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Biofeedback Via Telehealth: A New Frontier for Applied Psychophysiology[1]

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Psychophysiological diagnostic and therapeutic methods, to include biofeedback, have been found to be empirically effective in the treatment of a variety of physical disorders. In many areas of the country, however, certified biofeedback practitioners are not well distributed, limiting patient access to this treatment modality. Psychologists at Tripler Army Medical Center have pioneered efforts to develop and provide these needed services via a telehealth venue. Such capability significantly improves access to care, particularly for patient's located at considerable distance from the provider. As the telecommunications infrastructure in rural and remote areas is often quite basic, such a system must be capable of operating within these limited parameters. The system developed by the authors provides real-time video and audio interactivity and allows the therapist to monitor and control biofeedback equipment located at the remote site. The authors discuss the clinical applications, the technology, and relevant practical and ethical issues.

KEY WORDS: biofeedback via telehealth; telehealth; telemedicine; behavioral telehealth.

Telehealth, the new term for what was previously called telemedicine, is the use of telecommunications to provide health information and care across distance (Nickelson, 1998). Begun in the late 1950s at the University of Nebraska, the use of telecommunications technology to provide primary and specialty health care developed slowly but steadily during the 1960s through the 1980s, and has since grown exponentially over the last 5 years (Armstrong, 1998; Bashshur, Sanders, & Shannon, 1997; Coiera, 1997; Darkins & Cary, 2000; Jerome et al., 2000). In the medical and mental health arenas, this technology has been used primarily for diagnostic and assessment purposes, although recent attention has focused on the provision of treatment services as well.

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More recently, the term *behavioral telehealth* has begun to define the use of this technology in behavioral health care. Studies are currently underway to evaluate the feasibility and efficacy of providing clinical assessment and treatment services to patients at locations far removed from the clinician. Some of the programs currently being evaluated include two-way videoconferencing as the medium for providing obesity program follow-up, as well as the use of interactive web pages for patients to relay follow-up data to the clinician. Six-month results reveal that patients who receive follow-up services via telehealth have approximately the same percentage of body weight loss (7.0%) when compared to patients who receive in-vivo follow-up (7.5%; James & Folen, 1999). Studies are currently underway to assess telehealth versus in-vivo treatment equivalence in neuropsychological assessment, hypnotherapy, and tobacco cessation intervention.

The federal government and private health care systems are investing considerable resources in furthering the use of emerging technologies in health care (cf. http://prpo.tamc.amedd.army.mil). The goal is to increase patient access to primary and specialty care, as well as enhance the clinician's ability to acquire expert assistance with difficult clinical issues. Access to health care is a particular problem for those in rural settings, and telehealth is viewed as a mechanism for enhancing this capability. As the health care field and society in general develop a greater appreciation and awareness of mind–body integration, the need for interventions that effectively utilize these components in treatment is increasing. Biofeedback is one such application, where monitoring instruments are used to detect and amplify internal physiologic processes, then provide this information to the patient via auditory and visual feedback, allowing the patient to bring these processes under conscious control.

As biofeedback continues to demonstrate its utility in the treatment of a variety of physical conditions, clinicians are more likely to incorporate this treatment modality in the services being offered to the patient (Schwartz, 1995). Currently, the Biofeedback Certification Institute of America reports that there are 1,500 clinicians certified to provide biofeedback services in the United States. Most are located in urban areas, and the availability of this highly specialized service, like with many medical specialties, is severely limited in rural and lower socioeconomic (SES) settings.

At Tripler Army Medical Center, located on the Hawaiian island of Oahu, there are four psychologists trained in biofeedback. All are located at the medical center. Although this is often adequate to meet the needs of those federal health care beneficiaries located on Oahu, the Tripler catchment area covers the active duty military, their family members, and Pacific Islanders located in an area greater than 50% of the earth's surface. Flying the patient into Honolulu and providing the housing required for the 6–8-week period typically required for biofeedback training is prohibitively expensive. As a result, the Tripler Behavioral Medicine staff began to identify alternative methods for providing these services to distant patients.

NASA was the first institution to develop the use of telemetry to monitor physiological signals in order to determine the state of health of the astronaut in space. Their highly specialized equipment and programs monitor body temperature, heart rate, blood pressure, and a variety of other physiologic indicators, using sophisticated wireless systems. Scientists at the Life Sciences Laboratory have developed astronaut suits that incorporate a number of sensors with an attached light emitting diode (LED) biofeedback readout (Cowings, Toscano, Kamiya, Miller, & Sharp, 1985). The astronauts utilize this information to control

space sickness and orthostatic hypotension. This information is stored on a data belt worn by the astronaut and relayed back to the NASA scientists.

For most clinicians, the specialized equipment offered by NASA requires a level of technology and a budget far beyond what one can afford. In addition, the vast majority of remote sites lack the communications infrastructure to support such an operation. In a few highly selective rural sites, high-speed/high-bandwidth phone lines and broadcast quality interactive video communication equipment are available. However, at this time, the existing infrastructure in most rural communities will only support the telecommunications bandwidth available with standard phone lines.

SYSTEM DEVELOPMENT

With these telecommunication limitations in mind, we set out to determine the feasibility of providing remote biofeedback services utilizing equipment that placed a minimal demand on the communications capability of the remote site. The system designed also needed to be accessible to the patient, cost-effective to the clinician, reliable under a variety of conditions, and functionally capable of providing the equivalent of on-site biofeedback services. Thus, real-time visual and audio communications were required, as well as the capability to acquire, store, view, and manipulate the physiologic signal data in real-time.

Real-time combined simultaneous visual and audio communications have recently undergone major technological advancement, to the point that excellent audio and acceptable video signals can be sent over standard phone lines. The commercially available equipment selected for our project was the "8 × 8" VC105 set-top videophone developed by ViaTV (www.viatv.com). Other units (cf. www.leadtek.com) that include new refinements are also available commercially. All are designed to work over a single phone line. The unit used in our project attached to a standard TV and utilized a standard telephone for audio and control functions. It has a built-in high resolution color camera and has a maximum refresh rate of 15 frames per second (fps). Maximum data transmission speed is 33.6 K, although connections as low as 19.2 K provide an adequate video display. The unit works by compressing the video and audio signals so that they can be sent through the phone line at a rate that allows for an adequate refresh rate. It uses what is referred to as the H.324 standard (International Telecommunications Union), which specifies a common method for video, voice, and data to be shared simultaneously over a standard phone line.

To establish a videophone call, the sender and receiver must have H.324 compatible videophone units turned on at their respective site. One party then dials the other using a standard phone attached to the videophone. Once a connection is established, one party presses a key on the phone and the two videophones link up. This process takes approximately 60 s. No other operator intervention is required, and both parties can see and communicate freely with each other. The procedure to establish a connection is not complicated, but there are some drawbacks, albeit manageable, in the use of this *low-bandwidth* technology. Picture quality is not up to broadcast standards, and excessive movement will cause the picture to briefly "pixilate," or distort. Therefore, it is best to keep movement to a minimum. Adequate lighting is also necessary for the transmission of maximum visual detail. A telephone with a built-in full-duplex speakerphone is highly recommended for hands-free communication.

With this functional audio–visual communication system in place, developing a system to control the biofeedback equipment proved to be a more formidable challenge. We initially considered a system that would send raw data from the remote site over the phone to the host computer, which would process the data and then send the signal back to a visual display at the remote site. This proved to be a highly complicated process that required tremendous "bandwidth" (i.e., far more than standard phone lines will allow). We then decided to set up the biofeedback system (computer and biofeedback equipment) at the remote site. Using commercially available "remote control" software, we were able to control the remote computer. This setup was advantageous for a number of reasons. First, it allowed all computer-intensive activities (signal acquisition, processing, data collection, display) to occur at the remote site. The only signals required to be sent to the host were those necessary for the computer display. The only signals required to go back to the remote were those necessary to control the remote computer (basic mouse and keyboard commands). A number of remote control products are commercially available. Most are quite reliable, as was the product used in our project (pcAnywhere32, Version 8.0 [www.symantec.com]). To properly work with the biofeedback equipment, we found it necessary to use 100% Windows-based biofeedback software. For a number of technical reasons, biofeedback systems that were DOS-based were found to be completely incompatible with the remote control software. This was also true for DOS-based biofeedback programs running in a Windows environment. One system (and by the time of publication there may be others) found to meet the project criteria was the ProComp$^+$ system developed by Thought Technology (www.thoughttechnology.com). The ProComp$^+$ system uses the Biograph software package and is 100% Windows-based. Figure 1 illustrates the complete equipment setup.

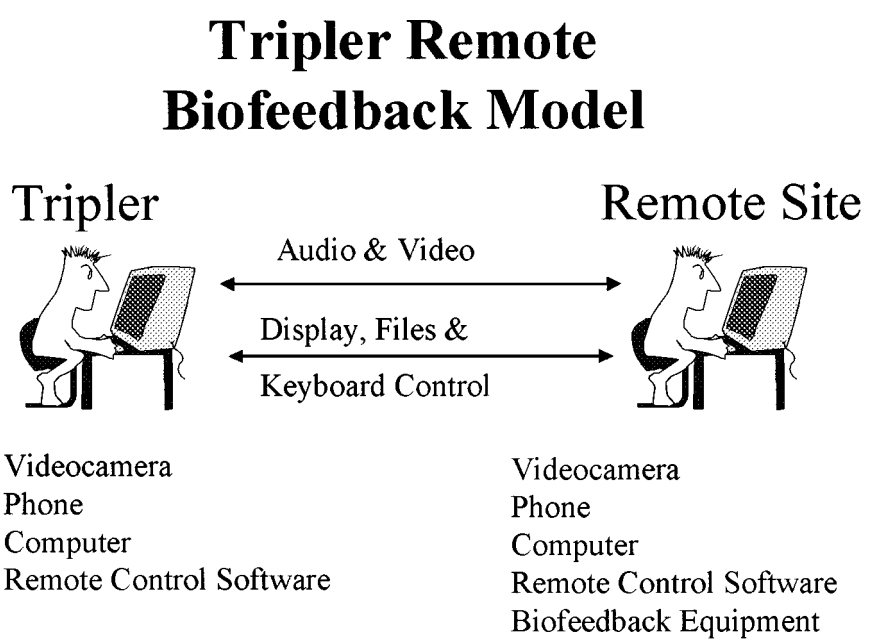

Fig. 1. Illustration of Telehealth Biofeedback Equipment.

PRELIMINARY FINDINGS

We have utilized the ProComp^{+}system with a number of patients. Initially, we tested the viability of the system in two separate rooms at the medical center. Connections were reliable and mean patient satisfaction was high (8 on a scale of 1–10). Patients were able to produce physiologic changes in the desired direction. Figure 2 illustrates temperature changes in two patients during the first 15 min of biofeedback following adaptation to room temperature. Patient 1 was a 38-year-old, married, Caucasian female U.S. Navy petty officer who was referred to the Behavioral Medicine Service for the treatment of migraine headaches without aura. She had an 18-year history of one migraine headache per month with a doubling in the frequency of headaches in the previous 3 years. The biofeedback via telehealth session was her sixth session of biofeedback treatment. Patient 2 was a 35-year-old, married, Caucasian female U.S. Navy petty officer who was referred to the Behavioral Medicine Service by the Neurology Service for the treatment of chronic daily headaches. She had a 4-month history of daily headaches. The biofeedback via telehealth session was her fifth session of biofeedback treatment.

In December of 1999, we established remote stations at the U.S. Army 121 General Hospital in Seoul, Korea, the U.S. Navy General Hospital in Yokosuka, Japan, and the U.S. Navy General Hospital in Guam. In each location, connections have been very reliable and patients are currently receiving biofeedback services for a variety of conditions. At this time, a study to more objectively evaluate the equivalency between telehealth and in-vivo treatment is underway.

One important practical finding has to do with the cost of providing services. We have determined that the total system requirements for establishing a remote biofeedback capability are as follows: one H.324 compatible videotelephone at each site, one TV and

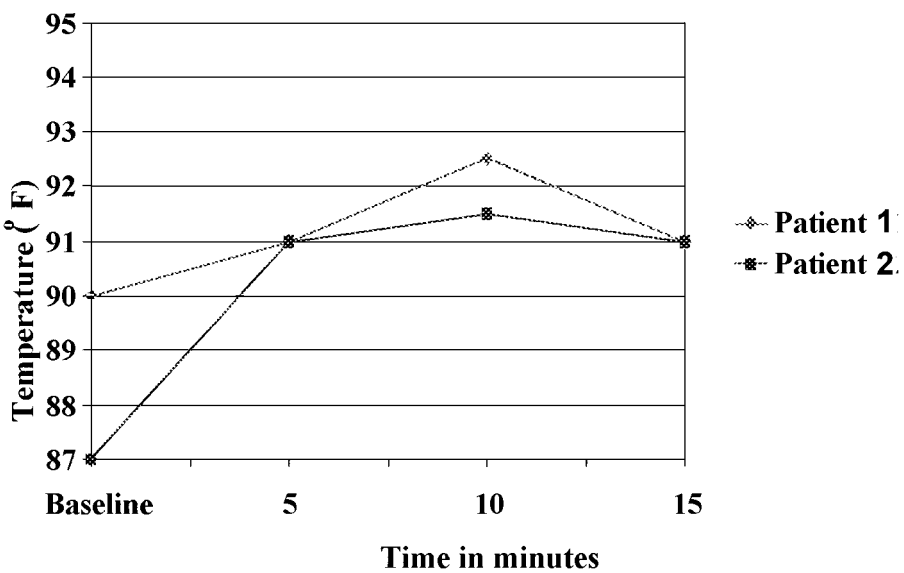

Fig. 2. Temperature change demonstrated with autogenic training during Session 6 with a patient with migraine, Patient 1, and during Session 5 with a patient with chronic daily headache, Patient 2.

telephone at each site, biofeedback equipment and software for the remote site, Pentium computer with modem for both sites, and remote-control software for both sites. Total cost for this system, not including the TVs or standard phones, was approximately $9000. The majority of that cost was for the biofeedback equipment and biofeedback software. Included in the total cost, the price for each videophone was approximately $450. At Tripler, standard in-vivo treatment involves the expense of transporting the patient from the remote site, as well as housing of the patient for the duration of treatment. These peripheral expenses cost approximately $4500 to treat a patient over a 6-week period. Total equipment cost has been recovered with the treatment of two patients. Thus, biofeedback via telehealth can be an extremely cost-effective means of treatment.

PRACTICAL AND ETHICAL CONSIDERATIONS

Other than basic biofeedback room environmental factors, the only infrastructure requirements for the remote site are two single phone lines (one for the videophone and one for the computer). The only other technical requirement at the remote site is the minimal training of a technician, sufficient for them to competently attach the sensors to the patient, turn the equipment on, and answer the phone. At that point, the practitioner has full control of the videocommunications and biofeedback equipment. The clinician can see and talk to the patient, while reviewing the computer display that is simultaneously being seen by the patient. The session data can be reviewed with the patient, and raw data stored on the remote computer can be easily downloaded to the host computer for subsequent analysis. The technology utilized for remote biofeedback training can also be used to control any hardware and software that is Windows-based. For the clinician considering implementing remote treatment services of this kind, there are a number of practical and ethical issues to be considered as well.

Equipment Costs

Until recently, the capital investment required to implement telehealth projects was prohibitive for smaller facilities. The more expensive telehealth systems can range in price from $20,000 to over $100,000. For these expensive models, a full-time technician and well-controlled environments are required in order to adequately maintain, monitor, and run such equipment. There is a natural tendency, particularly if funds are available, to purchase the “better” system. A more useful approach is to identify the minimum requirements necessary to provide the service and match that with the infrastructure that currently exists. In addition to significantly lower equipment costs, having minimum equipment infrastructure requirements allows for the greatest flexibility in establishing remote treatment sites.

Comfort With the New Technology

Despite recent advances, the technical aspects of telehealth can be intimidating. As a result, some professionals may be discouraged from participating in these programs. Clearly, the technology is such that a certain competency is required. For the equipment described

in this paper, however, a basic understanding of telephones and computers is sufficient. A willingness to learn and experiment with this new technology will help sustain the novice practitioner through the learning curve.

Exclusion Criteria for Patient Participation

Patients who are neurologically impaired may have difficulty incorporating the new learning necessary to respond via the telehealth medium. Some patients who have visual–spatial lesions or other right hemisphere disorders may have difficulty orienting themselves to the equipment. Although conversing with others is a well-learned behavior, talking to someone through a video display is not. Further, those with visual impairments may have difficulty recognizing facial expressions through the poorer quality VTC images. Image quality is dependent on modem speed, something that can be affected by distance and "dirty" phone lines. Thus, the images projected on to the television monitor may vary in quality, the degree of pixilation, and audio–visual dysynchrony.

Exclusion criteria would also include patients who are psychotic or suicidal. Despite careful screening, the possibility of a serious psychological problem presenting itself at some point during treatment still exists. For this reason, clear and reliable backup emergency procedures should be in place prior to conducting treatment or evaluations via telehealth.

Time Zone Differences

Most behavioral telehealth occurs within a few time zones of each site, although services have been provided as far as halfway around the globe. The Tripler project provides treatment to patients in Guam, Japan, and Korea, considerable distances from Hawaii. This may have a limiting effect on the availability of appointment times. For example, an appointment scheduled with a patient at 3:30 p.m. on Tuesday in Japan requires the clinician in Honolulu to be working at 8:30 p.m. on Monday.

Consent and Privacy Concerns

Norton, Lindborg, and Delaplain (1993) have provided some guidance on the issue of patient confidentiality/privacy and telemedicine. They have developed a consent form that provides the patient with rights to limit what is seen by others, explains the limitations to privacy inherent in the medium, and asserts the patient's right to discontinue the telecommunications activity at any time. Following this model, it is recommended that patient consent be secured prior to the video consultation. While security issues are of particular concern with internet telecommunications, the system described in this paper does not have the threats to security inherent in the internet, as all communication occurs over relatively secure phone lines. An example of a telehealth consent form is given in the Appendix.

The In-Vivo Bias

Allaert and Dusserre (1995) assert that the in-vivo physical examination is always preferable to examination by "tele-assistance." Moreover, they argue that "the excessive use

of tele-assistance when there is neither an emergency nor medical isolation is dangerous because it affects the integrity and quality of the medical act." We have found no data to support this assertion. Although it may appear that face-to-face contact is preferred, no well-controlled comparison of treatment modalities has been reported. In fact, with some patients, we have observed increased attention and comfort with the therapeutic process when the patient was switched to a telemedicine venue.

Licensure Across State Lines

Crump and Pfeil (1995) and Nickelson (1996) discuss the problems associated with practicing telehealth across state lines. Despite Medicare regulations supporting the use of telehealth technology, many states continue to prohibit providers from "crossing" state lines. At least one state has passed legislation expressly prohibiting telemedicine by providers located in another state. Violation of a state practice regulation, according to many professional organizations, is a violation of their ethical code. Anticipating this problem, some professional, state, and national associations are actively supporting telemedicine guidelines and uniform state licensing laws.

One should contact the state license board where telehealth is to be practiced in advance. Justification may be required in order to acquire a "telehealth waiver" to practice.

Hospital Credential Issues

Within a state, a provider of telehealth services treating a patient at a remote hospital may need to attend to credentialing issues at the remote hospital site. These issues are potentially complicated and may need the attention of hospital practice boards. All providers seeking to conduct telehealth services are encouraged to secure courtesy staff privileges at the representative site. In the absence of such privileges, the provider may need a colleague at the remote hospital to take overall responsibility for the patient's care.

Liability Issues

There are few, if any, legal precedents established yet for behavioral telehealth practice. The use of this medium may increase one's legal exposure, particularly in cases where an undesired treatment event occurs.

Insurance Reimbursement

The provision of treatment via telehealth is relatively new, and the vast majority of insurance carriers have not adequately developed reimbursement policies for such services. Medicare is a notable exception, although it appears that problems with this enabling legislation are still being resolved. There are reports that some insurance companies in the northern United States are reimbursing for telehealth services. Major marketing and lobbying efforts, as well as enabling legislation, will be needed to engender recognition by HMOs and insurance companies.

DISCUSSION

Biofeedback has undergone many technological changes and challenges since its inception. The field has moved from stand-alone equipment to the computer driven packages available today. Historically, biofeedback practitioners have been quite responsive to technologic changes designed to improve patient care. As the information age fuels technological advancements, a new extension for the provision of biofeedback services is now available. Up to this point, biofeedback has relied on the patient and provider being in the same location. This has severely limited access and continuity of care for those unable to come to the biofeedback professional.

The implications of telehealth biofeedback are far-reaching. By establishing satellite locations complete with equipment and minimal technical support, urban and rural patients may now receive services at distances that previously would have prevented biofeedback treatment. A whole new population of patients who in the past were unable to present for biofeedback treatment because of a lack of facilities or trained professionals now have access to care. Patients lost to premature termination will now be able to obtain follow-up treatment from a distance.

The implications of this application may extend well beyond the circumscribed area of biofeedback. Many medical assessment and treatment procedures that rely on Windows-based computers may be appropriate candidates for telemedicine. Services that primarily involve monitoring, or where clinical skills focus on visual/verbal communication and computer display and control, may best lend themselves to remote applications. When actual physical contact with the patient can be managed by a technician, the intervention or assessment procedure can often be managed remotely (Strode, Gustke, & Allen, 1999).

At this point, a number of questions remain unanswered. Although our preliminary findings suggest that telehealth biofeedback may be equivalent to in-vitro treatment, studies to support this assertion need to be conducted. Standards for patient care also need to be established, as the practitioner has a more limited ability to control aspects of the treatment encounter. For example, if one is faced with a suddenly suicidal patient, the need for adequate backup at the remote site becomes patently obvious. There are also concerns about licensing requirements and insurance reimbursement, issues that the entire telehealth community is struggling with. In several early studies, behavioral telehealth has proven to be cost-effective and efficacious and significantly improves patient access to care. For these reasons, the benefits of telehealth will likely far outstrip the growing pains associated with the emerging technology.

APPENDIX: TELEHEALTH CONSENT FORM

Date:_____
Patient Name:_____ SSN:_____

The reasons for this telehealth treatment/consultation have been discussed with me. I understand that the reason for my treatment through telehealth is(are):

_____

_____

_____

What will be done with the video taping of my treatment has been discussed with me. I agree/do not agree for my doctor to use the tape for teaching/research. My doctor discussed with me the limits of confidentiality in regards to who will be in the telehealth room and may see the video transmissions. Also, my doctor discussed with me his/her concern for my safety and that he/she will contact the proper authorities if I become a danger to either myself or others. I volunteer to participate in treatment through telehealth. I understand that I can discontinue telehealth video taping at any time, can request the removal of persons from the room during telehealth video taping, and that I have the right to stop treatment if I desire.

Patient Signature:_____
Provider Signature:_____
Witness Signature:_____

REFERENCES

Allaert, F. A., & Dusserre, L. (1995). Legal requirements for tele-assistance and telemedicine. *MEDINFO 95 Proceedings*, *8*(2), 1593–1595.

Armstrong, M. L. (1998). *Telecommunications for health professionals: Providing successful distance education and telehealth*. New York: Springer.

Bashshur, R. L., Sanders, J. H., & Shannon, G. W. (1997). *Telemedicine: Theory and practice.* Springfield, IL: Charles C. Thomas.

Coiera, E. (1997). *Guide to medical informatics, the internet and telemedicine.* New York: Oxford.

Cowings, P. S., Toscano, W. B., Kamiya, J., Miller, N. E., & Sharp, J. C. (1985). *Autogenic-feedback training as a preventive method for space adaptation syndrome* (NASA Flight Experiment #3AFT23. Spacelab-3. Progress Report I. NASA Conference Publication #2429: Spacelab 3 Mission Science Review, pp. 84–89).

Crump, W. J., & Pfeil, T. (1995). A telemedicine primer. *Archives of Family Medicine*, *4*, 796–803.

Darkins, A. W., & Cary, M. A. (2000). *Telemedicine and telehealth: Principles, policies, performance, and pitfalls.* New York: Springer.

James, L., & Folen, R. (1999). Behavioral telehealth: Using telemedicine to expand behavioral medicine services. *Journal of Healthcare Information Management*, *13*(4), 17–25.

Jerome, L. W., DeLeon, P. H., James, L. C., Folen, R. A., Earles, J., & Gedney, J. J. (2000). The coming of age of telecommunications in psychological research and practice. *American Psychologist*, *55,* 407–421.

Nickelson, D. (1996). Behavioral telehealth: Emerging practice, research and policy opportunities. *Behavioral Sciences and The Law*, *14*, 443–457.

Nickelson, D. (1998). Telehealth and the evolving health care system: Strategic opportunities for professional psychology. *Professional Psychology: Research and Practice*, *29*(6), 527–535.

Norton, S. A., Lindborg, C. E., & Delaplain, C. B. (1993). Consent and privacy in telemedicine. *Hawaii Medical Journal*, *52*(12), 340–341.

Schwartz, M. (1995). *Biofeedback: A practitioner's guide.* (2nd ed.). New York: Guildford Press.

Strode, S., Gustke, S., & Allen, A. (1999). Updates linking evidence and experience. *JAMA, 281,* 1066–1068.