Overview of Telehealth and Its Application to Cardiopulmonary Physical Therapy

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ABSTRACT

Advances in telecommunication technology provide unique opportunities for the provision of medical services to underserved and geographically displaced patients. Health care professionals currently use voice and video systems to communicate with patients and colleagues in a variety of clinical venues. Unfortunately, such systems have limited presence in physical therapy settings. A variety of factors, including lack of familiarity with existing devices and perceived system purchase and operation costs, appear to be limiting its use. Even the terminology is confusing with such terms as telehealth, telemedicine, and telerehabilitation often used interchangeably. The purpose of this paper is to present an overview of this technology and to provide a clinical perspective regarding the use of telehealth in cardiopulmonary physical therapy practice.

Key Words: technology and health care, physical therapy

"The future has a habit of suddenly and dramatically becoming the present."

Roger A. Babson

INTRODUCTION

On March 10, 1876, Alexander Graham Bell summoned his assistant Thomas Watson using a crude voice monitor. Speaking from another room with the words, "Watson, come here; I want you," the telephone age was born.[1] Perhaps today Bell himself would marvel at the subsequent acceptance of his invention. From commerce to national defense, the telephone plays a critical role in global communication.

Health care professionals soon realized the utility of this medium with telemedicine surfacing as a unique variant to direct patient care.[2,3] Digital imaging, fiber optics, virtual reality, and other technologies now enable clinicians to assess and treat patients almost anywhere in the world.[4,5]

TERMINOLOGY

It is inevitable that new technology brings with it a new or unique terminology; telemedicine is no exception to this observation. Hetherington[6] defines telemedicine as, "a form of medical clinical activity that relies on telecommunicated information exchange for consultation, medical diagnosis, and patient care." Grigsby and Saunders[7] view telemedicine as, "the use of electronic information and communication technologies to provide and support health care when distance separates the participants." These same authors, in an effort to expand this definition to include allied health professions, also perceive telemedicine as, "encompassing all of the health care, education, information, and administrative services that can be transmitted over distances by telecommunication technologies."[7] Considerable confusion arises, however, when similar concepts are identified with different words: telemedicine vs. telehealth. The problem was initially exacerbated when much of the physical therapy literature appeared to reference the word "telehealth" preferentially. Although the concepts embraced are similar, there are important differences (Table 1). Therefore, in an effort to offer "…clarification between similar terms" and to present guidelines for telehealth use, the APTA Board of Directors (BOD) authored Telehealth – Definitions and Guidelines. This document provided the operational definition of telehealth as follows:

> "Telehealth is the use of electronic communications to provide and deliver a host of health-related information and health care services, including, but not limited to physical therapy-related information and services, over large and small distances. Telehealth encompasses a variety of health care and health promotion activities, including, but not limited to, education, advice, reminders, interventions, and monitoring of interventions." (BOD GO3-06-09-19)

Accompanying this definition and guidelines document was the position statement regarding appropriate use of telehealth technology:

> "It is the position of the American Physical Therapy Association that telehealth is an appropriate model of service delivery for the profession of physical therapy when provided in a manner consistent with Association positions, standards, guidelines, policies, procedures, Standards of Practice for Physical Therapy, ethical principles and standards, and the *Guide to Physical Therapist Practice*. Telehealth may be used to overcome barriers of access to services caused by distance, unavailability of specialists and/or subspecialists, and impaired mobility. Telehealth offers the potential to extend physical therapy services to remote, rural, underserved, and culturally and linguistically diverse populations." (BOD P03-06-10-20)

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This 2006 position statement followed an earlier version authored in 2001 (BOD P11-01-28-71). Telehealth is now the preferred term for all applications involving the delivery of health-related information and services, including telerehabilitation (Table 1).

Table 1. Telemedicine Terminology

Word	Definition
Telehealth[1]	The use of electronic information and telecommunications technologies to support long-distance clinical health care, patient and professional health-related education, public health, and health administration.
Telemedicine[2]	The use of telecommunications technology for medical diagnostic, monitoring, and therapeutic purposes when distance separates the users.
Telerehabilitation	The use of electronic communication and information technologies to provide rehabilitation at a distance.
Consult	A telehealth consultation whereby a patient's primary care provider consults with a specialist at a distant site while care remains the responsibility of the patient's primary care provider.
Encounter	A telehealth event involving patient contact such as a patient being treated directly by a provider at a distant site or cases involving the patient along with providers at both the distant and originating site.
Analog Transmission	A transmitted signal whose frequency is proportional to the source voltage and having limited bandwidth (eg, standard telephone).
Digital Transmission	A transmitted signal whose voltage is converted to numeric values which are sent in sequential order from source to destination (eg, physiologic data).
Store-and Forward	Information that is stored in a specific format and sent to a consulting provider for a diagnosis, interpretation, confirmatory opinion, second opinion, or for any reason that the input of the consulting provider is requested.
Real Time	Information sent from originating site to receiving site as it occurs rather than being stored for later transmission.

[1] The Office for the Advancement of Telehealth (OAT) of the US Department of Health and Human Services' (HHS); Health Resource and Services Administration (HRSA)
[2] Agency for Healthcare Research and Quality

One further point of clarification is helpful at this juncture. Telehealth related to physical therapy is often viewed narrowly as only teleconferencing or teleconsulting. In actuality, the concept is much larger than this and encompasses a myriad of telerehabilitation adjuncts including digital monitoring instruments, patient surveillance devices, and real time applications.

The telemedicine concept was introduced to Americans in an April 1924 issue of *Radio News*.[8] Featured was a drawing of a physician viewing his patient on a "radio screen." In 1951, the first cross-state demonstration of telemedicine occurred at the New York World's Fair and 6 years later Albert Jutras initiated teleradiology in Montreal, Canada.[8] This was followed in 1959 by a Nebraska Psychiatric Institute tele-education and telepsychiatry program offered in conjunction with the University of Nebraska.[8] By the 1960's, the National Aeronautics and Space Administration (NASA) was using "biotelemetry" to monitor astronauts. Biotelemetry was defined by NASA as, "a means of transmitting biomedical or physiological data from a remote location to a location that had the capability to interpret the data and affect decision making."[7] The biotelemetric data obtained included heart rate, body temperature, electrocardiogram, oxygen, and carbon dioxide concentrations.[8] Several years later, researchers considered the possibilities of transmitting diagnostic and clinical information over a standard analog telephone line. Other landmark telemedicine developments are presented in Table 2.

Table 2. Milestones in Telemedicine

Year	Project	Description
1967	Massachusetts General Hospital/ Logan International Airport Medical Station	Physicians at MGH provides medical care to patients at Logan using a 2-way audiovisual microwave circuit.
1971	Alaska ATS-6 Satellite Biomedical Demonstration	Twenty-six Alaska sites chosen to determine whether reliable communication would improve village health care.
1974	Video Requirements for Remote Medical Diagnosis	NASA and SCI Systems of Houston conduct a study to determine the minimal television system requirements for telediagnosis.
1984	Memorial University of Newfoundland (MUN)	Hermes satellite provide Canadians with an opportunity to use satellite technology in distance education and medical care.
1984	North-West Telemedicine Project (Australia)	Satellite network established to provide health care in five remote towns south of the Gulf of Carpentaria.
1989	NASA SpaceBridge to Armenia/ Ufa	NASA conducts first international telemedicine program after an earthquake in the Soviet Republic of Armenia.

Transmitted voice and video quality is a function of signal bandwidth; the larger the bandwidth, the better the signal quality. Bandwidth is defined as "the amount of information that can be carried over a transmission line per second." This is most often expressed as kilobits per second (Kbps) or megabits per second (Mbps). At the low end of signal transmission spectrum is "plain old telephone service" (POTS) with digital satellite lines having the greatest signal carrying capacity. A summary of bandwidths by transmission mode is provided in Table 3.

The infrastructure supporting signal transmission, specifically the connection from one site to another, is called

Table 3. Methods of Telehealth Transmission and Associated Bandwidths

Mode	Signal Capacity
POTS (Plain Old Telephone Service)	20 Kbps
ISDN (Intergated Services Digital Network)	128 Kbps
T1 (Terrestrial 1)	1.54 Mbps
E1 (European 1)	2.1 Mbps
T3 (Terrestrial 3)	45 Mbps
ATM (Asynchronous Transfer Mode)	1.54 - 622 Mbps
ADSL (Asymmetric Digital Subscriber Line)	24 - 30 Mbps
Digital Satellite	3.2 Gbps and Growing
Kibps = kilobits per second (one thousand bits of data per second); Mbps = megabits per second (one million bits of data per second); Gbps = gigabits per second (one billion bits data per second)	

a "pipe." Pipes include wires, cables, optical fibers, and microwaves. As mentioned previously, bandwidths carried by these pipes vary. The larger the bandwidth, the better the amount and quality of data transmitted over a line per second. The larger the bandwidth, however, the greater the cost of equipment in terms of installation, maintenance, and use. Thus the expense associated with high-quality signal transmission historically limited widespread clinical utilization. Fortunately, bandwidth is becoming less costly and with this comes renewed interest in telemedicine services.

USE OF TELEHEALTH IN PHYSICAL THERAPY RESEARCH

The number of published studies specific to telehealth and physical therapy is rapidly growing. On-line PubMed searches matching "physical therapy" with the search terms "telehealth," "telemedicine," and "telerehabilitation" produced 6, 63, and 18 citations respectively. Only 5 citations were found using the search terms "occupational therapy" and "telehealth." However, these results do not fully represent the work reported since some studies reside in professional journals not listed by Index Medicus or they include telecommunications applications not inclusive of the descriptors used above. Several examples are found in research published by Clark and Scheideman-Miller,[9] Dawson,[10] Marsh,[11] Miller,[12] Sekerak,[13] Shaw,[14-16] and Walsh.[17]

Although the scope of this paper does not permit elaboration of all published work, several creative telehealth studies are highlighted. In research conducted by Holden, Dyar, and Dayan-Cimadoro[18] at Northeastern University, a virtual environment-based (VE) telerehabilitation system was used to promote upper extremity mobility in 11 patients following stroke. The VE device permitted a therapist to implement exercise sessions remotely while patients remained at home. The results were encouraging based on improvements in function followeding 30 one-hour VE treatment sessions. In addition, most improvements persisted well after physical therapy services were discontinued.

Iwatsuki, et al[19] video-recorded 2 patients during the performance of various upper and lower extremity movements. These images were then transmitted via Internet to a hospital-based 3-dimensional motion analysis system. Physical therapists at the hospital subsequently studied the images and provided consultation regarding a physical therapy plan of care. The authors concluded that such technology was efficacious and could be used to store video data for recall and analysis at a later date.

Investigators in the Netherlands evaluated an interinstitutional voice-video communication system in a pediatric physical therapy setting.[20] They found that the low band-width analog signal used in these institutions provided poor image quality for teleconsultation purposes. Although this technical difficulty precluded total acceptance of the system, researchers concluded that communication between medical team members in addressing complex postural and movement disorders appeared to be promising for both patient referral and physical therapy interventions.

Each of these three studies is interesting from the perspective of varied application. Indeed, the potential of telehealth technology appears limitless for therapists.

USE OF TELEHEALTH IN CARDIOPULMONARY POPULATIONS

The bulk of published research specific to cardiopulmonary telerehabilitation is found in the exercise physiology literature. In 1998, Shaw, Sparks, and Jennings,[21] presented a comprehensive review of published research on the topic. Of the nearly 40 papers cited, the majority involved patients who exercised at home with monitoring provided by medical professionals at a distant facility. Unfortunately, broad use of what the authors coined "transtelephonic exercise monitoring" (TEM) ended with Medicare's definition of cardiac rehabilitation as being a "hospital-based" service. Immediate access to both a physician and resuscitation equipment became mandatory.[22] Notwithstanding this turn of events, TEM was found to be as efficacious as hospital-based cardiopulmonary rehabilitation programs relative to functional capacity improvement and program compliance. Further, despite the inclusion of participants with high risk cardiac conditions in 2 studies,[23,24] no circulatory arrests were documented in over 30,000 TEM sessions.

Recent studies involving patients with cardiopulmonary disease have largely moved away from exercise and have focused on other telehealth applications. Two papers are representative in this regard. Wakefield, et al[25] evaluated the efficacy of both telephone and videophone for improving the outcomes of patients with acute exacerbations of heart failure. They concluded routine nurse telephonic and video monitoring of symptoms delayed

time to readmission compared to patients receiving usual follow-up care. In a similar study of patients with chronic heart failure, Balk et al[26] used a hospital-based video system to educate patients in their homes. Although no significant differences were found between treatment and control group quality of life and self-care behavior outcomes, a significant improvement in heart failure knowledge was seen in the telehealth group.

Only one published telerehabilitation study pertaining to pulmonary disease was found. This was a case study of a college student with bronchopulmonary dysplasia (BPD).[27] Investigators described the use of telerehabilitation technology to monitor the patient during exercise therapy sessions. Real-time pulse oximetry and electrocardiographic data were obtained while the patient exercised on a motor-driven treadmill located at an external site. While no differences in pre- vs. postpulmonary function tests were found, improvement in functional aerobic capacity was observed. The authors concluded that adult patients with BPD could be safely monitored via telerehabilitation equipment.

A Sampling of Telehealth Success Stories

Although not all of the kinks have been worked out, there are a number of agencies who have developed successful telehealth programs. Three of these programs will be presented here. The first is the INTEGRIS TeleRehab program operating from Oklahoma City, OK. In the late 1990's, INTEGRIS personnel saw a need for remote rehabilitation services in rural Oklahoma. Following the acquisition of an Office for the Advancement of Telehealth (OAT) grant, INTEGRIS representatives met with the Oklahoma Physical Therapy Board (and eventually with the Occupational and Speech Therapy Boards) to describe the program. The Board received the concept favorably and encouraged program implementation. Initially, physical therapist-to-physical therapist consultation for patients with stroke was provided using a high bandwidth T1 line (Table 2) and Polycom® system. Successes achieved with the TeleRehab program prompted expansion into the realms of occupational and speech therapy as well. INTEGRIS has participated in numerous telehealth research endeavors to assess patient and clinician satisfaction, to investigate the validity of information transmitted, and to evaluate the efficacy of this mode of practice. Results of these TeleRehab experiences have been shared nationally at American Telemedicine Association (ATA) and APTA Combined Sections Meetings.[28]

A unique program combining store-and-forward technology with at-home monitoring has been developed by Pinnacle Health Home Care in Harrisburg, PA. This program targets patients with a history of cardiopulmonary disease. In a recent Home Health Section *Quarterly Report*,[17] Pinnacle employee Jennifer Walsh, MPT, described the rehabilitation program. Vital sign and bipolar ECG data obtained at rest and during exercise were sent to Pinnacle using the HomeMed® Monitoring system and ECG@ Home® thumb electrode unit. Vital signs are secured prior to and during therapy with patient status periodically checked via telephone contact with an RN at the monitor. Walsh reported a drop in re-hospitalizations from 40% to 9.1% that she attributed to the added surveillance. Improvements in walking distance and dyspnea were also noted.

In a slight variation to the Pinnacle program, BeyondFaith Homecare & Rehab, Inc. (Lubbock and Garland, TX) provides real time monitoring of patients during physical therapy sessions. An ECG transmitter worn by the patient emits a telemetry signal detected by a telephone modem in the patient's home. This modem then forwards the ECG data to a BeyondFaith central monitoring station for continuous analysis. Using a Bluetooth®-enabled cell phone, the physical therapist remains in voice contact at all times with monitoring personnel. This real time feature permits early detection of heart rhythm and ischemic changes before they become critical.

Telehealth Issues Remaining to be Addressed

As previously discussed, various branches of medicine have embraced telehealth technology for decades. Illustrations include teleradiology, telepsychiatry, telecardiology, and teledermatology to name a few. Yet upon careful analysis several issues unique to physical therapy still await resolution, such as how much ground does the "hands on profession" yield to this technology? Case in point, how does a manual therapy specialist properly evaluate and treat a patient without being physically present? What are the quality-of-care and ethical issues involved in interacting with patients solely by audio-video link? For example, how does a physical therapist assist with transfers or assure safety during ambulation, while properly monitoring vital signs? What about reimbursement and malpractice concerns? How do agencies properly bill for this service? Further, if a patient should fall during distance monitoring, who is responsible? Also, no additional Medicare payment is currently available for telerehabilitation in the home (Table 4). All of these concerns, and a myriad of others, appear to warrant a cautious approach by the profession toward carte blanche acceptance of this technology.

CONCLUSION

Imagine a large video screen located in a patient's home. Attached to this screen are various sensors designed to monitor vital signs, voice patterns, and gait deviations. A small microphone built into the system allows for continuous 2-way communication with a physical therapist. Now imagine additional peripherals which automatically determine joint angles and muscle force. Are these Orwellian imaginings of the future? The answer is no – most of this technology exists today. Like it or not, the age of telehealth is upon us. It now befalls all physical therapists to prepare for the reality of this exciting and rewarding future.

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Table 4. Getting Started Using Telehealth: Key Questions to Ask

Issue	Question
Scope of Practice	• Does my agency need to better serve rural and geographically displaced populations? • What grant or gift resources are available to assist with program development? • Are there marketing benefits to be realized by adding a telehealth program?
Quality of Service	• Will a telehealth program positively impact patient and/or therapist safety? • Does the quality of my practice improve with the addition of this technology?
Equipment Vendors	• Can the American Telemedicine Association (ATA) assist in locating an appropriate vendor? (Yes – contact ATA at: http://www.atmeda.org/ • Are there area telehealth programs interested in expanding services to assist my agency (ie, hospitals, universities, etc)?
Insurance Coverage	• Some states now pay for telehealth services (ie, Pennsylvania) – is this true in my state? • Are third-party payors in my area open to the idea of telehealth coverage?
Telehealth Regulations	• What local, state, and federal regulations may affect my application? • Will the state physical therapy licensure board approve of my new program? • Does my new program address published APTA telehealth guidelines?
Technical Support	• Can local telephone/cable companies provide necessary technical support? • Does my vendor offer reasonable service on, and replacement of, defective equipment?
Costs-to-Benefit Ratio	• Can sufficient revenues be generated to support my program? • How well will this new technology be accepted by physical therapists and the medical community? • Can the necessary equipment be leased?

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