person receiving dialysis.

We propose that the challenge to sustaining an exercise program and inclusion in routine care, is vital to increase dialysis patient exercise rates and improve physical and psychological side effects of ESKD. Although examples of successful hemodialysis exercise programs have been reported (53, 101, 133, 140-153) the challenge to sustain such programs in busy dialysis centres is great (154-157).

Unfortunately, adherence to a particular mode of exercise in a dialysis research study does not always equate to the sustainability of that type of exercise. In all people living with chronic disease, the important goal is to include this exercise into routine care (138). This can be no more evident than in chronic kidney disease where sustaining exercise and activity for people receiving dialysis has been a challenge. Thus, the aim of this paper is to review the extant literature relating to 'sustaining' exercise in order to provide recommendations for dialysis staff to maintain ongoing hemodialysis exercise programs.

Methods

In 2009 a literature search for English language publications was conducted using the Medline (OVID), PubMed, CINAHL, EBSCOhost EJS, ProQuest Central, Web of Science, Cochrane Library, Google Scholar, ScienceDirect, SpringerLink (Kluwer) and Wiley Interscience (Blackwell) databases. The search included all articles up until February 28 2009. Search terms included: exercise, hemodialysis, haemodialysis, dialysis, physical activity, end-stage renal disease, end-stage kidney disease and rehabilitation. Reference list were hand-searched for further relevant articles (Figure 1).

Selection criteria were that the article was written between January 1980 and February 2009, and the articles main focus was exercise in adult hemodialysis patients. We accepted original, primary research (quantitative and qualitative), case studies and review articles. We excluded articles addressing exercise in children, peritoneal dialysis only, chronic kidney disease only and kidney transplantation only because our focus was on patients receiving hemodialysis.

Articles that were not primary research were included because the focus of our review was sustainability of exercise programs. These articles were case studies, reviews, opinion pieces and cross-sectional surveys, which may not have been well-designed research, but contained valuable information relevant to the sustainability of hemodialysis exercise programs. Well designed primary research may not reveal sustainable elements because the research is not performed over a long enough time period required to reveal these elements. In addition, ethical aspects, given the clear benefits of hemodialysis exercise programs may discourage longitudinal studies.

One hundred and seventy one articles that met our criteria were reviewed by two reviewers, one an experienced academic and one experienced clinician, experienced in exercise and hemodialysis. Each article was searched for any reference to maintaining, sustaining or continuing an exercise program for hemodialysis. Of the 171 articles, 28 primary research (Table 1) and 14 review articles (Table 2) addressed at least one aspect of sustaining, maintaining or continuing a hemodialysis exercise program.

Results

Analysis of articles that met the inclusion criteria revealed varied exercise associated interventions and important aspects of commencing an exercise program (101, 128, 136, 140, 142, 145, 151). However, there was less evidence of researchers focusing on maintaining hemodialysis exercise programs

following the research period. In saying this, analysis of the 171 articles revealed elements of care that may contribute to a sustained hemodialysis exercise program (Table 3). These elements were:

1. A sustainable program requires exercise professionals
2. Intradialytic exercise
3. Commitment from dialysis and medical staff
4. Adequate physical requirements of equipment and space
5. Exercise programs need to be interesting and stimulating
6. The cost implications of the exercise program need to be addressed
7. Exercise is not for everyone and requires individual prescription
8. Age is no barrier to exercise on hemodialysis

A sustainable program requires exercise professionals

The most frequently cited factor in sustaining a hemodialysis exercise program was to engage experts in physical therapy (62, 64, 79, 108, 114, 130, 133, 147, 158, 159). The benefits of this strategy contributed to safe, individually prescribed exercise regimens and thus, removing the pressure from busy hemodialysis staff who often considered exercise to be a low priority in their workload (133, 146). Furthermore, hemodialysis patients responded well to exercise focused professionals who motivated and provided an added element to the hemodialysis treatment.

Clinicians who led exercise programs were either exercise physiologists (62, 66, 86, 101, 114, 130, 133, 153, 158) or physiotherapists (physical therapists) (49, 66, 120, 147, 153, 158, 160). These exercise professionals were often a part of an exercise facility who partnered the dialysis unit (130, 140, 153, 161). Synergies have occurred with partnerships where the dialysis unit has created a venue for

exercise physiologists to practice while the exercise professionals increase the physical activity of the dialysis patients (155). Ridley et al. (49) suggested that each dialysis unit would benefit from an exercise professional equivalent to 0.4 full time equivalent. This would enable 45 to 60 minutes for each dialysis shift (49). In addition to exercise professionals, dietitians (86, 151), social workers (148, 153), physiatrists (rehabilitation physicians) (153), occupational therapists (157) and kinesiologists (88) have contributed their expertise to sustain hemodialysis exercise programs.

Exercise professionals can coach and encourage dialysis staff to embrace exercise as a part of the patients' prescription (3, 86, 114, 133, 158) which may contribute to staff increased confidence with exercise. However, our experience has shown that if exercise professionals are not involved, dialysis staff prioritise other tasks and patient exercise rates reduce (155). Furthermore, exercise professionals have been under-utilized in hemodialysis units (157) and we concur with Ridley et al. (49) who believe exercise professionals should be present in a dialysis unit at a minimum of two days per week in order to be visible to all patients. Thus, exercise professional involvement contributes immensely to the hemodialysis units' 'exercise culture'.

Intradialytic exercise

There is a consensus of opinion, although no empirical evidence, that the sustainability of hemodialysis exercise programs is complemented if exercise is conducted whilst the patients are on dialysis (4, 48, 49, 65, 70, 100, 108, 133, 139, 140, 150, 162). In a comparison of three different exercise regimes Konstantinidou et al. (65) found that both non-dialysis day and interdialytic programs were effective, however, the interdialytic program had greater adherence in the research study. In an earlier study, Painter et al. (83), also found high rates of intradialytic hemodialysis exercise adherence. Although this

may suggest that intradialytic exercise is more sustainable, conclusions linking adherence in a research study and sustainability of a long-term exercise program need to be made with caution. In saying this however, exercise on dialysis is convenient (65, 163) and assists in decreasing the boredom (130) of the dialysis treatment.

Although perceived barriers have been identified to intradialytic exercise (119) strategies to overcome these have been successful (126, 140). Strategies such as exercising early in the treatment (3, 49, 66) and using novel equipment designed specifically for dialysis exercise (101, 164) has helped overcome these barriers. Furthermore, concerns regarding vascular access complications while exercising (66) have been overcome to the extent where upper arm and dialysis arm exercises are performed intradialytically (165).

Dialysis and medical staff commitment

Commitment to physical activity and exercise is required by all dialysis and medical staff in order to contribute to a sustainable exercise program. The hemodialysis patient's journey through chronic kidney disease (CKD) to dialysis exposes them to many staff who should all have an equal commitment to encouraging physical activity (39, 64, 109). Therefore, from the initial consult with the nephrologist and the CKD nurse, through to the patient commencing dialysis (166), encouragement of physical activity, along with good nutrition and medication adherence, should be evident . If this does not occur the mixed messages from non-committed professionals may result in patients not prioritizing physical activity in their lives.

Nephrologists, nurses and dialysis staff are in an excellent position to encourage sustained physical activity and have the opportunity to act as role models for dialysis patients (3, 62, 114, 138, 140, 143, 147, 164). Unfortunately, Painter et al. (116) revealed that dialysis staff may not have the skills and may not believe it is their role to provide and assist patients to intradialytically exercise (116). This strengthens the requirement to involve exercise professionals in intradialytic exercise programs. Although Krause (117) found that 78% of nephrologists believed it was their responsibility to provide physical activity advice, Johansen et al. (115) conversely, found rates of nephrologist exercise counseling low. This finding supported Painter's call that all physicians recommend and encourage patients with chronic disease to adopt a physical activity program (138). To summarise, the literature has revealed inconsistent clinician beliefs and practices that may decrease the sustainability of intradialytic exercise programs.

Adequate physical requirements of equipment and space

Adequate space (155) and patient/staff friendly equipment (3, 4, 130) are both important elements in order to sustain an exercise program. The equipment needs to be visible and easily accessible for staff and patients to utilise (101, 140). This is not always possible in busy, crowded hemodialysis units however, with careful planning and design, future dialysis units can incorporate exercise strategies. These may include inbuilt resistance weight machines, interactive video games or gymnasium areas.

Exercise needs to be interesting and stimulating

Interventions and programs designed to increase physical activity need to be interesting and stimulating (146). Commonly used ergometers, stationary cycles and hand weights can be used in interesting and stimulating programs to encourage sustainable exercise practices such as: cycling across America (140,

150); chair dancing (167), twelve days of exercise (140), posters and pamphlets (101), videotapes (140, 168), aerobics (151), a rehabilitation fair (148) and American (Renal) Idol (140). Although most patients will not have the capacity of the dialysis patient who ran a half marathon (66), exercise can be competitive, fun and stimulating at many levels.

Many good ideas come and go, however, to continually maintain an interesting exercise program requires documentation, evaluation, and feedback, that measures the success of an exercise intervention or program (62, 130, 133, 146). Documenting progress parameters, particularly in an accessible patient management database system, spreads the exercise message creating awareness among other clinicians (140). Therefore, the combination of new and interesting exercise ideas coupled with a systematic documentation of progress, contributes to increasingly sustainable programs.

Cost implications of an exercise program need to be addressed

Few resources are required to commence and maintain a hemodialysis exercise program (147) that may lead to significantly reduced total healthcare costs (66, 81, 169). However, dialysis units are often tightly resourced and it may be a challenge to justify the upfront material and human resources to commence and sustain a dialysis program (88). The financial contribution to employing exercise physiologists or physiotherapists is significant (153, 170), however, in some countries can be reimbursed through health insurance funders who are enlightened enough to see the benefits of exercise programs (155). As there is evidence of resistance to funding exercise programs (150, 153), dialysis administrators, managers and nephrologists have a role to play in highlighting the benefits of these programs, as part of routine care, to encourage exercise physiologist referrals and funding (170).

Exercise is not for everyone and requires individual prescription

Not all patients are capable of exercising on hemodialysis however, our experience has supported our belief that most patients can sustain some activity on hemodialysis. Each patient requires individual assessment by exercise professionals to assess their capabilities and provide a formal treatment plan (4, 42, 78, 116, 149). Specific details regarding frequency, intensity, duration, and progression are required (34) with individualised charting and documentation of progress (4). However, if patients are unable or unwilling to exercise, dialysis staff should be aware of different values and beliefs towards exercise that may be incongruous with their own (171).

Age is no barrier to exercise on hemodialysis

Globally, the majority of people requiring hemodialysis to treat ESKD are over 50 years of age (172, 173). Similarly, in Australia, almost half of the prevalent hemodialysis population is over 65 years of age with 3%, or 215 patients, over 85 years (174). Therefore, dialysis staff often view hemodialysis patients as being too old to exercise (116). However, this review found a common theme that, although age is a determinant for physical performance (12), elderly hemodialysis patients respond well to some form of physical activity or exercise (43, 80, 101, 130, 146, 152, 160, 168, 175-177) and there is some support that older patients respond better to exercise programs (66).

In a multi-center German study the average age of exercising participants was 72 showing that older patients had higher adherence to the program. In this study, Daul et al. (66) associated an exercise program with five patients being able to travel by taxi rather than ambulance. Pianta & Kutner (160) maintained almost 50% adherence in their study where the median age was 70, and where the oldest patient, who was 83, showed marked improved physical function. Other studies report patients in their

eighties successfully undertaking exercise programs on dialysis (4, 146, 155, 168) while Forgeron (146) reported a 64 year old pedaling an average of two and a half kilometers per dialysis. Johansen (128) cites the recently published American College of Sports Medicine and the American Heart Association guidelines (178) and suggests that recommended aerobic physical activity for the older and chronically diseased individuals can be applied to the hemodialysis population (128). We concur and conclude that most older hemodialysis patients can be considered for a intradialytic exercise program.

Discussion

This review has identified elements that contribute to a sustained dialysis exercise program, and in doing so, has shed some further light on the meaning of a dialysis 'exercise culture'. Authors commonly referred to an 'exercise culture', however, only some identified what that might look like (66, 113, 130, 133, 140, 169, 179). We believe the elements that we have identified contribute to maintaining an exercise culture in a hemodialysis unit.

Our Australian metropolitan dialysis program has managed to maintain over 70% of patients exercising every dialysis over a period of three years (155). This compares well with other sustainable programs reporting 30% to 75% sustained patient exercise involvement (66, 104, 146). This dialysis exercise culture has required: a commitment from all staff (nephrologist, nurse manager, nurses); funded exercise professionals (exercise physiologists); a partnership with an exercise physiology organisation; a commitment to intradialytic exercise, and the resistance to encroach on funds, resources and space dedicated to the exercise program. Furthermore, we have instigated an 'opt out' policy, supported by all staff, where the patients are offered exercise from their first dialysis no matter what age they are.

Documentation and feedback by exercise professionals, promotion of the exercise program through posters and newsletters, individualized dialysis prescriptions, exercise data management program and a dynamic research partnership have also been contributing necessary elements of our program.

Limitations

We acknowledge that there were limitations to our review. Firstly, we chose to accept for inclusion in our study well-designed and less rigorous studies that have commented (from their research and/or experience) on issues of sustainability. Therefore, this study did not set out to compare the rigor of exercise research, and thus, we acknowledge that there is a vast difference between data and an author's opinion based on subjective experience. This review aimed to explore elements and aspects of sustainability that have been identified in both rigorous and non-rigorous publications such as primary research (quantitative and qualitative), case studies, review articles and reports describing experiential exercise programs.

The second limitation to this study was that no extant literature provided irrefutable evidence of elements of sustainability. This limitation is related to the challenges of undertaking long-term research studies that would be required to better answer the questions around sustainability of exercise programs. These would be very hard to ethically justify given the benefits of exercise that have been clearly identified in previous studies.

A final limitation to this review is that issues of sustainability may vary from region to region. In those countries where dialysis is not available an exercise program may not be a priority. In regions with well

developed and universal access to dialysis care, sustainability elements may vary considerably. Addressing variations in sustainability depending on the region was beyond the scope of this paper.

Conclusion

The extant literature reviewed here was unanimously positive in recommending exercise or physical activity for people receiving dialysis. Elements contributing to sustainability found in the literature were: exercise professional involvement; intradialytic exercise; dialysis and medical staff commitment; physical requirements of equipment and space; exercise needs to be interesting and stimulating; cost implications need to be addressed; exercise is not for everyone and requires individual prescription, and there is no age barrier to exercise on hemodialysis. We suggest that well-designed multi-centre longitudinal research studies be undertaken to test these elements. Furthermore, we are hopeful that this review may assist dialysis staff in their quest to establish and sustain their exercise programs.

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Table 1. Primary research publications (1980-2008) addressing aspects of sustainability of hemodialysis exercise program

Author, Country (Ref)	Year	Design	*n*	Exercise Intervention	Results	Comments related to sustaining a hemodialysis exercise program
Bennett et al. Australia (101)	2007	Non-randomized, prospective trial	22 (11E, 11C)	12 mth PRT and aerobic	↑ QoL ↑ PhF ↓ PO4 ↑ URR	• Exercise culture needed • Documentation and feedback needed • Posters, policies, procedures, newsletters • Visible exercise equipment • Exercise expertise • 6 months post 68% patients exercise every dialysis
Cheema et al. Australia (86)	2006 2007	RCT	49 (24E, 25C)	12 wk PRT	↑ PhF ↑ QoL ↑ Proinflammatory state ↑ Muscle quality	• Considers financial restrictions. • Full time ex. Physiologists. • Training nurses / dietitians / therapists to supervise exercises.
Colangelo et al. USA (79)	1997	Single center exercise program case study	N/A	4 wk Multi-d education and aerobic exercise	↑ PhF ↑ PsF	• Enroll patients early • Individual care • Multi-d expertise
Daul et al. Germany (66)	2004	Multi-center exercise program	N/A	Ongoing • aerobic • bed bicycle • gymnastics • relaxation techniques	20% of all pts in 200 German centres exercise Some centres reach 75%	• Supervised by trained sports therapists and physiotherapists • Age is no restriction • Cost effective with few resources required
Death et al. Singapore (147)	1999	Multi-center exercise program	N/A	Ongoing • stretching • PRT • aerobic	Anecdotal improvements	• Cost effective • Physiotherapist expertise • Exercise nurse • 12 months continuing program
DePaul et al. Canada (88)	2002	RCT	20 (10E, 10C)	12 wk PRT and aerobic	↑ sub-maximal exercise test	• Resource intensive • Kinesiologist expertise • Improvements lost after 5 month follow up
Fitts et al. USA (39)	1999	RCT	16 HD (8E, 8C) 17 CKD (9E, 8C)	12 mth • Low intensity PRT and stretching	↑ PhF ↑ PsF	• Start in CKD before dialysis • QoL monitoring should continue
Forgeron et al. Canada (146)	2001	Single center exercise program	20	Ongoing	12 months post 30 to 35% patients exercising	• Documentation and feedback essential • Age no barrier • Needs to be interesting. Cycling across USA.

Goodman et al. USA (119)	2004	Survey	50	N/A	Various motivators and barriers to exercise	• Multi-D team important
Iborra Molto et al. Spain (166)	2000	Cross-sectional survey and intervention	82	• ex testing • information brochure	Low rates of exercise	• Start when pt starts dialysis
Kolewaski et al. Canada (48)	2005	Interpretive interview	7	8 wk • intradialytic aerobic cycle and mini-stepper	↑ ADLs ↑ sense of control ↑ QoL	• Intradialytic recommended
Konstantinidou et al. Greece (65)	2002	RCT	48 (16E ND, 10E ID, 10E Home, 12C)	6 mth PRT and aerobic	Exercise off dialysis is more effective however ID is more sustainable	• Intradialytic recommended
Kontos et al. Canada (4)	2007	Interpretive descriptive coding	18	N/A	Staff rarely encourage ex, not part of routine care plans, staff not trained to encourage ex	• Intradialytic recommended • Light user-friendly equipment • Formal inclusion in treatment plan
Levendoglu et al. Turkey (42)	2004	Non-randomized, prospective trial	14	12 wk aerobic and stretching	↑ PhF ↑ PsF ↑ QoL	• Formal inclusion in treatment plan
MacDonald et al. UK (70)	2005	Non-randomized, prospective trial	9	12 wk high intensity cycle	↑ PhF ↓ ECW No change in muscle atrophy	• Intradialytic recommended
Moug et al. UK (108)	2004	RCT	16 (9E, E10, C7)	6 wk aerobic	↓ anxiety ↑ PhF	• Supervision • Intradialytic recommended
Painter et al USA (78)	2000	Center randomized	286 (87 LowPCS 79 High PCS 28C)	8 wk E Home followed by 8 weeks ID aerobic	↑ PhF	• Include in routine care • Individual design based on available resources
Painter et al. USA (116)	2004	Cross-sectional descriptive multi-	130 staff	N/A	Nurses don't believe it is their role	• Include in routine care • Administrative support

		center survey				
Pianta et al. USA (160)	1999	Non-randomized, prospective trial	25	3 mth before dialysis	↑ PhF in older dialysis patients	• Physiotherapy support necessary
Pugh-Clarke et al. UK (50)	2002	RCT	37 (10E, 8EPD, 19C)	6 mth aerobic	↑ QoL	• Longer term required for QoL change
Ridley et al. Canada (49)	1999	Single center exercise program	8	12 wk • Stretch • PRT • Aerobic	↑ PhF	• Intradialytic recommended • 0.3 to 0.4 FTE physiotherapist required • Multi-D • Bicycles and weights which have cost implications
Shalom et al. USA (73)	1984	Single center exercise program	14	12 wk • Aerobic • Calisthenics	↑ PhF	• Not for everyone
Snyder et al. USA (143)	1989	Single center exercise program	5	3 mth ND	↑ PhF ↑ PsF	• Nurses need to role model
Solomon-Dimmit et al. USA (148)	1999	Single center exercise program	4 to 11	Ongoing • Aerobic • Weights	Nil reported	• Multidisciplinary with social work lead • Bicycles and weights which have cost implications • Needs to be interesting (Rehabilitation Fair)
Stewart et al. USA (149)	1999	Narrative autobiography	1	Ongoing	↑ PhF ↑ PsF	• Formal inclusion in treatment plan
Stivers et al. USA (150)	1996	Single center exercise program	18	Ongoing • aerobic	25% pts exercising	• Needs to be interesting (Map of USA) • Intradialytic recommended • Interesting (map of USA etc), • Bicycles and weights which have cost implications Not for everyone
Stugart et al. USA (153)	1999	Single center exercise program	Not reported	Social worker run progra,m. PDCA	↑ PhF ↑ PsF	• Social work lead • Physiotherapist and physiatrist expertise • Insurance a barrier
Torkington et al. UK (120)	2006	Single center exercise program	8 wk aerobic	Cycling 22 out 0f 46 pts	17 pt (70%) were still exercising	• Physiotherapist expertise • Intradialytic recommended

E, exercising group; c, control group; ↑, improved; ↓, decreased; QoL, quality of life; PhF, physical functioning; URR, urea reduction ratio; PO4, serum phosphate; PsF, Psychosocial function; CKD, chronic kidney disease; ADL, activities of daily living;; ND, non-dialysis days; ID, intradialytic; ECW, extracellular water; PCS, physical component score; EPD, exercising peritoneal dialysis; FTE, full time equivalent;

Table 2. Review publications (1980-2008) addressing aspects of sustainability of hemodialysis exercise program

Author, Country (Reference)	Year	Journal	Aim	Maintenance/ Sustainability
Bayliss USA (140)	2006	Nephrology News and Issues	Define the components needed to begin and manage an effective intradialytic exercise program	• Staff encouragement • Staff/pt buddy program • Resource assessment • Physician prescription • Education and counseling?, • Make it interesting (cycle across USA), 12 days of exercise (like the 12 days of xmas), teams of exercisers, games, prizes, American Idol (renal Idol), • Feedback and documentation
Carlson & Carey USA (133)	1999	Advances in Renal Replacement Therapy	Define staff's role and the systematic integration of an exercise program	• Exercise expertise involvement • Individual exercise prescriptions • Motivational strategies for both patients and staff • Not for everyone • From day one (included in the orientation pack) • Documentation and feedback
Johansen USA (114)	2007	Journal of the American Society of Nephrology	Exercise in the end-stage renal disease population	• Individual prescription • Exercise expertise • Goal setting • Nursing staff support
Karmiel USA (168)	1999	Journal of Renal Nutrition	Presents exercise programs and equipment options and the role for renal dietitian	• Right equipment • Interesting (chair dancing, aerobics, videotapes) • Part of routine prescription • Age no barrier • Expert dietitian involvement
Knap et al. Slovenia (132)	2005	Therapeutic Apheresis and Dialysis	Effects of a Regular Exercise Program	• Intradialytic in first hour • Both aerobic and resistance exercises
Kong UK (100)	2004	Dialysis and Transplantation	Review of exercise and solute rebound	• Intradialytic dialysis recommended
Kouidi Greece (164)	2002	Artificial Organs	Summarises current knowledge about the effects and benefits of exercise training in hemodialysis patients	• Family support • Appropriate screening mode, • Individual duration, intensity, frequency • Physician support • Transport and time • Appropriate program hours

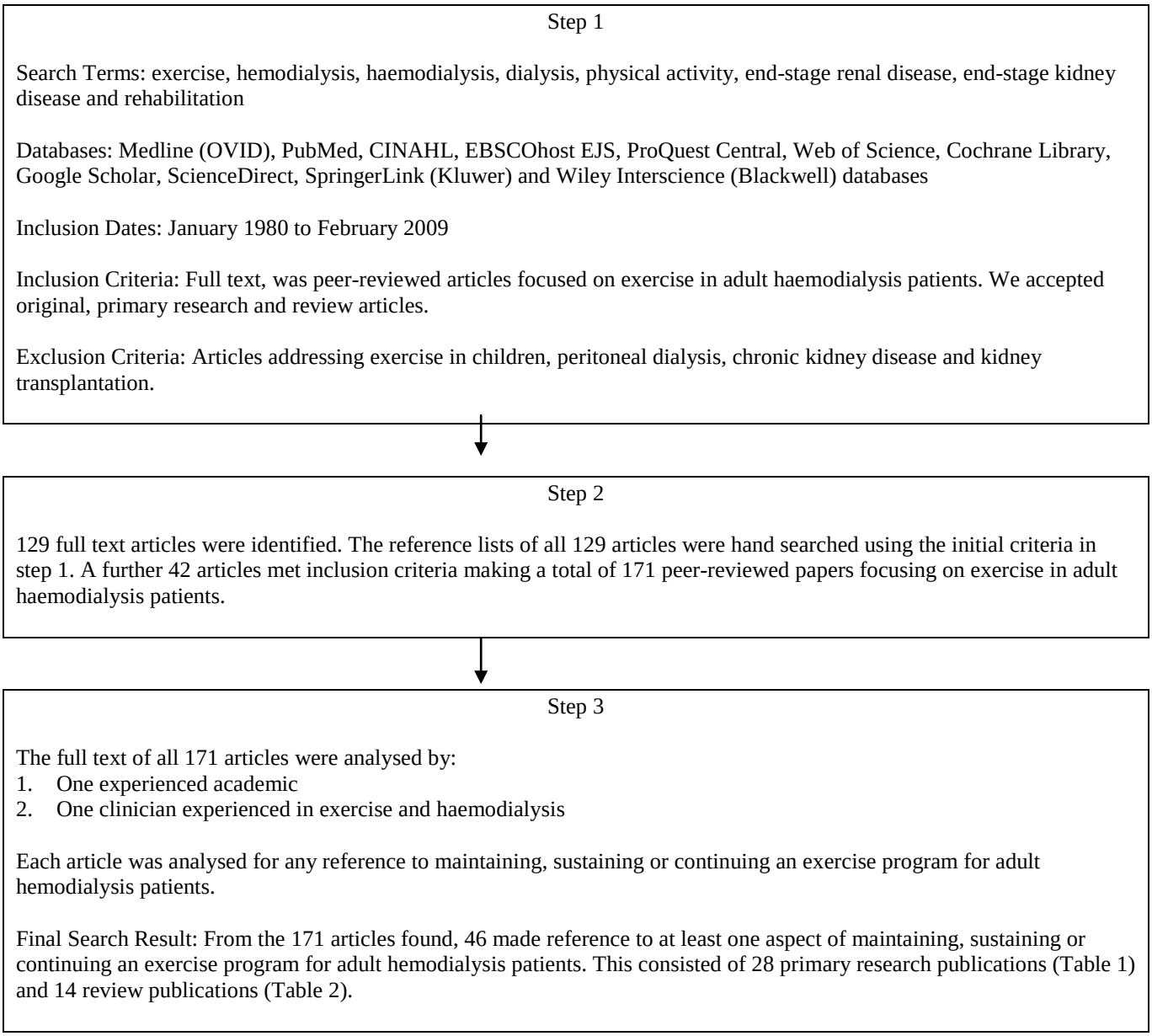
Kouidi Greece (162)	2004	Clinical Nephrology	The effects of renal rehabilitation	• Intradialytic preferred • Not for everyone
Kutner USA (130)	2007	International Journal of Urology and Nephrology	Incorporation of exercise into routine dialysis care	• Part of patient care prescription • Individual assessment of patients • Right equipment • Age no barrier • Exercise experts needed
Martin (3)	2003	Nephrology Nursing Journal	Exercise in dialysis: magic bullet or unnecessary risk?	• Costs • Equipment • Exercise culture • Nephrology nurses as role models/exercise coordinators
Painter (138)	2003	Sports medicine	Physician's responsibility in physical activity for people with chronic disease	• Physician should reinforce exercise as part of care • Individualised prescription and individualised barriers • Use the terminology physical activity rather than exercise
Pianta USA (158)	1999	Advances in Renal Replacement Therapy	Role of PT for renal patients	• PT or exercise physiologist important. • PT can train dialysis staff • Physician referral to experts
Stefanovic Serbia (134)	2005	International Journal of Artificial Organs	Status and recommendations for exercise in HD PD and transplant	• Physician and nephrologist involvement important
Tawney (144)	2000	Nephrology Nursing Journal	Developing a dialysis rehabilitation program	• Nurses need to be exercise role models • Evaluation, documentation and feedback • Nephrologist involvement • Referral to physical activity experts

PT, physical therapist; HD, hemodialysis; PD, peritoneal dialysis

Table 3. Elements required to sustain a hemodialysis exercise program

Element	Details	Source (Reference)
• Exercise expertise	Exercise physiologist, physiotherapy, physiatrist	Bennett 2007(101), Carlson 1999(133), Cheema 2007(86), Couto 2007(180), Daul 2004(66), Death 1999(147), DePaul 2002(88), Goodman 2004(119), Johansen 2007(114), Karmiel 1999(168), Kutner 2007(130), Pianta 1999(158), Ridley 1999(49), Stugart 1999(153), Tawney 2000(144)
• Intradialytic exercise	Patients time-poor, transportation aspects,	Bayliss 2006(140), Kolewaski 2005(48), Kong 2004(100), Konstantinidou 2002(65), Kontos 2007(4), Kouidi 2004(162), MacDonald 2005(70), Moug 2004(108), Ridley 1999(49), Stivers 1996(150)
• Dialysis and medical staff commitment	Buddy system, reinforcement	Bayliss 2006(140), Bennett 2007(101), Carlson 1999(133), Colangelo 1997(79), Death 1999(147), Forgeron 2001(146), Johansen 2007(114), Martin 2003(3), Painter 2004(116), Snyder 1989(143), Tawney 2000(144)
• Physical requirements of equipment and space	Cycles, machines	Bennett 2007(101), Karmiel 1999(168), Kontos 2007(4), Kutner 2007(130), Martin 2003(3), Ridley 1999(49), Solomon- Dimmit 1999(148)
• Exercise needs to be interesting and stimulating	Games, goals, teams	Bayliss 2006(140), Forgeron 2001(146), Karmiel 1999(168), Solomon- Dimmit 1999(148), Stivers 1996(150)
• Cost implications	Human, equipment	Cheema 2007(86), Daul 2004(66), Death 1999(147), DePaul 2002(88), Martin 2003(3), Ridley 1999(49), Stivers 1996(150)
• Exercise is not for everyone	Individual beliefs and values respected	Bennett 2007(101), Carlson 1999(133), Kouidi 2002(164), 2004(162), Shalom 1984(73), Stivers 1996(150),
• Age no barrier	Patient and staff aspects	Bennett 2007(101), Daul 2004(66), Forgeron 2001(146), Karmiel 1999(168), Kutner 2007(130)

Figure 1. Literature review methods flow chart



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