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Contents

Monthly Volume 11 Number 6 June 15, 2020

EDITORIAL

MINIREVIEWS

ORIGINAL ARTICLE

Basic Study

Clinical and Translational Research

Case Control Study

Contents

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Volume 11 Number 6 June 15, 2020

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MINIREVIEWS

Telerehabilitation intervention for type 2 diabetes

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Abstract

Diabetes has become an increasingly important health problem worldwide due to its prevalence. Although effective treatments for diabetes management have been developed, many patients have difficulty in achieving their therapeutic goals. Regular exercise training is suggested to prevent or delay the symptoms and complications of type 2 diabetes along with other medical treatments. It has become necessary to develop new rehabilitation models and practices in order to cope with the changing needs of the population. Treatment models using technology can be effective in disease management. Telerehabilitation may be effective as part of the rehabilitation program in the home environment, especially for patients who are unable to participate in conventional center-based rehabilitation due to transport difficulties or work resumption. Telerehabilitation is defined as the delivery of rehabilitation services *via* telecommunication technology, including phone, internet, and videoconference communications between the patient and health care provider. It is possible that telerehabilitation may benefit people with type 2 diabetes in similar ways with telemonitoring and interactive health communication systems. Although the applicability of telehealth methods has been proven in previous studies, telerehabi-litation studies in type 2 diabetes are inadequate in the literature. With larger, multi-centered randomized controlled studies, established clinical guidelines can be developed that will ultimately improve patient outcomes.

Key words: Type 2 diabetes; Telerehabilitation; Exercise; Telehealth; Healthcare; Telecommunication

Core tip: Diabetes is a global burden that can have fatal consequences for human health and has a significant impact on healthcare system costs. Although effective treatments for type 2 diabetes have been developed, many patients have difficulty in achieving their therapeutic goals. Most of these problems are due to difficulties in patients reaching the relevant centers or the lack of care models. Telerehabilitation may be effective as part of the rehabilitation program in the home environment, especially for patients who are unable to participate in conventional center-based rehabilitation due to transport

difficulties or work resumption.

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INTRODUCTION

Diabetes is a global burden, and can have fatal consequences on human health and a significant impact on healthcare system economics. Due to its high prevalence, diabetes has become a significant health problem worldwide. Diabetes is a metabolic disease that can cause severe complications and mortality if not treated effectively and quickly[1].

Diabetes is a complex disease in which self-management, training, regular monitoring, and multiple drug use are required to obtain an appropriate treatment outcome. Although an effective treatment for type 2 diabetes has been developed, many patients have difficulty in achieving their therapeutic goals. Most of these problems are due to challenges in patients reaching the relevant centers or the lack of care models[1].

Therefore, it has become necessary to develop new rehabilitation models and practices to cope with the changing needs of the population due to aging and lack of resources for public health. In addition to hospital rehabilitation practices in the acute phase of the disease, another challenge that has emerged in the modern healthcare system is the maintenance of health care outside the hospital, especially in type 2 diabetes[2]. Health care for diabetic patients includes innovative management strategies to improve disease control. Treatment models using technology can be effective in disease management[3].

Diabetes-related symptoms, co-morbidities, and complications may impair quality of life, affect mortality and lead to psychosocial problems. Consequently, these factors influence the exercise and physical capacity of patients. Patients show lower physical activity and reduced cardiorespiratory fitness than healthy individuals. Exercise therapy is thus essential for the management of type 2 diabetes[4]. Regular exercise training along with dietary approaches and pharmacological treatment is recommended to prevent or delay the symptoms and complications of diabetes[5]. Rehabilitation programs are safe and effective, with benefits including enhanced quality of life, increased functional exercise capacity, reduced hospital readmissions, and reduced mortality rate. Exercise programs performed generally consist of supervised and center-based programs[6].

Systematic reviews that have included exercise training in type 2 diabetes defined statistically and clinically significant improvements in blood glucose, HbA1c (8%-9%), lipid profile, and peak oxygen uptake (12%)[7,8]. Furthermore, exercise capacity has been observed to be a strong predictor of all-cause mortality in type 2 diabetes[9]. Exercise-based rehabilitation in a hospital or rehabilitation center results in the best outcome as evidenced by scientific studies. Based on these obvious evidence-based benefits, rehabilitation is recommended by several associations[10].

Despite the various benefits of rehabilitation, attendance at such programs is low. The regularity of rehabilitation programs is the leading problem with high drop-out levels. There are several factors for suboptimal participation which include lack of time, availability, accessibility of a program, psychological barriers, and obligations at home or work. Therefore, new models are needed to increase participation rates, and long-term adherence to recommendations, as well as support new lifestyle change[11].

Telerehabilitation may be effective as a part of the rehabilitation program in the home environment, especially for patients unable to participate in conventional center-based rehabilitation due to transport difficulties or work resumption. The factors associated with suboptimal participation in rehabilitation at home are less prevalent. In telerehabilitation, patients are not limited to the hospital or rehabilitation center environment, hence they are able to perform the exercise program during their daily routine at home[12].

CO-MORBIDITIES AND COMPLICATIONS OF TYPE 2 DIABETES

Type 2 diabetes is a leading cause of severe morbidities and disabilities. Due to the presence of comorbidities and chronic conditions in addition to type 2 diabetes; diabetes-related healthcare, treatment options, care needs, and associated costs are complicated. In order to provide effective diabetes care, the increased burden of complex comorbidity, can affect treatment quality. Previous studies examining chronic conditions in patients with type 2 diabetes have found an association between an increasing number of comorbidities, increased rates of healthcare use and impaired physical function. It is also stated that patients with type 2 diabetes have more chronic diseases than the non-diabetic population[13]. The development of specific treatments for patients with complex comorbid disease has also gained importance in disease care. Clinical guidelines have recently significantly changed diabetes care with more evidence to provide effective treatment and reduce treatment variation. However, it remains unclear how to successfully define the main goals of interventions in complex comorbid patients.

People with type 2 diabetes have a higher risk of cardiovascular complications, end-stage kidney disease and hypertension due to risk factors such as obesity, endothelial dysfunction, vascular inflammation and dyslipidemia. However, individuals with type 2 diabetes have also been shown to have a higher risk of depression, thyroid gland diseases, and chronic obstructive pulmonary disease.

Important risk factors for type 2 diabetes are overweight or obesity, an unhealthy diet and physical inactivity, which accounts for approximately 80% of the increase in the prevalence of diabetes. In addition, these risk factors are modifiable risk factors. Physical inactivity alone is estimated to cause 7% of type 2 diabetes burden According to World Health Organization (WHO) reports, as physical activity decreases, non-communicable diseases increase. Diabetes is one of the four main non-communicable diseases along with cardiovascular diseases, cancer and respiratory diseases, and diabetes accounts for most of the burden of disease and early deaths[14]. A decrease in the level of physical activity is considered an urgent public health problem worldwide. In today's conditions, the most important causes of physical inactivity are environmental and systemic factors. As our living conditions begin to become sedentary, it becomes increasingly difficult to maintain adequate levels of physical activity[15]. Therefore, more effective disease control and behavioral approaches should be integrated into patients' lives in order to reduce these comorbidities and complications.

REHABILITATION METHODS FOR TYPE 2 DIABETES

Although drug treatments have been revealed to be effective in treating type 2 diabetes, these treatment approaches are often costly and can have side effects. On the other hand, adopting a healthy lifestyle has become one of the main approaches to relieve the burden of glucose and lipid metabolic disorders in combination with appropriate drug therapy[15]. Consequently, exercise can become a parallel therapy to traditional treatment programs and diet control or medications in patients with type 2 diabetes.

Physical therapy and rehabilitation is the cornerstone of diabetes prevention and treatment. Individually developed exercise programs are clinically effective in patients with type 2 diabetes. Table 1 summarizes the major benefits of exercise in individuals with diabetes. Different modes of exercise in patients with type 2 diabetes are important due to their effects such as increased glucose uptake by muscles, improved usage, altered lipid levels, increased high-density lipoprotein and reduced triglyceride and total cholesterol. In individuals with type 2 diabetes, any type of physical activity which requires more muscle work than daily living activities can help lower blood glucose, as the vast majority involve the use of muscles during exercise[16].

Active and passive joint movement exercises, stretching techniques, strengthening exercises, and aerobic exercise training are some of the most effective physical therapy and rehabilitation techniques that can be used in patients with type 2 diabetes, such as inpatients, outpatients, and prediabetes[16]. Clinical studies in recent years have shown that the combination of both aerobic and resistance exercise training has a significant effect on glycemic control compared to aerobic exercise or resistance exercise alone[17].

Despite the benefits that can be achieved through rehabilitation, the majority of patients cannot participate in the exercise programs offered to them. Some refuse rehabilitation due to socio-demographic factors, others due to long-distance travel or

Table 1 Major benefits of exercise in individuals with diabetes

	Major benefits
1	Increases quality of life
2	Improves blood cholesterol profiles
3	Increases heart function
4	Decreases blood pressure
5	Improves insulin sensitivity and blood glucose control
6	Improves muscular strength
7	Improves gait and balance
8	Helps to lose weight

working conditions. As a result, a large number of patients do not benefit from the advantages of rehabilitation programs. For ongoing effective diabetes management, long-term adherence to exercise is required; thus, to improve this adherence rate and solve this issue, new rehabilitation models are needed. Telerehabilitation therapy may be considered part of rehabilitation, as this globally increasing method of delivering healthcare services uses information and communication technologies. Thus, telerehabilitation may be more suitable to a patient's lifestyle and thereby increase the patient's self-management[18].

TELEREHABILITATION

The progression in communication facilities and computer-based technologies has led to innovative changes in health. In recent years, with the development of new computer science technologies and advanced telehealth devices, applications in the field of telehealth have been increasing. A review stated that telehealth promises to be a novel 21st century tool in diabetes healthcare to improve quality and reduce the costs by enabling communication with patients[19].

The most encouraging applications in telehealth interventions include telerehabilitation, prevention and lifestyle interventions, chronic disease management (hypertension, diabetes, and heart failure), arrhythmia detection (early detection of atrial fibrillation), and telemonitoring of devices such as pacemakers[20].

In recent years, new telecommunications-based applications in rehabilitation are being developed in the field of medicine all over the world. These approaches are defined as telerehabilitation, which consists of a system controlling remote rehabilitation and should be considered a sub-field of telehealth[21]. "Telerehabilitation" is defined as the delivery of rehabilitation services *via* communication and information technology, including phone, internet, and video conference communications between the patient and the healthcare provider. Clinically, the term telerehabilitation covers a range of rehabilitation services, such as assessment, monitoring, intervention, supervision, education, and counseling[22].

Telerehabilitation is closely associated with and is mostly confused with telehealth or telemonitoring. "Telemonitoring" which is an automated process of data transmission regarding a patient's health status from home to the respective healthcare setting, has proven to be beneficial in patients with chronic diseases, including coronary heart disease, cystic fibrosis, and chronic obstructive pulmonary disease[23-26]. Telerehabilitation with telemonitoring and interactive health communication systems may benefit people with diabetes in a similar way.

"Telehealth" is the use of medical information through electronic communication to improve patients' health status. Telehealth, which covers a broader definition of remote healthcare, does not always include clinical services. Telehealth enables remote communication technology and computer applications to transmit the physiological signals of patients at home, in the community, and institutions to the medical units for analysis and evaluation. Telehealth services include education, patient visit-control service, emergency treatment, and disease prevention. Additionally, it also allows the transmission of physiological signals such as blood pressure or sugar ratio to real-time healthcare providers. Therefore, telehealth aims to make patients independent of the management of their condition[27,28].

According to the WHO, telehealth is the use of telecommunication and virtual technology to deliver healthcare outside traditional healthcare facilities. Well-designed telehealth programs can improve outcomes by facilitating access to

healthcare, especially for chronic disease treatment and vulnerable groups. WHO also stated that it is effective in reducing the demand for crowded facilities and is cost saving[29].

The fundamental research on telerehabilitation has been based on a telephonic conversation for follow up and to administer self-assessment measures. Furthermore, telerehabilitation continued to progress in the 1980s with pre-recorded video materials[30]. In the 1990s, live interactive video conferencing was introduced. After the 1990s, due to the emerging needs of people and the rapid development of new communication and computer technologies, the number of articles and new technological support have increased[31]. In the following years, a virtual environment was introduced to healthcare as another technological method. This method allows users to interact with the computer-generated environment in real-time. It is also possible for health professionals to use it in places such as surgery, rehabilitation, education and training (Table 2). In recent years, smartphones and the applications that can be used with them have revolutionized communication in the medical field. Today, there is a wide range of mobile applications for healthcare professionals, students, patients, and the general public[32]. Telerehabilitation also encourages patients to adopt a healthier lifestyle (smoking cessation, activity tracking) and in adhering to medication use by health information technology applications[20].

Telerehabilitation, which involves health services by using electronic communication systems, is an essential treatment option for improving sustainability in patient care and ensuring practicability. Telerehabilitation procedures can provide glycemic control, blood pressure, lipidemia, weight, diet, and complications monitoring as well as exercise awareness particularly in patients with type 2 diabetes, an essential step in disease management. Diabetes education provides interactive seminars, video conferences, and phone calls. During these conversations, patients are encouraged to exercise. Patients can also easily discuss exercises and rehabilitation programs with their physiotherapist. Telerehabilitation allows patients to take part in their treatment and thus adopt exercise by taking responsibility[6]. Using this technology in rehabilitation services is not only beneficial for the clinician but also for the patient. It promotes a sense of personal autonomy and empowerment by enabling active participation in disease management[33] (Table 3).

Another advantage of telerehabilitation is providing care to inpatients and transferring them home after the acute phase of a disease, therefore, reducing hospital stay and costs for both patients and healthcare providers. These new approaches allow treatment of the acute phase of the disease by overcoming the requirement of a traditional face-to-face inpatient rehabilitation interaction approach. This includes, in particular, patients' challenges to access traditional rehabilitation infrastructures distant from their homes.

Telerehabilitation can never replace face-to-face consultations, but aims to reduce travel and accommodation costs, waiting times and stress on the patient, the patient's family members and caregivers by combining appropriate treatment methods tailored for the patient. Based on all these effects the goal of the telerehabilitation program is to encourage patients with chronic diseases to adopt active behavior and continuously receive medical supervision, thereby enhancing the healthcare behavior of patients.

On the other hand, patients can encounter some participation problems and difficulties while using such telecommunication applications. A study investigating the predictive effect of depression and anxiety on patients' willingness to participate in a trial comparing telerehabilitation *vs* center-based cardiac rehabilitation concluded that despite the proven effectiveness of telerehabilitation, several factors influence the willingness to participate in telerehabilitation. It was demonstrated that patients with symptoms of depression are less willing to participate in telerehabilitation[34].

According to a study that evaluated the use of telehealth in diabetic patients[26], the greatest difficulties in using the monitoring systems were operational problems and equipment quality. The same study also evaluated the satisfaction of participants in telehealth using a questionnaire, which indicated that most participants were satisfied with the equipment but expected additional assistance with its operation. After the 3-mo study period, it was concluded that the program was beneficial in increasing HbA1c control.

TELEREHABILITATION IN TYPE 2 DIABETES

In the last decade, the feasibility and effectiveness of telehealth strategies in the treatment of diabetes patients have been discussed in several studies[3]. The applicability of telehealth methods has been proven; however, due to the incidence of inconsistency between the results in different studies, the actual effect of these

Table 2 Most promising applications of telerehabilitation

Chronic disease management	Physical activity telemonitoring
Prevention and lifestyle interventions	Exercise training planning
Smoking cessation	Exercise training counseling
Activity tracking	Simultaneous exercise training
Adhering to medication	Exercise training follow up

applications in specific and general clinical situations is not yet known[35,36]. With its proven clinical benefits, its use in clinical practice can become widespread and help reduce the burden of the disease[3]. In addition, there have been many telerehabilitation studies on the musculoskeletal system, neurologic, cardiopulmonary, and orthopedic diseases[37-40], but there have been few telerehabilitation studies in type 2 diabetes.

In diabetes-related telehealth applications, many systems such as computers, analog telephones, network systems, cell phones, video-conference systems, satellite technologies, and electrocardiography transmission devices are used. Previous telehealth studies in type 2 diabetes observed glycemic control, complications, and quality of life in diabetic patients. These studies indicated that telehealth applications can increase glycemic control and quality of life as well as reduce HbA1c values[41-46].

In a literature review of studies, only our study conducted in 2019 was found to use telerehabilitation methods in type 2 diabetes[6]. Earlier studies were conducted with exercise training or physical activity alone, and several studies have referred to telehealth practices, including exercise, counseling or other management strategies[47-49].

The only telerehabilitation study[6] conducted in type 2 diabetes mellitus patients was a double-blind, randomized, controlled trial. The participants in the telerehabilitation group performed breathing and callisthenic exercises, three times a week for six weeks, at home by internet-based video conferences under the supervision of a physiotherapist. To precept the exercises, only the first session of the training was performed at the clinic. The patients measured their heart rate, SpO2 with a pulse oximeter as well as blood pressure themselves during all exercises for safety after the initial intervention by the physiotherapist. At the end of the study period, the telerehabilitation intervention was found to be effective in improving exercise capacity, physical fitness, muscle strength, psychosocial status, and controlling HbA1c levels. Compliance with the intervention was excellent and the telerehabilitation interventions were found to be safe and practicable, which could be an alternative treatment model for type 2 diabetes management.

Another study that included exercise, counseling, or management strategies[47] consisted of a program designed to be delivered *via* the internet to improve the participants' diabetes self-management behaviors using behavioral and motivational strategies. Additional strategies included instructions on disease management, diet, and exercise, and the introduction to interventions to deal with the physical and emotional demands of the disease. The interaction between the caregivers and participants included both synchronous (instant messaging and chat) and asynchronous communication (e-mail and bulletin board) methods. The participants also accessed a website to enter their blood sugar readings, exercise programs, weight changes, blood pressure, and medication data. The study caregiver followed participants' logs to monitor changes in their self-management patterns. The study concluded that the participants who received a 6-month diabetes web-based intervention improved their HbA1c, systolic blood pressure, weight, high density lipoprotein, and total cholesterol levels compared to the control group.

Glasgow *et al*[48] included exercise, counseling, or management strategies and evaluated minimal and moderate support versions of internet-based diabetes combined (internet and automated telephone) self-management programs in adults with type 2 diabetes. The internet-based intervention resulted in a greater improvement, compared with the usual care condition, on three of four behavioral outcomes (healthy eating, fat intake, and physical activity). They concluded that more frequent, longer-term, or more personal support might be needed to improve the results of an effective internet-based behavioral change intervention.

Marios *et al*[49] conducted a study that included exercise, counseling, or management strategies. They used telemonitoring to improve exercise adherence, which assessed the number of hours of exercise completed, as well as peak VO_2, HbA1c and quality of life in a six-month unsupervised, home-based exercise program in people with type 2

Table 3 Advantages of telerehabilitation

	Advantages of telerehabilitation
1	Improves health service efficiency and processes
2	Improves healthcare quality or effectiveness
3	Saves paperwork and saves time for caregivers
4	Reduces healthcare costs
5	Facilitates and extends access to economic care
6	Improves sustainability
7	Facilitates long-term home care for patients
8	Promotes a sense of personal autonomy in participants

diabetes. Cost analysis was also conducted. The exercise group was instructed to record their heart rates during exercise using a monitor and received weekly telephone calls from a physiologist. Although telemonitored patients completed more hours of exercise and demonstrated improved peak VO_2 compared to controls, they neither improved HbA1c nor quality of life. The exercise volume was also insufficient to improve glycemic control. They concluded that telemonitoring has the potential to enable people with diabetes to meet exercise training guidelines.

A systematic review[2] that assessed the quality and the evidence of telerehabilitation and included 10 studies, which was conducted in patients with chronic or long-term conditions and neurologic disorders, suggested that the number of telerehabilitation experiences worldwide is growing. However, evidence of its clinical and economic effectiveness is still insufficient, particularly in routine care. Moreover, these systematic reviews have been interpreted based on a lack of methodological rigor and diversity of approaches used in the studies. There is some evidence concerning users' acceptance and satisfaction, and overall feasibility related to the discipline. However, there is insufficient evidence to state that telerehabilitation is a cost-saving or cost-effective approach, although its potential has been highlighted scientifically.

CONCLUSION

Technology-based rehabilitation applications are developing rapidly and becoming an essential component of medical care. Therefore, using these new techniques, it is necessary to continue to focus on the individual needs of the patient. Although the telerehabilitation interventions in type 2 diabetes are less well-defined, initial results of small studies are highly favorable. With more extensive, multi-centered randomized controlled studies, clinical guidelines could ultimately improve patient outcomes. However, additional research is needed to interpret long-term outcomes, as well as to enhance effectiveness and cost-effectiveness.

REFERENCES

1 **Siminerio L**, Ruppert K, Huber K, Toledo FG. Telemedicine for Reach, Education, Access, and Treatment (TREAT): linking telemedicine with diabetes self-management education to improve care in rural communities. *Diabetes Educ* 2014; **40**: 797-805 [PMID: 25253624 DOI: 10.1177/0145721714551993]

2 **Rogante M**, Kairy D, Giacomozzi C, Grigioni M. A quality assessment of systematic reviews on telerehabilitation: what does the evidence tell us? *Ann Ist Super Sanita* 2015; **51**: 11-18 [PMID: 25857379 DOI: 10.4415/ANN_15_01_04]

3 **Marcolino MS**, Maia JX, Alkmim MB, Boersma E, Ribeiro AL. Telemedicine application in the care of diabetes patients: systematic review and meta-analysis. *PLoS One* 2013; **8**: e79246 [PMID: 24250826 DOI: 10.1371/journal.pone.0079246]

4 **Hamasaki H**. Effects of glucose-lowering agents on cardiorespiratory fitness. *World J Diabetes* 2018; **9**: 230-238 [PMID: 30588285 DOI: 10.4239/wjd.v9.i12.230]

5 **Colberg SR**, Sigal RJ, Fernhall B, Regensteiner JG, Blissmer BJ, Rubin RR, Chasan-Taber L, Albright AL, Braun B; American College of Sports Medicine; American Diabetes Association. Exercise and type 2 diabetes: the American College of Sports Medicine and the American Diabetes Association: joint position statement. *Diabetes Care* 2010; **33**: e147-e167 [PMID: 21115758 DOI: 10.2337/dc10-9990]

6 **Duruturk N**, Özköslü MA. Effect of tele-rehabilitation on glucose control, exercise capacity, physical fitness, muscle strength and psychosocial status in patients with type 2 diabetes: A double blind randomized controlled trial. *Prim Care Diabetes* 2019; **13**: 542-548 [PMID: 31014938 DOI: 10.1016/j.pcd.2019.03.007]

7 **Boulé NG**, Kenny GP, Haddad E, Wells GA, Sigal RJ. Meta-analysis of the effect of structured exercise

training on cardiorespiratory fitness in Type 2 diabetes mellitus. *Diabetologia* 2003; **46**: 1071-1081 [PMID: 12856082 DOI: 10.1007/s00125-003-1160-2]
8 **Yoo JS**, Lee SJ. [A meta-analysis of the effects of exercise programs on glucose and lipid metabolism and cardiac function in patients with type II diabetes mellitus]. *Taehan Kanho Hakhoe Chi* 2005; **35**: 546-554 [PMID: 16027506 DOI: 10.4040/jkan.2005.35.3.546]
9 **Kokkinos P**, Myers J, Nylen E, Panagiotakos DB, Manolis A, Pittaras A, Blackman MR, Jacob-Issac R, Faselis C, Abella J, Singh S. Exercise capacity and all-cause mortality in African American and Caucasian men with type 2 diabetes. *Diabetes Care* 2009; **32**: 623-628 [PMID: 19196898 DOI: 10.2337/dc08-1876]
10 **Smith SC**, Benjamin EJ, Bonow RO, Braun LT, Creager MA, Franklin BA, Gibbons RJ, Grundy SM, Hiratzka LF, Jones DW, Lloyd-Jones DM, Minissian M, Mosca L, Peterson ED, Sacco RL, Spertus J, Stein JH, Taubert KA; World Heart Federation and the Preventive Cardiovascular Nurses Association. AHA/ACCF Secondary Prevention and Risk Reduction Therapy for Patients with Coronary and other Atherosclerotic Vascular Disease: 2011 update: a guideline from the American Heart Association and American College of Cardiology Foundation. *Circulation* 2011; **124**: 2458-2473 [PMID: 22052934 DOI: 10.1161/CIR.0b013e318235eb4d]
11 **Buys R**, Claes J, Walsh D, Cornelis N, Moran K, Budts W, Woods C, Cornelissen VA. Cardiac patients show high interest in technology enabled cardiovascular rehabilitation. *BMC Med Inform Decis Mak* 2016; **16**: 95 [PMID: 27431419 DOI: 10.1186/s12911-016-0329-9]
12 **Frederix I**, Vanhees L, Dendale P, Goetschalckx K. A review of telerehabilitation for cardiac patients. *J Telemed Telecare* 2015; **21**: 45-53 [PMID: 25475219 DOI: 10.1177/1357633X14562732]
13 **Cho YY**, Cho SI. Treatment variation related to comorbidity and complications in type 2 diabetes: A real world analysis. *Medicine (Baltimore)* 2018; **97**: e12435 [PMID: 30213022 DOI: 10.1097/MD.0000000000012435]
14 **World Health Organization**. Physical inactivity and diabetes 2015. [updated 12 Nov 2015]. Available from: http://www.euro.who.int/en/health-topics/disease-prevention/nutrition/news/news/2015/11/physical-inactivity-and-diabetes
15 **Wang Q**, Zhang X, Fang L, Guan Q, Gao L, Li Q. Physical Activity Patterns and Risk of Type 2 Diabetes and Metabolic Syndrome in Middle-Aged and Elderly Northern Chinese Adults. *J Diabetes Res* 2018; **2018**: 7198274 [PMID: 30155489 DOI: 10.1155/2018/7198274]
16 **Kaur J**, Sıngh Sk, Sınghvıj J. Physiotherapy and Rehabilitation In The Management of Diabetes Mellitus: A Review. *Indian J Sci Res* 2015; **6**: 171-181
17 **Sigal RJ**, Alberga AS, Goldfield GS, Prud'homme D, Hadjiyannakis S, Gougeon R, Phillips P, Tulloch H, Malcolm J, Doucette S, Wells GA, Ma J, Kenny GP. Effects of aerobic training, resistance training, or both on percentage body fat and cardiometabolic risk markers in obese adolescents: the healthy eating aerobic and resistance training in youth randomized clinical trial. *JAMA Pediatr* 2014; **168**: 1006-1014 [PMID: 25243536 DOI: 10.1001/jamapediatrics.2014.1392]
18 **Spindler H**, Leerskov K, Joensson K, Nielsen G, Andreasen JJ, Dinesen B. Conventional Rehabilitation Therapy Versus Telerehabilitation in Cardiac Patients: A Comparison of Motivation, Psychological Distress, and Quality of Life. *Int J Environ Res Public Health* 2019; 16 [PMID: 30759761 DOI: 10.3390/ijerph16030512]
19 **Klonoff DC**. Using telemedicine to improve outcomes in diabetes--an emerging technology. *J Diabetes Sci Technol* 2009; **3**: 624-628 [PMID: 20144303 DOI: 10.1177/193229680900300401]
20 **Saner H**. eHealth and telemedicine: current situation and future challenges. *Eur J Prev Cardiol* 2013; **20**: 1-2 [PMID: 23702982 DOI: 10.1177/2047487313487483]
21 **Zampolini M**, Todeschini E, Bernabeu Guitart M, Hermens H, Ilsbroukx S, Macellari V, Magni R, Rogante M, Scattareggia Marchese S, Vollenbroek M, Giacomozzi C. Tele-rehabilitation: present and future. *Ann Ist Super Sanita* 2008; **44**: 125-134 [PMID: 18660562]
22 **Russell TG**. Physical rehabilitation using telemedicine. *J Telemed Telecare* 2007; **13**: 217-220 [PMID: 17697506 DOI: 10.1258/135763307781458886]
23 **Paré G**, Jaana M, Sicotte C. Systematic review of home telemonitoring for chronic diseases: the evidence base. *J Am Med Inform Assoc* 2007; **14**: 269-277 [PMID: 17329725 DOI: 10.1197/jamia.M2270]
24 **Neubeck L**, Redfern J, Fernandez R, Briffa T, Bauman A, Freedman SB. Telehealth interventions for the secondary prevention of coronary heart disease: a systematic review. *Eur J Cardiovasc Prev Rehabil* 2009; **16**: 281-289 [PMID: 19407659 DOI: 10.1097/HJR.0b013e32832a4e7a]
25 **Cox NS**, Alison JA, Rasekaba T, Holland AE. Telehealth in cystic fibrosis: a systematic review. *J Telemed Telecare* 2012; **18**: 72-78 [PMID: 22198961 DOI: 10.1258/jtt.2011.110705]
26 **Dinesen B**, Haesum LK, Soerensen N, Nielsen C, Grann O, Hejlesen O, Toft E, Ehlers L. Using preventive home monitoring to reduce hospital admission rates and reduce costs: a case study of telehealth among chronic obstructive pulmonary disease patients. *J Telemed Telecare* 2012; **18**: 221-225 [PMID: 22653618 DOI: 10.1258/jtt.2012.110704]
27 **Lee TT**, Huang TY, Chang CP, Lin KC, Tu HM, Fan CJ, Mills ME. The evaluation of diabetic patients' use of a telehealth program. *Comput Inform Nurs* 2014; **32**: 569-577; quiz 578-579 [PMID: 25251861 DOI: 10.1097/CIN.0000000000000103]
28 **Fursse J**, Clarke M, Jones R, Khemka S, Findlay G. An automated personalised intervention algorithm for remote patient monitoring. *Stud Health Technol Inform* 2008; **136**: 181-186 [PMID: 18487728]
29 **World Health Organization**. Health and sustainable development 2019. Available from: https://www.who.int/sustainable-development/health-sector/strategies/telehealth/en/
30 **Wertz RT**, Dronkers NF, Bernstein-Ellis E, Sterling LK, Shubitowski Y, Elman R, Shenaut GK, Knight RT, Deal JL. Potential of telephonic and television technology for appraising and diagnosing neurogenic communication disorders in remote settings. *Aphasiology* 1992; **6**: 195 [DOI: 10.1080/02687039208248591]
31 **Rogante M**, Grigioni M, Cordella D, Giacomozzi C. Ten years of telerehabilitation: A literature overview of technologies and clinical applications. *NeuroRehabilitation* 2010; **27**: 287-304 [PMID: 21160118 DOI: 10.3233/NRE-2010-0612]
32 **Theodoros D**, Russell T. Telerehabilitation: current perspectives. *Stud Health Technol Inform* 2008; **131**: 191-209 [PMID: 18431862]
33 **Brennan DM**, Mawson S, Brownsell S. Telerehabilitation: enabling the remote delivery of healthcare, rehabilitation, and self management. *Stud Health Technol Inform* 2009; **145**: 231-248 [PMID: 19592797]
34 **Peretti A**, Amenta F, Tayebati SK, Nittari G, Mahdi SS. Telerehabilitation: Review of the State-of-the-Art and Areas of Application. *JMIR Rehabil Assist Technol* 2017; **4**: e7 [PMID: 28733271 DOI:

10.2196/rehab.7511]
35 **Brouwers RW**, Kraal JJ, Traa SC, Spee RF, Oostveen LM, Kemps HM. Effects of cardiac telerehabilitation in patients with coronary artery disease using a personalised patient-centred web application: protocol for the SmartCare-CAD randomised controlled trial. *BMC Cardiovasc Disord* 2017; **17**: 46 [PMID: 28143388 DOI: 10.1186/s12872-017-0477-6]
36 **Costa BM**, Fitzgerald KJ, Jones KM, Dunning Am T. Effectiveness of IT-based diabetes management interventions: a review of the literature. *BMC Fam Pract* 2009; **10**: 72 [PMID: 19917136 DOI: 10.1186/1471-2296-10-72]
37 **Laver KE**, Schoene D, Crotty M, George S, Lannin NA, Sherrington C. Telerehabilitation services for stroke. *Cochrane Database Syst Rev* 2013; CD010255 [PMID: 24338496 DOI: 10.1002/14651858.CD010255.pub2]
38 **Mani S**, Sharma S, Omar B, Paungmali A, Joseph L. Validity and reliability of Internet-based physiotherapy assessment for musculoskeletal disorders: a systematic review. *J Telemed Telecare* 2017; **23**: 379-391 [PMID: 27036879 DOI: 10.1177/1357633X16642369]
39 **Hwang R**, Bruning J, Morris N, Mandrusiak A, Russell T. A Systematic Review of the Effects of Telerehabilitation in Patients With Cardiopulmonary Diseases. *J Cardiopulm Rehabil Prev* 2015; **35**: 380-389 [PMID: 26034937 DOI: 10.1097/HCR.0000000000000121]
40 **Tousignant M**, Moffet H, Nadeau S, Mérette C, Boissy P, Corriveau H, Marquis F, Cabana F, Ranger P, Belzile ÉL, Dimentberg R. Cost analysis of in-home telerehabilitation for post-knee arthroplasty. *J Med Internet Res* 2015; **17**: e83 [PMID: 25840501 DOI: 10.2196/jmir.3844]
41 **Shea S**, Weinstock RS, Starren J, Teresi J, Palmas W, Field L, Morin P, Goland R, Izquierdo RE, Wolff LT, Ashraf M, Hilliman C, Silver S, Meyer S, Holmes D, Petkova E, Capps L, Lantigua RA. A randomized trial comparing telemedicine case management with usual care in older, ethnically diverse, medically underserved patients with diabetes mellitus. *J Am Med Inform Assoc* 2006; **13**: 40-51 [PMID: 16221935 DOI: 10.1197/]
42 **Gómez EJ**, Hernando ME, García A, Del Pozo F, Cermeño J, Corcoy R, Brugués E, De Leiva A. Telemedicine as a tool for intensive management of diabetes: the DIABTel experience. *Comput Methods Programs Biomed* 2002; **69**: 163-177 [PMID: 12100795 DOI: 10.1016/s0169-2607(02)00039-1]
43 **Liesenfeld B**, Renner R, Neese M, Hepp KD. Telemedical care reduces hypoglycemias and improves glycemic control in children and adolescents with type 1 diabetes. *Diabetes Technol Ther* 2000; **2**: 561-567 [PMID: 11469619 DOI: 10.1089/15209150050501970]
44 **Rossi MC**, Nicolucci A, Di Bartolo P, Bruttomesso D, Girelli A, Ampudia FJ, Kerr D, Ceriello A, Mayor Cde L, Pellegrini F, Horwitz D, Vespasiani G. Diabetes Interactive Diary: a new telemedicine system enabling flexible diet and insulin therapy while improving quality of life: an open-label, international, multicenter, randomized study. *Diabetes Care* 2010; **33**: 109-115 [PMID: 19808926 DOI: 10.2337/dc09-1327]
45 **Weinstock RS**, Teresi JA, Goland R, Izquierdo R, Palmas W, Eimicke JP, Ebner S, Shea S; IDEATel Consortium. Glycemic control and health disparities in older ethnically diverse underserved adults with diabetes: five-year results from the Informatics for Diabetes Education and Telemedicine (IDEATel) study. *Diabetes Care* 2011; **34**: 274-279 [PMID: 21270184 DOI: 10.2337/dc10-1346]
46 **Verhoeven F**, Tanja-Dijkstra K, Nijland N, Eysenbach G, van Gemert-Pijnen L. Asynchronous and synchronous teleconsultation for diabetes care: a systematic literature review. *J Diabetes Sci Technol* 2010; **4**: 666-684 [PMID: 20513335 DOI: 10.1177/193229681000400323]
47 **Bond GE**, Burr R, Wolf FM, Price M, McCurry SM, Teri L. The effects of a web-based intervention on the physical outcomes associated with diabetes among adults age 60 and older: a randomized trial. *Diabetes Technol Ther* 2007; **9**: 52-59 [PMID: 17316098 DOI: 10.1089/dia.2006.0057]
48 **Glasgow RE**, Kurz D, King D, Dickman JM, Faber AJ, Halterman E, Wooley T, Toobert DJ, Strycker LA, Estabrooks PA, Osuna D, Ritzwoller D. Outcomes of minimal and moderate support versions of an internet-based diabetes self-management support program. *J Gen Intern Med* 2010; **25**: 1315-1322 [PMID: 20714820 DOI: 10.1007/s11606-010-1480-0]
49 **Marios T**, A Smart N, Dalton S. The Effect of Tele-Monitoring on Exercise Training Adherence, Functional Capacity, Quality of Life and Glycemic Control in Patients With Type II Diabetes. *J Sports Sci Med* 2012; **11**: 51-56 [PMID: 24137063]

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