



Resistance Training as a Countermeasure for Key Non-communicable Diseases in Low-Resource Settings: A Review

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Abstract

Background: Non-communicable diseases (NCDs) are responsible for 60% of global deaths. Of these NCD-attributable deaths, about 80% are in low- to middle-income countries (LMICs). The role of exercise in major NCDs is evident; however, popular and cost-effective aerobic modes of exercise, such as walking, consistently do not meet minimum intensity guidelines for health improvement. Interestingly, low-cost resistance training (using callisthenics, Pilates, elastic tubing, etc.) has proven equally effective to conventional resistance training using weight machines in improving several health parameters related to NCDs, although their effectiveness in LMICs is not as well documented as in high-income countries (HICs).

Objectives: This review aimed to examine low-cost approaches of resistance training to health promotion, NCD risk reduction, and NCD rehabilitation/management to mitigate the epidemic of NCDs in lower-resource settings.

Methods: An electronic search was performed on the following databases from inception until December 2019: PubMed/Medline, Sport Discuss, Embase, Science Direct, Current Contents, CISTI Source, Google Scholar, Cochrane Library, Cochrane Database of Systematic Reviews, CINAHL EBM Reviews, and international e-catalogues.

Results: Data on resistance training provision cost in low-resource settings indicates that it is not reasonable to use this mode of training in low-resource settings in the same way as it is used in high-resource ones. This review summarized some strategies which can be employed to ensure the delivery of all core resistance training components in low-resource settings. The data suggests that resistance training be adapted for delivery in non-clinical settings in LMICs.

Conclusions: Program design variables of resistance training are similar in low- and well-resourced settings. However, only individuals with low-risk will be able to perform exercise without adverse consequences in home-based settings. Health care practitioners in LMICs should take an active role in promoting resistance training when promoting health, reducing NCD risk, and NCD rehabilitation.

Keywords: Diseases of Lifestyle, Hypokinetic Disease, Inactivity, Strength Training, Weight Training

1. Background

Non-communicable diseases (NCDs) are responsible for 60% of global deaths and affect individuals of all ages, nationalities, and classes (1). These diseases may be chronic or acute and include most cardiovascular diseases (CVDs), cerebrovascular attacks (CVAs), diabetes, most cancers, autoimmune diseases, neurological disorders, such as Parkinson's disease and Alzheimer's disease, skeletal disorders, such as osteoarthritis and osteoporosis, chronic kidney disease, cataracts, and other conditions and diseases (2). The mortality from NCDs, and specifically, the major CVDs (CVA, hypertension), metabolic diseases (obesity, diabetes), and lung diseases (COPD), is double that of a combination of infectious diseases (including tuberculosis (TB), malaria, and human immunodeficiency virus infec-

tion/acquired immune deficiency syndrome (HIV/AIDS)), maternal and perinatal conditions, and nutritional deficiencies (3). The significance of NCD reduction has further been stressed with the recent rise of the novel coronavirus COVID-19 pandemic that mainly resulted in the deaths of those with pre-existing NCDs. The major pre-existing conditions (comorbidities) resulting in death in individuals infected with COVID-19 are/were the main NCDs, namely (in descending order of contribution to mortality); cardiovascular disease, diabetes, chronic respiratory disease, hypertension, followed by cancer (4, 5).

Moreover, while the prevention of morbidity and mortality from NCDs gets scant consideration in Sub-Saharan Africa and worldwide, the massive mobilization of resources for the HIV/AIDS response has been unmatched in the history of public health (3). Even in low- to middle-

income countries (LMIC), US\$19.1 billion (57% from domestic resources) was made available for the HIV/AIDS response in LMICs in 2016 (6). Of the 35 million deaths associated with NCDs annually, approximately 80% are in LMICs (1) and in low-resource settings, such as South Africa (7). These NCDs exert a considerable effect on individuals and healthcare structures (1), and in most cases, it is the economically-productive workforce that is affected by these NCDs (8).

Fortunately, NCDs are largely preventable (9) and research is unequivocal that NCD mortality and morbidity can be limited through appropriate public health strategies focusing on the control of risk factors (10). The rise of NCDs has been driven by primarily three modifiable, and thus preventable, risk factors, namely, physical inactivity, unhealthy diets, and tobacco use (8). Specifically, evidence has demonstrated that almost 80% of premature deaths from CVD, CVA, and diabetes can be avoided with already established pharmaceutical and behavioral intercessions (8). However, to lessen the impact of NCDs on individuals, societies, and health systems, a comprehensive approach is needed. Problematically, while there has been considerable application of expensive interventions in many LMICs, evidence suggests that already proven, low-cost prevention strategies, such as exercise rehabilitation, are not being employed (11). Despite the World Health Organization (WHO) publishing a seminal report in 1993 entitled 'Rehabilitation after cardiovascular diseases, with special emphasis on developing countries', recommending how exercise interventions could be provided in low-resource settings (12), formalized exercise rehabilitation is only available in approximately one-tenth of low-income countries (LICs) and one-quarter of medium-income countries (MICs) (13). While the reasons for the lack of availability of formalized exercise rehabilitation settings are complex, some reasons include the scarcity of randomized trials examining exercise rehabilitation in LMICs (14), and the lack of strategies regarding the optimal implementation of exercise for disease prevention in low-resource settings (12).

Exercise rehabilitation as an approach to health promotion, NCD risk reduction, and NCD rehabilitation/management has almost exclusively focused on cardiorespiratory forms of exercise (15). In this regard, walking continues to be the touchstone when prescribing programs for exercise rehabilitation (15). Even in LMICs, walking (either as part of the structured exercise or as active forms of transportation) and step counting for 6500 - 10000 steps per day is one of the most popular recommendations to presumably meet the recommendations to accumulate 150 minutes of physical activity per week (16, 17). This is despite this mode of exercise consistently being

demonstrated to not meet minimum intensity guidelines for health improvement (18). This is problematic in that evidence indicates that resistance training effects are equal to and sometimes superior to that of cardiorespiratory training (15). In addition, the effects on both fitness and health are enhanced when resistance training is added to cardiorespiratory training (15, 19). In addition, as demonstrated by the global lockdowns observed during the COVID-19 pandemic, significant proportions of the globe were confined to their homes where they were unable to engage in cardiorespiratory forms of exercise due to an inability to leave their homes to exercise outside, lack of space indoors and/or a lack of related personal equipment (such as treadmills, indoor/personalized pools, etc.); making resistance training a more practical solution to the continued curbing and management of NCDs.

Given the rapid increase in NCDs worldwide, it is essential to establish a safe, simple, but effective, low-cost intervention for halting the development of NCDs and their management once diagnosed, especially in low-resource settings. Thankfully, low-cost resistance training (using calisthenics, Pilates, elastic tubing, etc.) has proven equally effective to conventional resistance training using weight machines in improving several health parameters (20-23). Understanding and reporting on the successful use of resistance training in exercise settings for health promotion, NCD risk reduction, and NCD rehabilitation/management may offset the reported low uptake of resistance training in such settings and may reduce the ever-increasing morbidity and mortality associated with NCDs.

2. Objectives

This review aimed to examine low-cost approaches of resistance training to health promotion, NCD risk reduction, and NCD rehabilitation/management to mitigate the epidemic of NCDs in lower-resource settings.

3. Methods

To review the scholarly literature of resistance training as a countermeasure for key NCDs in low-resource settings, an electronic search was performed on the following databases from inception until December 2019: PubMed/Medline, Sport Discuss, Embase, Science Direct, Current Contents, CISTI Source, Google Scholar, Cochrane Library, Cochrane Database of Systematic Reviews, CINAHL EBM Reviews, and international e-catalogues. A keyword search yielded MeSH headings: "Resistance Training and Non-Communicable Disease", "Weight Training and

Non-Communicable Disease”, “Strength Training and Non-Communicable Disease”, “Diseases of Lifestyle”, “Hypokinetic Disease”, “Inactivity”, “Strength Training and Health”, “Weight Training and Health” which were combined and explored. Searches were restricted to peer-reviewed articles in the English language. Original articles were identified and grouped for discussion. Recommendations were advanced based on articles where evidence in a low-resource setting was forthcoming. Data were extracted in a standardized manner using two independent investigators.

4. Results

The electronic searches yielded 617 citations, and 349 after de-duplication screening. Further screening of titles and abstracts yielded 162 papers for formal inclusion. Following the further removal of duplicates and review of full-text versions, a total of 70 articles remained for inclusion in this study.

5. Discussion

5.1. Resistance Training Cost and Affordability

Resistance training, as with cardiorespiratory training, can range from the cost-effective to the lavish, irrespective of whether the resistance training is home- or facility-based. Lavish resistance training equipment can take the guise of that equipment using electromagnetism to create resistance and/or equipment that are digitally-connected for on-demand coaching/personalized exercises. Not only is the initial outlay for such exercise equipment, but such equipment usually required expensive routine maintenance. Furthermore, necessary personnel are required to prescribe exercise using the advanced equipment.

The practicalities and realities of providing comprehensive resistance training for the prevention and management of NCDs in low-resource settings require minimal monitoring and provision of no/cost-effective resistance training equipment. Therefore, in low-resource settings, non-equipment based exercise programs (e.g. calisthenics, Pilates, yoga, etc.) provide the most sensible solution (20, 21). However, low-cost options to implement resistance training in low-resource settings are also available (e.g. resistance bands, ‘home-made’ weights, etc.) (15, 24).

While it is supposed that resistance training may save funds by limiting the use of healthcare resources (25), few studies have evaluated the cost-effectiveness and cost-utility analyses of resistance training. One such study demonstrated, from the Canadian Healthcare System perspective, that delivering a once-weekly and twice-weekly

resistance training program costs 353.06 Canadian dollars (CAD\$) and 706.12 CAD\$ per person per year in 2008, respectively (26).

5.2. Resistance Training Program Design

The core program design variables (i.e., frequency, exercise selection, order of exercises, volume, load, sets, and repetitions) of resistance training have been established by the major associations (15) and are similar in low- and well-resourced settings. However, resistance training, as with all exercise training, should be based on an individual’s clinical status and personal preferences.

5.3. Stratification of Patient Risk for Participation in Resistance Training in Low-Resource Settings

Unsupervised exercise should be prescribed wherever possible in low-resource settings to ensure affordability. However, individuals can be found at both ends of the functional spectrum in low-resource settings, and several relative and absolute contraindications do exist limiting involvement in any form of regular or structured exercise. Some individuals with low-risk will be able to perform the exercise without adverse consequences, while other individuals will have very limited exercise capacity and contraindications to their participation in exercise. Thus, it is essential to apply the process of risk stratification to guide resistance training program design and the level of monitoring required. Problematically for low-resource settings, those patients stratified as having high-risk need be supervised during even moderate exercise by a healthcare provider qualified in not only the basic and advanced principles of exercise prescription but also patient monitoring and the management of emergency cardiac events.

5.4. Effectiveness of Non-Equipment Resistance Training on Non-communicable Disease

In low-resource settings, non-equipment based exercise programs provide the most practical option to curb the expansion of and manage NCDs (20, 21). Pilates as a form of resistance training is a type of exercise with emphasis on alignment, breathing, and improving coordination and balance by targeting muscles and joints which are involved in daily activities such as sitting, walking, carrying loads, and bending (27, 28). An accepted advantage of Pilates is that this form of resistance training can be performed by many individuals in many conditions (29), including low-resource settings. While more research is needed to unequivocally demonstrate Pilates’ role in NCD prevention and management, it appears that there is research supporting its role in improving symptomology, exercise tolerance, functional status, body composition,

muscular strength, balance, range of motion, lung function, and quality of life (QoL) (29).

As with Pilates, primary evidence is scarce for the role of yoga on NCD prevention and management. The evidence that is available suggests that yoga is effective in preventing and/or reducing NCDs, even in children (30, 31). In fact, yoga is being incorporated into the United Kingdom's National Health Service (NHS) due to its cost-effectiveness, and its ability to prevent and assist in the management of NCDs (32).

However, before any form of resistance training can be integrated into a comprehensive model for NCD prevention and/or rehabilitation in low-resource settings, it is necessary to closely examine its effectiveness and feasibility on the main NCDs namely; CVDs, cancers, chronic respiratory diseases (such as COPD and asthma), and diabetes (2).

While Pilates has been increasingly used for its therapeutic benefits, little scientific evidence supports its use in the prevention or management of CVD (33). However, Pilates may prove useful in the prevention and management of CVD due to its ability to impact on numerous CVD risk factors. In this regard, Pilates has been demonstrated to positive changes in blood pressure (34); cholesterol levels (34); cardiorespiratory endurance (20, 35, 36); body composition (including reducing body fat (34), reducing abdominal circumference (37), reducing body mass index (BMI) (34, 37), and even increasing lean mass (34). Similarly, there is some evidence that yoga has favourable effects on blood pressure, high-density lipoprotein cholesterol and triacylglycerol, and possibly low-density lipoprotein cholesterol (38).

Pilates, like most exercise, enhances energy expenditure and affects cellular metabolism and thus has several effects on metabolic control. Research on the effect of Pilates has indicated improvements in blood glucose levels (34, 39), and improved glycemic control (40). Yoga has been unequivocally demonstrated for its usefulness in controlling both the symptoms and the complications associated with diabetes. In this regard, yoga has a proven role in controlling diabetes, by improving measures of fasting glucose and glycolated hemoglobin (HbA1c) (41, 42).

There is a paucity of evidence on Pilates for improving health in patients suffering from cancer. However, existing evidence almost exclusively supports the inclusion of Pilates in patients with and/or following breast cancer (43, 44). When additional research is forthcoming, it does support the use of Pilates in the treatment of other cancers, such as post-prostatectomy (45). Results from the recent research on yoga and cancer demonstrate support for the safety, effectiveness, and viability of yoga for use in cancer patients (46, 47). Problematically, there is inconsistency

across the forthcoming data that limits the use of yoga in the management of cancer-related symptoms (46, 47).

Yoga is commonly utilized as an adjunct treatment of a variety of chronic respiratory diseases, including COPD (48), and asthma (49). Pilates has a proven effectiveness at improving lung function across numerous populations (50). Pilates has also proven its use in a variety of respiratory-NCDs, including COPD (29, 51), and asthma (52).

5.5. Effectiveness of Low-Cost Resistance Training on Non-communicable Disease

While a large proportion of individuals, especially in LMICs do not engage in regular or structured physical activity, the use of low-cost resistance training with components such as elastic bands could prove useful to prevent or manage NCDs. This is especially relevant that such training could be done in low-resource settings, such as at home, in community-based settings, the workplace and even low-resource clinical settings.

Research has demonstrated that elastic band training adaptations are comparable to conventional resistance training even when using assorted program designs in different populations (53). Elastic band training may too prove useful in the management of CVD in that this mode of training has previously demonstrated improvements in total cholesterol, low-density lipoprotein cholesterol, C-reactive protein, functional capacity, cardiorespiratory endurance, and body composition (i.e. body mass, and waist circumference) (54).

Previous studies demonstrate that calisthenics may be a beneficial adjunctive therapy to manage CVD due to its efficacy at improving hemodynamic measures (i.e. resting heart rate, resting systolic and diastolic blood pressures, resting mean arterial pressure, and rate pressure product), exercise capacity, and improving body composition (i.e., sum of skinfolds, percentage body fat, fat mass, lean mass, skeletal muscle index, and conicity index) (21, 55, 56).

Since the basis for exercise, therapy focuses on the ability of skeletal muscle contractile activity to improve insulin sensitivity and resultant glucose uptake and clearance, most forms of resistance training may prove effective in the management of diabetes. In this regard, elastic resistance training has proved effective at improving blood markers of glucose control, such as HbA1c, fasting glucose, postprandial glucose, insulin, and C-peptide (57, 58). Resistance training using calisthenics, as frequently included in rehabilitation or physical therapy programs, has a pivotal role in the management of diabetes (59). Studies have demonstrated that resistance calisthenic training has the ability to improve glucose, HbA1c (60), and postprandial hyperglycemia (61) in diabetics.

Resistance training is effective for targeting the sequelae of cancers and its treatment given the unique anabolic nature of this exercise modality (62). In this regard, elastic-band resistance training has demonstrated its ability to lower chromosomal damage. This is particularly important in that age-related diseases, such as cancer, are associated with increased DNA and chromosomal damage (63). Not only has resistance training been shown to decrease the incidence of cancer, but resistance training, and more particularly calisthenics, has been demonstrated to have a positive effect on recurrence or survival after a cancer diagnosis. Although much of the research is focused on cardiorespiratory forms of calisthenic training (i.e. walking, running, etc.), resistance calisthenics training has been shown to decrease the risk of developing breast cancer and improve survival following such a diagnosis (64).

A vast majority of resistance training studies in pulmonary rehabilitation have demonstrated conventional resistance training's ability to improve outcomes. However, information on the efficacy of resistance training equipment other than costly conventional isokinetic, isotonic, and isometric machines or equipment, such as elastic resistance equipment, is scarce (65). Further, while pulmonary rehabilitation is an essential component of chronic respiratory disease management, only 2% - 5% of individuals with COPD have access to programs due to cost implications (66). Alison and McKeough (66) demonstrated that randomized controlled trials using minimal, low-cost equipment for resistance training (three trials) resulted in improvements in functional capacity, muscular strength, and QoL. Specifically, elastic band resistance training has been shown to increase functional capacity and muscular fitness in patients with COPD (66). With regards to calisthenics, a study by Baumann et al. (67) using simple resistance training devices, such as elastic bands, neoprene dumbbells, chairs, and sticks resulted in improvements in six minute-walk-distance, maximum workload, and St. George's Respiratory questionnaire score at a total staff cost for the program of \leq €625 per patient with COPD. Another study utilizing home-based, lower-body calisthenics using only heel raises, lunges, and forward and sideways step-ups, found improvements in six minute-walk-distance after eight weeks of training (68). Similarly, a three-month seated calisthenics study found improvements in vital capacity (VC), percentage vital capacity (%VC), forced VC (FVC), residual volume (RV), RV/total lung capacity (TLC), and functional residual capacity (FRC), six minute-walk-distance, and Chronic Respiratory Disease questionnaire scores (69). While the amount of research is limited at present, increasing evidence demonstrates that minimalistic, low-cost resistance training could provide a substitute for conventional and costly pulmonary rehabil-

itation programs (66).

While sufficient evidence exists that low-cost resistance training can be utilized as an adjunct treatment in NCDs, comparative studies using elastic bands and conventional resistance training devices could elucidate and directly compare the NCD benefits and outcomes provided by both approaches to resistance training.

5.6. Limitations

While an in-depth search was performed to find low-cost approaches of resistance training to health promotion, NCD risk reduction, and NCD rehabilitation/management, there is the possibility that there are other low-cost resistance training modalities that could not be identified. This may be related to articles not being published in the English-language, the use of only published citations, and the use of the defined/selected databases due to time, budget, and resource constraints. In addition, the inclusion criteria may be considered either too narrow resulting in eligible evidence not being found or even too loosely defined, increasing the possibility of poor reproducibility due to many subjective decisions regarding what to include.

5.7. Conclusions

Resistance exercise equipment differs substantially with regard to costs and the need for specialized supervision. However, the implementation of resistance training programs for the management of NCDs in low-resource settings requires the selection of equipment that is not only effective but also safe and available. Accessibility in low-resource settings may require health professionals to become increasingly creative, such as delivering resistance exercise training programs via radio as opposed to online instruction as in HICs. Recently, the use of low-cost resistance training approaches has grown in acceptance. Sufficient evidence now exists demonstrating that resistance training is as effective in LMICs as in HICs, regardless of if delivery is in a formal facility or in a home-based setting. Thus, this paper proposes a comprehensive model for resistance training delivery in low-resource settings. Since substantial disparities exist in the availability of healthcare resources in low-resource settings, the recommendations of this study should be employed as far as possible. Resistance training modalities are able to be adapted for delivery in home- and community-based settings and in low-resource primary care settings. The model is proposed as flexible for use in an assortment of low-resource settings. Implementation of such models will depend upon both the availability and type of resistance training equipment and trained healthcare professionals.

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Footnotes

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