Title:

Factors influencing implementation of aerobic exercise after stroke: A systematic review

Running Head:

Implementation of aerobic exercise after stroke

Article Category:

Review

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Abstract:

Title

Factors Influencing Implementation of Aerobic Exercise after Stroke: A Systematic Review

Objectives:

This systematic review aimed to explore the perspectives of healthcare, exercise, and fitness professionals working with people post-stroke regarding the factors affecting the implementation of aerobic exercise after stroke.

Data Sources:

OVID SP MEDLINE, OVID SP EMBASE and CINAHL were searched from inception to December 2018 using a combination of search terms with synonyms of stroke, aerobic exercise and barriers/facilitators.

Review methods:

Studies focusing on the factors affecting implementation of aerobic exercise after stroke from staff perspectives were included with no restriction on the types of study design. For inclusivity, a broad definition of aerobic exercise was used.

Review authors independently extracted data from included studies using domains from the Consolidated Framework for Implementation Research, then synthesised using a framework synthesis approach. Retrospective automated screening was conducted using Rayyan software.

Results

Twenty studies were included. Four reported on implementation of aerobic exercise, sixteen on general exercise interventions, all post-stroke. Factors identified as influencing implementation of aerobic exercise after stroke included professionals' self-efficacy and knowledge about stroke, patients' needs, communication and collaboration within and between organisations and resources such as equipment, staff and training.

Conclusions

Key factors influencing the implementation of aerobic exercise after stroke included characteristics of the staff and intervention and system-level issues, some of which are modifiable. Further research

should evaluate strategies which specifically target these modifiable factors to facilitate implementation in practice.

Keywords:

Stroke; exercise; rehabilitation; implementation; Attitude of Health Personnel*; Health Knowledge, Attitudes, Practice; systematic review;

Word Count: 3978

Introduction

An estimated 7 million people in the United Kingdom (UK) have cardiovascular disease [1]. Over 1.3 million have survived a stroke or transient ischaemic attack [1]. This burdens the UK considerably in terms of both health and economic costs [1-3]. Stroke patients often suffer from poor cardiovascular health and physical, psychosocial and cognitive impairments [3,4] and are at increased risk of further cardiovascular events [5]. Aerobic exercise is an evidence-based intervention which promotes cardiovascular health [6] and is recommended for both healthy populations [7] and specific conditions, including stroke [8-11]. It is defined as any activity which uses large muscle groups, is rhythmic and can be sustained continuously [12], for example, walking, cycling, swimming and dancing. Aerobic exercise is beneficial during all phases of stroke including acute [13] subacute [14] and chronic [15], and should be included throughout stroke rehabilitation [11]. Research has shown improvements in mobility and walking speed [16,17], balance [18], cognition [17], blood pressure [19,20], and a reduction in disability [21]. However, despite guideline recommendation [22-25] and robust evidence supporting aerobic exercise in stroke rehabilitation [11,21,26,27] , the majority of patients in stroke rehabilitation spend most of their time sitting or lying [28] with minimal focus on aerobic fitness [29]. This chronic inactivity leads to a negative cycle of de-conditioning, decreased function and increased chance of further cardiovascular events [30]. To date, research has tended to focus on the delivery of additional exercise programmes of various formats on patient outcome [31,32] (e.g. seated vs standing aerobic exercise [33], cycling [34], walking [35], group exercise [36]), with scant attention given to how to implement aerobic exercise into stroke rehabilitation.

Despite the recognition by staff that aerobic exercise is important in stroke rehabilitation [37], clinical implementation remains challenging [38]. This systematic review aimed to collate existing evidence and explore the factors influencing implementation of

aerobic exercise after stroke from the perspectives of staff whose roles were within healthcare, exercise, or fitness settings.

Methods:

The review was registered with PROSPERO, the international prospective register of systematic reviews (registration number CRD42018099579), and reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement [39].

Search Strategy

The SPIDER (Sample, Phenomenon of Interest, Design, Evaluation, Research type) search tool, specifically adapted from the PICO (Population/problem, Intervention/exposure, Comparison, and Outcome) tool for use in qualitative research [40], was used to develop an effective search strategy. The three domains identified using the SPIDER search tool [40] for this review were; the sample (patients with stroke), the phenomenon of interest (aerobic exercise) and evaluation (of the barriers and facilitators from a healthcare, exercise and fitness professionals' perspective). Synonyms of each domain and corresponding full search strategy are shown in supplementary material.

Reference lists of included full text papers were scanned to identify any further potential studies ("snowballing") [41]. In the case of abstracts identified as potentially relevant but with no accessible full text available, efforts were made to contact authors.

Data Sources:

The electronic databases OVID SP MEDLINE, OVID SP EMBASE and CINAHL were searched from inception until December 2018. Articles were limited to the English language

as resources were not available for foreign language translation. Search hits were imported into EndNote where duplicates were removed.

Selection criteria

Studies with a formal objective which involved the exploration of factors (barriers and/or facilitators) affecting the implementation of aerobic exercise from the perspectives of staff were included. No restrictions were imposed based on age, stroke characteristics or time since stroke. A scoping exercise indicated that, due to issues with reporting and defining of interventions, the definition of 'aerobic exercise' needed to be comprehensive. Therefore, any exercise interventions which were potentially aerobic in nature, following the broad definition provided in the introduction, but not reported using the term 'aerobic exercise' were included, for example, exercise after stroke, community-based exercise, treadmill training.

The population were any staff working within stroke-related healthcare, exercise, or fitness settings, with no restrictions based on qualifications or experience. Please note that henceforth, the term 'physiotherapists' refers to both 'physiotherapists' and 'physical therapists', and the term 'exercise professionals' includes 'exercise professionals', 'fitness instructors' and 'kinesiologists'.

Screening

A single reviewer (NG) completed the title and abstract screening. Articles relevant for inclusion were each independently screened by two of the three authors (NG and LC or EB). Uncertainty was resolved by discussions, and if consensus could not be reached, arbitration was carried out by the third author. Reasons for exclusion at the full text screening stage were documented.

Post-Protocol Automated Screening

Following completion of data analysis, the reviewers chose to add a post-protocol adaptation in the form of retrospective automated screening using Rayyan [42,43], a web and mobile app. Automated screening can optimise the results of the screening process by increasing recall of relevant studies, thereby strengthening a review [44]. The original search records were uploaded to Rayyan, with the included and excluded studies indicated. The software then calculated and rated how likely the excluded studies were to be related to the included studies. The 200 most relevant studies were then re-screened by NG.

Data Extraction and Synthesis

All papers were imported into NVIVO 12 Pro, a data analysis software tool. Two of three review authors (NG,LC,EB) independently extracted data from each of the included studies using domains from the Consolidated Framework for Implementation Research [45], a pragmatic taxonomy of the factors that influence implementation consisting of five domains: characteristics of the intervention, inner setting, outer setting, characteristics of individuals, and processes. Nodes for data extraction were as per the Consolidated Framework for Implementation Research (table 1) with extra nodes created as required**.** Initially, one study was coded by all three reviewers followed by a discussion to ensure that interpretation of the framework was consistent. Results were then synthesised using a framework synthesis approach [46].

[Table 1 near here]

Care was taken during data analysis and synthesis to refer back to the primary data to ensure

that there was no loss of context or misinterpretation of results [47]. Regular team meetings focusing on discussion of the evidence were carried out to facilitate a shared understanding as recommended in the Cochrane guidance [47].

Quality assessment and Sensitivity Analysis

Excluding studies risks the loss of valuable data and the contribution of individual studies may only become apparent during data synthesis [48], hence no studies were excluded on the basis of quality. We included all studies, and then undertook a sensitivity analysis after completion of the data synthesis to ensure that any valuable contributions from individual studies were included. This process involved extracting data from the conference abstracts separate to the full texts and then comparing these with the full texts' data.

Reflexivity

The lead researcher (NG) is a physiotherapist with clinical experience in both stroke and cardiac rehabilitation. Three other members of the team also have a background in physiotherapy: LC is a clinician-scientist specialising in implementation research and stroke rehabilitation, PD has over 20 years of working experience as a clinical academic in cardiac rehabilitation and Director of the National Audit for Cardiac Rehabilitation and JH is a senior fellow in evidence synthesis with experience of systematic reviewing and automated screening. EB is a chartered psychologist with an interest in health interventions and experience of designing and conducting NHS-based health interventions, and AH a Health Services researcher specialising in modes of delivery in cardiac rehabilitation.

Results

Study identification

A total of 11,683 hits were identified through the search strategy, of which 63 progressed to full text review including 4 additional texts (3 abstracts and 1 full text) identified through automated screening. A total of 20 studies were identified for the review which comprised of eleven full text articles and nine conference abstracts (figure 1). A summary of the included studies is shown in table 2.

[Figure 1 near here]

[Table 2 near here]

Description of included studies

Included studies were conducted in North America (n=10), Europe (n=7) and Australia (n=3). Studies with the greatest number of participants were generally from North America and the Netherlands. All were set within either healthcare, exercise, or fitness settings including hospitals, primary practice, leisure services and charities. Four of the North American studies [37,38,49,50] provided data on the factors perceived by physiotherapists [37,38,50] and clinicians (specific profession not given) [49] to influence implementation of aerobic exercise after stroke. The remaining sixteen studies in this review reported on the barriers and/or facilitators to participation in, or implementation of, an exercise intervention after stroke from the perspectives of staff. Examples of these interventions were 'exercise programme' [51], 'community-based exercise' [52,53], 'high intensity interval training' [54] and 'fitness programmes' [55] . These were included under this review's broad definition of aerobic exercise to avoid the possibility of excluding valuable data. Three of these sixteen studies involved service providers, fitness facilities and cardiac rehabilitation programmes [55-57].

Staff included healthcare professionals [52,53,58-62], physiotherapists [54,63,64] and fitness instructors [53,65], cardiac and stroke rehabilitation teams [66], exercise professionals [51,62] and others [53,55-57,62]. The views of physiotherapists (n=909) were predominant with a lesser number of exercise professionals (n=114), medical staff (n=8) and nurses (=11) represented. The number and/or specific profession of participants were not reported in six of the abstracts [49,58,60-62,66].

Sensitivity analysis

The sensitivity analysis conducted on the conference abstracts (n=9) revealed that, despite containing less methodological detail, they either confirmed or added depth to the findings and added valuable insight. For example, confirming the need for specialist staff to help implement the intervention post-stroke into an existing model (in this case, cardiac rehabilitation) [66] and the challenge of integrating exercise testing and prescription into patient and clinician schedules [49].

Factors identified as influencing implementation

The factors influencing implementation, derived from the Consolidated Framework for Implementation Research, are summarised with identification of the source references in table 3. The following descriptions have been presented as per the framework domains of Intervention Characteristics, Outer Setting, Inner Setting and Characteristics of Individuals.

[Table 3 near here]

Intervention Characteristics

This domain relates to the attributes of the intervention which have been shown to influence the effectiveness of implementation. The importance of being able to adapt the intervention for stroke patients, the format and prescriptiveness of the intervention, as well as the number of steps and cost required to implement were the main 'intervention characteristics' perceived by staff within healthcare, exercise, and fitness settings.

Adapting exercise interventions by having access to suitable adaptive equipment for screening for safety, and for individual exercise prescription was a need identified by clinicians, physiotherapists and exercise professionals [37,49,51], for example, body-weight supported treadmills and cycle ergometers. This is because use of standard exercise equipment may be challenging for some people after stroke depending on physical and cognitive abilities [65]. A suitable accessible physical space and appropriate environment were factors reported by exercise professionals and healthcare professionals [51,53]. Depending on patients' physical and cognitive abilities, specialist stroke or additional staff may also be required during the delivery of the intervention [57,66]. The potential number of professionals involved in implementation added to the complexity [37,61], with Miller et al (2017) [61] advocating an interdisciplinary approach to ensure success. Screening to determine whether aerobic exercise should be prescribed to an individual and its required resources also added to the complexity [37].

The potential cost of providing necessary extra resources was also identified as a factor, for example, concerns of self-employed fitness instructors about the source of funding for training in stroke [51,65] and funds to sustain a community-based exercise programme [53].

Outer Setting

The needs of the patients and networking between organisations were factors in the '*outer setting*'.

Concerns about the varied physical and cognitive needs and comorbidities of the patients and the impact of this on ability to participate in aerobic exercise were reported by physiotherapists [37,38,50,54]. To maintain patient safety, exercise professionals perceived that greater levels of supervision may be required, as well as adaptive equipment [51,61,65]. Physiotherapists perceived that the patient may be at risk of a cardiac event during the intervention [37,50], and, amongst exercise professionals, there was a fear of making the patient worse [51] . One UK study [66] noted social and cultural barriers to implementation of aerobic exercise whilst health care professionals in Canada noted language skills as a barrier [52]. Accessibility to, and inclusivity of services varied depending partly on how ambulatory the patient was and how complex their needs were [53,56]. An example of this was in Exercise after Stroke services in Scotland where there was a greater provision for ambulatory stroke survivors rather than those with complex disabilities [56].

The rehabilitation goals and motivation of the patients were found to be an area of conflicting opinion. Physiotherapists reported that aerobic fitness was not identified as a patient goal [38] and some healthcare professionals (physiotherapists, kinesiologists, physicians and nurses) [52,59] reported that patients were perceived to have a lack of motivation, whereas conversely, cardiac rehabilitation and stroke teams reported that patients were generally motivated after stroke [66].

The development of networking and skill-sharing between organisations can facilitate implementation. Examples of this include liaison between physiotherapists and fitness instructors during patients' transition from the health service to exercise on prescription in leisure centres in the UK [51,65] and in a healthcare-recreation partnership involving delivery of exercise programmes in community centres in Canada [53]. In contrast, American

outpatient physiotherapists reported a lack of knowledge regarding suitable community-based exercise programmes for people post-stroke [38].

Inner Setting

Staff recognised that there is a definite need for sufficient resources including staff, training, equipment and space, as well as accessibility to appropriate screening and exercise testing to implement aerobic exercise within the stroke population. A culture of communication and collaboration within organisations would aid the sharing of knowledge between professions and services, facilitate methods of onward referral to other services and work to ascertain how the intervention would fit into the individuals' role and responsibilities. The "Together in Movement and Exercise" [67] collaboration is an example of knowledge-sharing between physiotherapists and fitness instructors which facilitates implementation of exercise programmes but which still faces challenges to sustaining collaboration and communication between the organisations involved [53].

There was an acknowledgement amongst physiotherapists [37,38] that aerobic exercise after stroke is desirable, even amongst those who were not currently providing this. Exercise professionals [51], physiotherapists[50] and cardiac and stroke rehabilitation teams [66] displayed a willingness to engage with the intervention through training, one example being physiotherapists providing training on stroke to fitness instructors within the Exercise on Prescription setting [65]. The perceived need for further information, knowledge and training about stroke was strongly expressed by physiotherapists, exercise professionals, rehabilitation clinicians and fitness instructors [50,51,56,61,64-66]. Exercise professionals were interested in training on safety, the physical and cognitive aspects of stroke, adaptive exercise and equipment and communication [51] and physiotherapists wanted to improve their skills to incorporate aerobic exercise into stroke rehabilitation [50]. The need for

suitable equipment was a recurring factor amongst these same staff groups; one study noted that standard exercise equipment may not be appropriate for some patients and led to physiotherapists referring only more able patients to gyms [65]. A lack of time to incorporate the intervention into their practice was cited by physiotherapists [38,50] and exercise professionals [51].

The structural characteristics of the organisation referred to in the literature included the organisation of the service and staffing as well as service provision for people post-stroke and the geographical areas covered by these services. For example, in Scotland the reported number of Exercise after Stroke services only equates to less than one per 7000 stroke survivors [56]. Provision of funding for specialist training and professional certification was an identified incentive for exercise professionals [51,65] to implement the intervention. Another factor was funding models which influenced organisations' service provision [55,63].

Characteristics of Individuals

The individuals' knowledge and beliefs about the intervention played an important role in implementation. Their self-efficacy (a person's belief in their own ability to carry out courses of action to achieve goals) and other personal attributes influenced how likely they were to prescribe aerobic exercise.

It was generally agreed by physiotherapists that aerobic exercise was important and should be prescribed post-stroke [37,38,50] although not all exercise professionals [65] or physiotherapists [37,38] possessed factual knowledge about the intervention in relation to screening, prescription and guidelines. A fear of liability and of making the patients worse was identified as a barrier amongst some exercise professionals, especially those who lacked training on stroke [51], whereas potential cardiovascular risk to the patient was a barrier for

physiotherapists in two Canadian studies [37,50]. Concerns about the ability [37] and motivation [59] of their patients to participate in aerobic exercise after stroke were raised by physiotherapists, and nurses, allied health professionals and medical staff respectively. Some physiotherapists and exercise professionals expressed confidence in their own ability to prescribe the intervention for people post-stroke whilst others did not [38,66].

Physiotherapists and exercise professionals displayed a willingness and interest in learning and in improving their skills to facilitate implementation [50,51]. For example, exercise professionals identified a need for training on psychological problems post-stroke [51]. Exercise professionals agreed that stroke-specific training would lead to improvements in safety [51] and even those with experience of working with people with stroke reported that further training would be of benefit [65].

Non-Consolidated Framework for Implementation nodes

These nodes, for example, '*content of aerobic exercise'*, created during data extraction were identified as descriptors rather than findings.

Discussion

The main factors perceived by staff as influencing the implementation of aerobic exercise post-stroke were staff self-efficacy, their beliefs about the intervention and their patients' needs, and system-level issues relating to staffing, resources, knowledge and training. Twenty studies were identified, predominantly from a North American and physiotherapists' perspective, with 25% (n=4) exploring the implementation of aerobic exercise post-stroke. The remaining studies (n=16) involved implementation of other exercise interventions after stroke under this review's broad definition of aerobic exercise.

The quality of a review relies on the data reported within the primary studies [68]. A lack of comprehensibility in the exercise intervention descriptions in sixteen of the studies led to difficulties in ascertaining whether aerobic exercise was included. Improved reporting which clarified the intervention would have eliminated the need to adopt a broad definition of aerobic exercise for this review [69]. Similar reporting challenges were found with respect to detail regarding staff and setting. Initiatives such as the template for intervention description and replication (TIDieR) checklist [70], which has been developed as a template for intervention description and replication in response to the poor quality in reporting of interventions, may help overcome some of these issues for future reviews.

The Consolidated Framework for Implementation Research had been used successfully and meaningfully in other areas [71] but not in the context of exercise implementation within stroke services. A systematic review of use of this framework reported that it has mostly been used retrospectively in the post-implementation phase [71]. The advantages of using this framework prior to intervention implementation include the identification of potential barriers, appropriate selection of implementation strategy and adaptation of the strategy to maximise likelihood of success [71]. The information identified in this review regarding the potential barriers to implementing aerobic exercise after stroke can be used to facilitate the steps to successful implementation and inform the direction of future research.

The factors identified are not unique to the implementation of exercise in the stroke context [72-75]. Similar factors including patient needs, staff knowledge and beliefs and resources have been identified within rheumatology, weight management and implementation of evidence-based practices in healthcare [72,74,75]. As such, these factors may be relevant to other long-term conditions in the context of multi-morbidities.

Factors such as staffing, equipment, training and staff self-efficacy are potentially modifiable depending on the specific individual settings, staffing profiles, knowledge, experience and support within the broad range of staff groups. Criteria such as APEASE (Acceptability, Practicability, Effectiveness/cost-effectiveness, Affordability, Safety/side-effects, Equity) [76], which were developed for use with behaviour change interventions, may provide a starting point for prioritising which modifiable factor(s) to target. These criteria indicate that factors around affordability, practicability, effectiveness and cost-effectiveness, acceptability, side-effects/safety and equity should be considered when designing or evaluation interventions. Aerobic exercise is a proven effective intervention after stroke, however, its effectiveness is irrelevant if it cannot be afforded, implemented as designed or by the appropriate professionals, or if it is not accepted by staff and people post-stroke.

Physiotherapists and exercise professionals in this review reported a need for knowledge and training on stroke and appropriate exercise interventions. There are links between staff beliefs and knowledge which have a subsequent influence on implementation [77,78]. Van Kessel et al [78] found that physiotherapists' knowledge and beliefs influenced their implementation of circuit classes and seven-day therapy in stroke rehabilitation. However, changing behaviour is complex and education in isolation is likely to be ineffective [79]. Other strategies must therefore be considered, such as provision of support for staff through facilitation, tailoring of strategies to staff groups and settings and use of care pathways or a combination of these [79].

Successful implementation of interventions requires sufficient resources to address the needs of a population [74]. Increasing demands on resources within current systems mean that alternative mechanisms of delivery of interventions need to be explored. This could

include, for example, resource reallocation or skill-sharing amongst colleagues both within and between organisations.

There is also a lack of clarity as to whose role it is to initiate and implement change. This is likely to vary from one setting and staff group to the next. This review identifies the involvement of a range of staff from budget holders and senior managers to staff delivering the intervention. Changes are often led by clinicians [73] and there is evidence that middle management [80], leadership engagement and collaboration between organisations are important for successful implementation [74]. One possible means of facilitating this process is via co-production where stakeholders work collaboratively to facilitate service re-design [62].

Factors influencing implementation as perceived by staff have been identified in this review, some of which, such as knowledge and self-efficacy could be modified. To facilitate the complex process of implementation of aerobic exercise after stroke, further research should evaluate strategies which target these modifiable factors. Recent research aiming to assist with appropriate selection of theories and frameworks to plan and guide implementation could be used [81-83]. The cost of modifying and sustaining these changes should also be investigated due to the overlapping of health and leisure organisations and the continuous state of flux of health and political systems.

Strengths and Limitations

There were several limitations to this review. These included the low number of full-text studies (n=11), the predominance of healthcare professionals' views, geographical coverage limited to the three continents of North America, Europe and Australia and limiting the language to articles in English. Aerobic exercise was expressly reported as the intervention in just four studies, all of which were North American. These factors potentially limit the generalisability of the findings and highlight the shortfall in research in this area.

The use of automated screening with the Rayyan app [42] enhanced the screening process. This efficient, accurate, user-friendly addition to manual screening, which could be used as an alternative to this, also has the benefit of free availability. In future, the option of using automated screening as a tool for enhanced screening during systematic reviewing should be considered.

A further strength of this review involved the use of an implementation framework. This ensured a comprehensive, structured and consistent approach to considering the factors influencing implementation.

Conclusion

This is the first systematic review to explore the factors that staff identified as influencing implementation of aerobic exercise after stroke. Characteristics of staff (self-efficacy, beliefs about the intervention and their patients' needs) and system-level issues (staffing, resources and training) were identified as key factors. Factors such as knowledge, training and beliefs are modifiable. Further research should evaluate strategies which specifically target these modifiable factors to facilitate implementation in practice.

Accompanying statements

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Tables

Table 1: Consolidated Framework for Implementation Research Constructs from The Consolidated Framework for Implementation Research [internet]. Michigan; 2019. [Cited 04/04/2019]. Available from: https://cfirguide.org/constructs/

Consolidated Framework for Implementation Research Constructs		
CFIR Website		
Construct		**Short Description**
I. INTERVENTION CHARACTERISTICS		
A	Intervention Source	Perception of key stakeholders about whether the intervention is externally or internally developed.
B	Evidence Strength & Quality	Stakeholders' perceptions of the quality and validity of evidence supporting the belief that the intervention will have desired outcomes.
C	Relative Advantage	Stakeholders' perception of the advantage of implementing the intervention versus an alternative solution.
D	Adaptability	The degree to which an intervention can be adapted, tailored, refined, or reinvented to meet local needs.
E	Trialability	The ability to test the intervention on a small scale in the organization, and to be able to reverse course (undo implementation) if warranted.
F	Complexity	Perceived difficulty of implementation, reflected by duration, scope, radicalness, disruptiveness, centrality, and intricacy and number of steps required to implement.
G	Design Quality & Packaging	Perceived excellence in how the intervention is bundled, presented, and assembled.
H	Cost	Costs of the intervention and costs associated with implementing the intervention including investment, supply, and opportunity costs.
II. OUTER SETTING		
A	Patient Needs & Resources	The extent to which patient needs, as well as barriers and facilitators to meet those needs, are accurately known and prioritized by the organization.

B	Cosmopolitanism	The degree to which an organization is networked with other external organizations.
C	Peer Pressure	Mimetic or competitive pressure to implement an intervention; typically because most or other key peer or competing organizations have already implemented or are in a bid for a competitive edge.
D	External Policy & Incentives	A broad construct that includes external strategies to spread interventions, including policy and regulations (governmental or other central entity), external mandates, recommendations and guidelines, pay-for-performance, collaboratives, and public or benchmark reporting.
III. INNER SETTING		
A	Structural Characteristics	The social architecture, age, maturity, and size of an organization.
B	Networks & Communications	The nature and quality of webs of social networks and the nature and quality of formal and informal communications within an organization.
C	Culture	Norms, values, and basic assumptions of a given organization.
D	Implementation Climate	The absorptive capacity for change, shared receptivity of involved individuals to an intervention, and the extent to which use of that intervention will be rewarded, supported, and expected within their organization.
1	Tension for Change	The degree to which stakeholders perceive the current situation as intolerable or needing change.
2	Compatibility	The degree of tangible fit between meaning and values attached to the intervention by involved individuals, how those align with individuals' own norms, values, and perceived risks and needs, and how the intervention fits with existing workflows and systems.
3	Relative Priority	Individuals' shared perception of the importance of the implementation within the organization.
4	Organizational Incentives & Rewards	Extrinsic incentives such as goal-sharing awards, performance reviews, promotions, and raises in salary, and less tangible incentives such as increased stature or respect.
5	Goals and Feedback	The degree to which goals are clearly communicated, acted upon, and fed back to staff, and alignment of that feedback with goals.
6	Learning Climate	A climate in which: a) leaders express their own fallibility and need for team members' assistance and input; b) team members feel that they are essential, valued, and knowledgeable partners in the change process; c) individuals feel psychologically safe to try new methods; and d) there is sufficient time and space for reflective thinking and evaluation.

E	Readiness for Implementation	Tangible and immediate indicators of organizational commitment to its decision to implement an intervention.
1	Leadership Engagement	Commitment, involvement, and accountability of leaders and managers with the implementation.
2	Available Resources	The level of resources dedicated for implementation and on-going operations, including money, training, education, physical space, and time.
3	Access to Knowledge & Information	Ease of access to digestible information and knowledge about the intervention and how to incorporate it into work tasks.
IV. CHARACTERISTICS OF INDIVIDUALS		
A	Knowledge & Beliefs about the Intervention	Individuals' attitudes toward and value placed on the intervention as well as familiarity with facts, truths, and principles related to the intervention.
B	Self-efficacy	Individual belief in their own capabilities to execute courses of action to achieve implementation goals.
C	Individual Stage of Change	Characterization of the phase an individual is in, as he or she progresses toward skilled, enthusiastic, and sustained use of the intervention.
D	Individual Identification with Organization	A broad construct related to how individuals perceive the organization, and their relationship and degree of commitment with that organization.
E	Other Personal Attributes	A broad construct to include other personal traits such as tolerance of ambiguity, intellectual ability, motivation, values, competence, capacity, and learning style.
V. PROCESS		
A	Planning	The degree to which a scheme or method of behavior and tasks for implementing an intervention are developed in advance, and the quality of those schemes or methods.
B	Engaging	Attracting and involving appropriate individuals in the implementation and use of the intervention through a combined strategy of social marketing, education, role modeling, training, and other similar activities.
1	Opinion Leaders	Individuals in an organization who have formal or informal influence on the attitudes and beliefs of their colleagues with respect to implementing the intervention.
2	Formally Appointed Internal Implementation Leaders	Individuals from within the organization who have been formally appointed with responsibility for implementing an intervention as coordinator, project manager, team leader, or other similar role.

3	Champions	“Individuals who dedicate themselves to supporting, marketing, and ‘driving through’ an [implementation]” [101] (p. 182), overcoming indifference or resistance that the intervention may provoke in an organization.
4	External Change Agents	Individuals who are affiliated with an outside entity who formally influence or facilitate intervention decisions in a desirable direction.
C	Executing	Carrying out or accomplishing the implementation according to plan.
D	Reflecting & Evaluating	Quantitative and qualitative feedback about the progress and quality of implementation accompanied with regular personal and team debriefing about progress and experience.

Table 2: Summary of Included Studies

Author, year, country	Design	Setting	Population & Participant Characteristics	Methods	Results
*Ali et al, 2018 [62]; United Kingdom	Workshops	Not reported	30-40 stakeholders including stroke survivors, carers, therapists, exercise professionals, doctors, social services, commissioners, the voluntary and private sector.	Double diamond approach for 2 workshops co-facilitated by a multidisciplinary team and 2 designers aiming to promote exercise post-stroke. Data analysed thematically.	Key themes identified: - a variation in information exchange amongst patients & clinicians - a need to integrate exercise & rehabilitation and for support to access services 3 main barriers: - Lack of access to information, accessibility and infrastructure
*Axelson et al, 2014 [49]; Canada	Development and implementation of aerobic fitness programme in sub-acute post-stroke rehabilitation guided by a literature review.	Neuro-Rehabilitation Unit	People post-stroke and clinicians delivering aerobic exercise to this population. Number of participants not stated	Development of an Aerobic Fitness Programme for subacute post-stroke rehabilitation guided by a literature review and based on 'The Aerobic Exercise Recommendations to Optimize Best Practices Care after Stroke'	Challenges: Patients' cognitive & physical abilities, comorbidities - exercise testing and intensity monitoring - incorporation into schedules

				(Mackay-Lyons et al 2013)	
Best et al, 2012 [56]; United Kingdom (Scotland)	Scoping study - internet survey & interviews	Health service, leisure services and stroke charities	Service providers: 45 Health boards, 61 local authorities, 105 private gyms 19 charities	Survey on models of community-based Exercise after stroke services & how these meet needs of people post-stroke. Interviews conducted to complete data.	230 survey responses + 14 interviews. 14 Exercise After Stroke services identified: 12 Stroke-specific services run by health services, leisure centres & charities; 2 Multipathology services: by collaboration between health and leisure services. Service capacity in terms of safety, effectiveness and sustainability.
Boyne et al, 2017 [38]; USA	Cross-sectional web-based survey study	Primary practice settings of acute care, home health, inpatient rehabilitation, extended care or outpatient rehabilitation in 5 US states	1212 Physical Therapists (actively licensed) including a subset of 568 currently working in clinical practice and stroke rehabilitation whose responses were focused upon in the analysis	Survey to assess aerobic exercise prescription for people post-stroke was emailed to physical therapists.	Aerobic exercise important post-stroke & majority able to prescribe. *Barriers:* Patients' physical & cognitive abilities, motivation Knowledge about exercise intensity Confidence Safety – screening, adverse effects short length of stay, Lack of equipment & time.
*Clague-Baker et al, 2015 [66]; United Kingdom	Qualitative interpretive with focus groups	Cardiac rehabilitation (CR) and stroke rehabilitation	CR and stroke teams Number of participants not given	Investigated attitudes of CR & stroke teams to people post-stroke participating in CR. Conducted 7 focus	Four main themes identified as factors affecting implementation of CR post-stroke:

				groups prior to stroke patients participating in CR & 5 focus groups after participation. Data analysed thematically.	1) Confidence in delivering the service 2) Stroke and exercise 3) Lack of knowledge 4) Cardiac adaptations
Condon and Guidon, 2018 [51] ; Ireland	Cross-sectional descriptive study using an online survey.	Community - various	87 Exercise Professionals (EPs) (31% response rate) registered with the Register of Exercise Professionals (REPs) in Ireland. Median of 5 years' experience, n=19 had experience with people post-stroke. 40% based in gyms, 36% in for-profit exercise facilities**.** 25% received training on stroke as part of EP training with 17% completing CPD on stroke post-qualification.	Researcher-designed survey used to investigate the opinions of EPs on working with people post-stroke. This included rating barriers and facilitators, quantifying experience & skills and exploring how training related to the barriers and facilitators. Survey link emailed to eligible REPS members by REPs. Calculation of descriptive statistics using IBM SPSS 22.0.	Most were interested in working with people post-stroke. **Barriers:** - training, equipment, safety and cost of staffing **Facilitators:** - training, professional certification and funding for this, - equipment, environment, - liaison between physiotherapists and EPs.
Desveaux et al, 2016 [52]; Canada	Quantitative study using a cross-sectional design using a patient-barriers questionnaire	Hospital-based rehabilitation facilities	35 health care professionals (HCPs): 19 physiotherapists 10 kinesiologists 6 physicians 83 patients with multimorbidities including stroke	Barriers to physical activity post-rehabilitation explored via modified version of the Cardiac Rehabilitation Barriers Scale (CRBS) completed by patients with heart failure, stroke, diabetes & COPD and by HCPs	**Barriers perceived by HCPs:** Travel time lack of motivation cost severity of symptoms **Facilitators:** Referral from HCP Facilitated transition to the programme.

				working with these populations. Questionnaires delivered via 1:1 interviews, face-to-face apart from 5 via phone. Perceived barriers to participation in community-based exercise were evaluated quantitively.	**Suggested solutions:** Reduced rehabilitation-to-community transition time. Transportation strategy Accessible and supportive community environment.
*Diehl et al, 2017 [54]; USA	Pilot, non-experimental descriptive study using anonymous surveys	Healthcare, exact setting not given	31 Indiana-based physical therapists with 50% practice time spent with people with sub-acute CVA	To explore the familiarity with and understanding of the use of high intensity interval training (HIIT) in CVA rehabilitation and barriers to implementation of HIIT	16.1% reported using HIIT in practice Barriers: - 51.8% inadequate understanding of HIIT - 48.1% patient comorbidities - 77.8% unable to perform exercise testing - 48.1% lack of access to support personnel
Doyle et al, 2013 [37]; Canada	Quantitative cross-sectional web-based survey study	Rehabilitation centres, Public/private outpatient clinic, Community/home Stroke unit, General hospital ward	155 Physical therapists practicing adult neurorehabilitation (Response rate 36%)	Electronically distributed Survey regarding use of aerobic exercise (AEx) in clinical practice for neurological populations including stroke. Closed questions (profile, screening,	Most agreed AEx should be part of treatment programs for neurological population & prescribed AEx in their practice. **Barriers**: - safety, patients' inability to participate - resources (staffing, training, screening tools, knowledge),

				prescription and implementation AEx)	-role of AEx in neurorehabilitation. - lack of availability of exercise stress test but few said test was essential for safety
*Eng et al, 2015 [58]; Australia	Pilot study - 1:1 interviews and focus groups	Tertiary metropolitan hospital	20 Clinical staff (professions not stated) 7 People post-stroke who were inpatients 6 main carers	Explored factors affecting people post-stroke performing inpatient independent therapeutic practice outside therapy time. Interviews with people post-stroke & their main carer. 2 focus groups with clinical staff. Data analysed thematically.	**Barriers**: Majority of time outside therapy spent dealing with loss caused by stroke. Differences in patient and staff perceptions of key motivation for rehabilitation. **Facilitators:** - accessible exercise equipment, - private space for structured therapy homework, - simulated real world engagement
Fullerton et al, 2008 [55]; Canada	Descriptive cross-sectional study with survey/questionnaire	Fitness facilities (community-based) in Greater Toronto Area	213 analysed after exclusions. Of the 213, 105 were from for-profit organizations, 56 from government-sponsored agencies, 44 from non-profit and 8 did not identify funding model. Range of health care professionals employed	Exploration of characteristics & availability of fitness programs for people post-stroke via questionnaire with 5 subcategories: facilities' background, program availability and barriers, characteristics, physical and educational components & demand	Response rate 42%. Of the 213 facilities, 62 had specific programmes for people with chronic disabilities and of these, 26 had fitness programmes for people post-stroke. **Facilities with stroke-specific progs only:** All delivered aerobic exercise

				for fitness programmes for people after stroke. Completed by staff member most qualified to answer. Excluded facilities with mainly cardiac rehabilitation or hospital outpatient rehabilitation (different to community-based fitness facilities); home-exercise program provision only: education-only programs specialising in a specific skill, eg, dance or Tae Kwon Do.	85% had specific acceptance criteria, 35% were fixed lengths with 1:7 instructor-client ratio. Barriers to implementation of stroke-specific programmes: - cost, lack of qualified staff & time. **Facilities without stroke-specific programmes:** Barriers to offering stroke-specific programmes were - lack of qualified staff, - low demand & cost
*Miller et al, 2017 [61]; USA	Explorative qualitative study – focus groups and interviews	Healthcare – setting not specified	Stroke survivors, caregivers, rehabilitation clinicians, nurse practitioners and physicians. Number of participants not given.	Development of a stroke-specific cardiac rehabilitation programme using stakeholder input via separate focus groups with stroke survivors, caregivers, rehabilitation clinicians, nurse practitioners and interviews with physicians.	4 main themes: - safety - individual prescription of programme - return to function & maximise potential - long-term maintenance of activity Main components: - individualised education for SSs - exercise testing pre-exercise

				Analysis of resulting themes, patterns and issues.	- timely implementation (needs, resources, benefits), individualisation - staff training/education - interdisciplinary approach - onward referral to community/home programmes
Otterman et al, 2012 [63]; Netherlands	Descriptive survey using web-based questionnaire	Hospitals with inpatient neurological department	91 Physiotherapists practicing in acute stroke rehabilitation	4-part web-based survey used to examine physiotherapists' current practice and adherence to clinical practice guidelines for patients with stroke at acute hospital stroke units, the 4th part of which had questions regarding the barriers and facilitators for start of mobilisation and time dedicated to exercise therapy.	95% response rate **Barriers to adherence to guidelines**: - time, cooperation by colleagues, professional characteristics, flexibility, applicability and belief. **Barriers for early mobilisation and exercise therapy** were mainly patients' health status and policy & funding of the organisation.
Prout et al, 2016 [50]; Canada	Prospective cross-sectional study with survey and literature review	Three Hospital-based rehabilitation centres – with and without structured AEx programme as part of inpatient stroke rehab	16 Physiotherapists actively practising in inpatient acute stroke rehabilitation	A questionnaire to identify physiotherapists' perceptions of people post-stroke, the practice environment and training on aerobic exercise post-stroke was administered via face-to-face interview	Most agreed aerobic exercise is essential part of inpatient stroke rehabilitation. All willing to upskill to incorporate aerobic exercise into their practice. Site with aerobic exercise programme had more equipment available for

				by member of research team; A literature review was conducted on potential barriers to physical activity and aerobic exercise for healthcare providers and people post-stroke. Comparisons made between rehabilitation centre with aerobic exercise program and the two without.	equipment for exercise testing & training, screening & monitoring **Main barriers** At facilities with aerobic exercise programs: - cardiovascular risk and cognitive impairment, - lack of time in the session At facilities without aerobic exercise program: - physical impairment, - lack of necessary resources and - lack of support staff. Fatigue was common barrier at both.
Salbach, et al 2015 [53]; Canada	Mixed methods including a 1-day stakeholder meeting and online survey	Academic, healthcare and recreation centre settings	53 multidisciplinary and multi-professional participants working within academia, healthcare and recreation, of whom; n=40 discussed challenges/solutions (7 healthcare professionals, 9 healthcare system representatives, 11 fitness instructors,9 recreation managers, 3 researchers, 1 ex participant), n=42 rated priorities	A 1-day meeting with community-based exercise programme ("Together in Movement and Exercise") stakeholders and subsequent completion of an online survey to identify challenges and solutions to implementation of this programme model.	**Challenges – 7 themes:** - resources (staff, space, equipment, training) - marketing of programme to ↑ uptake - transportation to programme (cost) - accessibility (availability, appropriateness) - maintenance of programme integrity - sustaining communication & collaboration between organisations & services

			n=17 completed online questionnaire		- Funding (staff, equipment, training)
*Stewart et al 2017 [59]; Australia	Qualitative- focus groups	Rehabilitation unit	Multidisciplinary: 11 nurses 8 AHPs 2 medical staff	5 multidisciplinary focus groups conducted to explore factors influencing implementation of practice books & nurse-led weekend classes which aimed to increase practice by inpatient stroke patients. Analysed using framework analysis and the Theoretical Domains Framework. Barriers mapped to behaviour change interventions using Behaviour Change Wheel framework.	**Barriers:** - staff beliefs about patient motivation to participate in rehabilitation, - ward environment - resources - ability of staff to motivate & supervise active practice.
Tang et al, 2009 [57]; Canada	Survey via email, phone, fax or post. Retrospective database review.	Cardiac Rehabilitation programmes' facilities	40 Cardiac rehabilitation (CR) programmes	Two-part study to identify the potential opportunity and effectiveness of CR for people post-stroke using: 1) Questionnaire/survey containing multiple choice questions (on	40 responses analysed - 24 accepting people post-stroke. - of these 14 had no specific stroke-related restrictions to program eligibility. - remaining 10 facilities accepted people with 2^{o} diagnosis of stroke and/or

				programme use) and open-ended questions (barriers to enrolment) 2) Retrospective database review to compare effects of CR for people with 1° diagnoses of TIA/stroke with those with 2° diagnosis TIA/stroke with those cardiac diagnoses only	those with mild or moderate impairments only. Reasons for exclusion from programs: - impaired walking - cognitive or communication ability. Some adaptation to accommodate people post-stroke (equipment, staffing, individual exercise prescription) provided by 16 facilities
*Waters et al 2014 [64]; Australia	Qualitative study. Semi-structured interviews and focus groups	Rehabilitation facilities - one rehabilitation and one acute care	14 Physiotherapists: 8 at rehabilitation facility and 6 at acute care facility	Focus groups (using semi-structured questions) were conducted to explore perceptions about treadmill training during inpatient stroke rehabilitation. These were recorded, transcribed, coded and analysed thematically.	**Themes:** Treadmill training potentially beneficial for function & early walking practice. Mixed perceptions on walking quality/normal gait pattern. **Factors influencing use of treadmill:** - patient comorbidities & ability - safety & resources - culture & organisation - access to training - encouragement
Wiles et al, 2008 [65]; United Kingdom	Qualitative methodology:	Exercise on Prescription (EoP) schemes in leisure	9 People post-stroke participating in EoP schemes.	Fitness instructors', physiotherapists' and patients' perspectives	Most patients referred to EoP were men. **Main themes:**

	Focus groups and interviews	centres in urban, rural and suburban areas	6 Fitness instructors running the schemes including one scheme coordinator 15 Physiotherapists who can refer patients to these schemes.	about EoP schemes for people post-stroke explored through interviews with the stroke patients, fitness instructors and two of the physiotherapists and focus groups with 13 of the physiotherapists.	- Method of continuing with physiotherapy post-discharge from NHS - safety (knowledge, training about stroke, equipment, patient ability). - supervision, support and interaction during participation - collaboration between fitness instructors and physiotherapists, **Barrier**: training and funding Comparison of patients' perceptions with those of physiotherapists and fitness instructors.
*Zinger et al, 2011 [60]; Netherlands	Questionnaire	Rehabilitation facilities- hospitals, rehabilitation centres and nursing homes	186 Team members of the rehabilitation facilities	Exercise guide to increase exercise intensity for people post-stroke was developed with therapists and rehabilitation facility team members regarding content, format and implementation.	Decision to create 2 versions: 1) Ready-to-use version categorising exercise levels for hospital use 2) Customisable version for individual exercise prescription for use in nursing homes and rehabilitation centres.

1

2 *abstract only

Table 3: Factors Identified as Influencing the Implementation of Aerobic Exercise in Stroke

INTERVENTION CHARACTERISTICS	
Adaptability	- Exercise can be adapted for stroke patients needs through equipment, changing the environment, and presence of specialist or additional staff [49,51,53,57,60,61,63,66]
Complexity	- The steps required prior to implementation (screening) [37,54,61,63,66] - The number of (potential) professionals involve [37,52,55,61,66]
Design Quality & Packaging	- Prescriptiveness and format of the aerobic exercise influences if and how it is implemented[60,63]
Cost	- Costs for implementation includes staff, training, equipment and environment [51,53,55,62,65]
OUTER SETTING	
Patient Needs & Resources	- Physical and cognitive needs, safety and perceived risk to the patient [37,38,49-52,54-60,63-66] - Social and cultural factors [37,66] - Accessibility of services [38,52,53,55,56,62]
Cosmopolitanism	- Networking and skill-sharing between organisations, such as between physiotherapists and fitness instructors [51,53,65]
INNER SETTING	
Structural Characteristics	- Service organisation and staffing [37,38,53,55,61,64] - Geographical coverage of services [52,56] - Funding models [55,63] - Service provision for the stroke population [55-57,63]

Networks & Communications	- Communication and collaboration between professionals within organisations [53,56,63] 1
Compatibility	- How implementation fits within the individuals' role, responsibilities and workflow and the method for onward referral to other services or professionals [37,38,49,51,53,63,65,66]
Relative Priority	-Perceived as desirable with an identified willingness to facilitate through training, [55,65] e.g. physios providing training on stroke to fitness instructors in the Exercise on Prescription setting.
Organizational Incentives & Rewards	- Provision of funding for training and professional certification in the area of stroke for exercise professionals would be an incentive. [51,63,65]
Available Resources	- Available resources included staff, training, equipment, physical space, accessibility to screening and exercise testing and funding for these. [37,38,49-53,55-59,61-63,65,66]
Access to Knowledge & Information	- Communication within organisations and knowledge-sharing between both professionals and services [38,51,54,56,64,66].
CHARACTERISTICS OF INDIVIDUALS	
Knowledge & Beliefs about the Intervention	- Generally agreed that aerobic exercise was important and should be prescribed post-stroke [37,38,50,57,59,64,65] - Not all staff possessed factual knowledge about the intervention [38,50,51,54,57,65] - Concerns about their patients' ability and motivation to participate in aerobic exercise [37,38,52,58-60,65]
Self-efficacy	- Individuals' confidence in their abilities to prescribe aerobic exercise to people post-stroke varied [38,50,51,56,59,65,66] - Some fears of liability or making the patient worse [51,64]
Other Personal Attributes	- Individuals displayed an interest and willingness to upskill in order to implement aerobic exercise for this population [50,51,55,56,65,66]

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