

DISCUSSION OF AFTERNOON PAPERS

Dr. Basmajian: I propose in this final discussion period to have ten or fifteen minutes of directed discussion of an area that has been neglected so far in these discussions, and that is, animal or quadruped locomotion studies, and how they fit into the picture. I hope that the neurophysiologists and the other persons in the group who work with animals will take the leadership in this discussion. Then, I propose that Dr. Akeson and myself try to summarize what has happened during the day and with your help establish some national priorities in locomotion and gait studies. This would be our collected opinions about the needs in the field and some concept of the ways that those needs are being met and how they might be better met in the future. We might also discuss who should have fiscal responsibility for meeting these needs. This may be an impossible task; then again it could be an approach that could be useful at several levels of government, as well as providing some criteria for the Study Section.

Dr. Stein: I would like to make a few brief comments that will give you some idea about current research on animals. One of the things we can do in animal studies that may be useful to people in the human areas, is to study the role of sensory feedback. Over the last couple of years our group, and others in various places around the world, have developed techniques which permit us to look at the sensory fibers not as they are activated in anaesthetized animals but as they function in behaving animals, e.g. animals walking on the treadmill. Within the next few years, basic neurophysiologists will probably be able to provide some information on the normal roles of various sensory fibers.

Another area where some interest is developing is the question of the flexibility of the nervous system; the extent to which retraining might take place if you cut nerves and resuture them in appropriate ways. A related area that has been totally absent from our discussions is bio-feedback, and whether it can be of any value in training people who have an inappropriate pattern of activity, to show them their pattern, and ask them if they can do anything about it. A third item that I could mention is an area that is receiving intense effort on the part of basic scientists, namely the hierarchical organization of the motor systems. We have all been brought up on the idea of spinal reflexes, but now neurobiologists can record from the motor cortex and cerebellum with microelectrodes. With these electrodes it is possible to record activity in brain cells during behavior and it is becoming more and more apparent that in addition to the basic spinal reflexes, there are cerebral and cerebellar "reflex" pathways which are affected to a greater or lesser extent, depending on the pathology. In the last couple of years it has been shown, for example, that a "long-loop" pathway involving the motor cortex is affected in Parkinson's disease, and maybe in some other pathological conditions.

Dr. Basmajian: Perhaps Dr. Perry can comment on this.

Dr. Perry: The ability to respond to biofeedback depends on the level of selective control the patient has retained or regained. It certainly is an excellent way of instructing the patient on how he should try to perform compared to how he currently is doing. His ability to respond depends on existence of selective control pathways which let him instruct his muscles appropriately. Voluntary activation of primitive mass action patterns also may yield some gains if the total limb function includes the desired activity without inducing unwanted events as well. Patients who move only by reflex or automaticity will not profit.

Dr. Basmajian: My experience with biofeedback in gait has been limited to training spastic patients to inhibit specific muscles. When you talk about your experience--when a person says "in my experience,"--it means one case (laughter)--but if he says "in my series," he's had two cases, and if he says, "in case after case after case," he's had three patients. So in case after case after case, we have been able to train teenagers who have cerebral palsy with spasticity, to inhibit the spasticity during locomotion. But we have not had long experience in this area and we certainly have not had long experience with some of the smaller muscles. In a few patients with spastic equinus deformity, we could train them to put their heel on the ground.

The possibilities in biofeedback will require a great deal of research. A small fraction of the total population of patients we are concerned with, might benefit from biofeedback training. But it's not going to solve the problems of the majority.

Dr. Houk: I would urge the people who are working in this area to acquaint themselves more fully with the recent, very exciting work that is being conducted on animal locomotion. These studies have revealed some basic principles of motor control in tetrapods that is probably relevant also to the bipedal gait of man, although some of the details may differ, due to the inherent mechanical differences between two-legged and four-legged posture. There are three recent reviews on different aspects of these studies: M.C. Wetzell and D.G. Stuart, Ensemble characteristics of cat locomotion and its neural control, Prog. in Neurobiol., 7:1-98, 1976; J.L. Shik and G.N. Orlovsky, Neurophysiology of locomotor automatism, Physiol. Rev. 56:465-501, 1976; S. Grillner, Locomotion in vertebrates: central mechanisms and reflex interaction. Physiol. Rev. 55:247-304, 1975; and there is a useful book that summarizes a recent symposium on locomotion: R. Herman, S. Grillner, P. Stein and D. Stuart, Neural Control of Locomotion, Plenum Press, New York, 1976. I would also like to call attention to recent developments concerning the mechanisms and function of the stretch reflex in the control of muscle length and tension. I have summarized this latter area in a recent review chapter: J.C. Houk, Participation of reflex mechanisms and reaction-like processes in the compensatory adjustments to mechanical disturbances, in Cerebral Motor Control in Man: Long Loop Mechanisms, J.E. Desmedt, ed., Progr. in Clinical Neurophysiol. Vol. 4: Karger, Basel, in press. The chapter by Nashner in the same book also contains information that would be useful to those of you studying gait.

Dr. Basmajian: Jim, there are differences in the biomechanics, but don't you think that the basic neurophysiology is related or evolutionary to the bipedal locomotion of man?

The intermediate animal that we've been studying for some years at the Yerkes Primate Center is the gorilla (and a few chimpanzees, and other apes). We find that there are more similarities than dissimilarities between man and ape when the ape attempts to walk bipedally for reasons such as when you hold up something they want to get above their heads. There are more similarities than dissimilarities in gorilla locomotion on two feet. The dissimilarities would seem to be biomechanical; that is, the gorilla, to stand upright, has difficulty that is based upon its anatomy between the lower thoracic region and the hip joint. But given enough incentive, when he does walk bipedally, there are more resemblances in the electromyography than we had expected. This includes the gluteus maximus muscle which physical anthropologists said for half a century was the limiting factor to preventing the gorilla walking on two feet.

Dr. McMahon: Let me say some words about animal workers in gait. Together with my colleagues, C.R. Taylor and Farish Jenkins of the Biology Department at Harvard, I have been interested in the extent to which running is like the bouncing of a ball. There seems to be the following evidence in support of that analogy.

Firstly, if you look at the frequency of striding during galloping, it is nearly constant in quadrupedal animals. As the animal runs faster, he takes longer steps, but doesn't increase stride frequency. A simple theory which assumes the animal behaves like a hunk of rubber vibrating like a tuning fork can make the correct prediction of stride frequency as a function of animal size, from mice to horses.

Secondly, a new technique we are using shows that the tendons store enormous quantities of energy during a running stride cycle. We tie steel balls inside the achilles tendon (lateral gastrocnemus tendon) and run the animal on a treadmill before a high-speed x-ray machine. The tendon stretches by more than 5 percent while the foot is on the ground. This represents a storage of elastic energy of nearly 40 percent of the energy required to take a stride.

Dr. Basmajian: Tom, that was a lovely dissertation. It raises all sorts of questions. I think you're familiar with the work of Ed Taub on the deafferented monkeys--the amount of residue of behavior--of apparently normal behavior that remains in monkeys who are almost completely deafferented at an early period in life. They manage to walk pretty well and get along quite nicely. We would all assume that such an animal would be like a human being who is denervated in the lower limbs and would be in similar trouble. But the Taub monkeys are not in bad trouble; they can do all sorts of things.

Does the roundtable see as a problem the fact that man's locomotion is practically entirely a learned phenomenon; one that is learned rather late in life compared to most of the quadrupeds you've been referring to, who

were born with a genetic pattern of locomotion, and only hours after birth are beginning to imitate their adult counterparts? When I say learn, I mean at a fairly conscious level. A baby learns to walk by imitating what its parents are doing. Then there is a progression over many years in acquiring the adult pattern of locomotion, to the point where it is said, a person's footfall in the corridor can be recognized as that person's signature. In learning this pattern, do we have something that is truly human and different than other animals:

Question: Can man walk like a gorilla?

Dr. Basmajian: It's not easy. My colleague who worked mostly with the gorillas would get down and play with them, and do their kind of locomotion, and he'd become very tired; his back got tired.

Let us now discuss the presentations of Drs. Perry, Murray, and Chao, and the issues that were raised in their papers.

Dr. Rose: To turn to a more general question, that of the characterization of normal gait, one accepts this pattern as an optimum means of locomotion. We have a system however, with different capabilities and different limitations and the question I wish to pose is, why in that case do you accept normal gait as the optimum means of locomotion--in other words, why shouldn't some people limp?

Dr. Basmajian: That's a very good question. Why shouldn't you even attach wheels to their knees and have them roll along? Why do we have to be so anthropocentric in our thinking? Why do we have to have knee joint replacements which are absolute duplicates--except for the embarrassing fact that they will not work otherwise. Dave, why don't you give them the San Francisco dicta about what are the limitations of gait? Can you remember the six determinants of gait?

Dr. Sutherland: The six determinants are: pelvic rotation, pelvic tilt, knee flexion in the stance phase, foot and knee mechanisms (4th and 5th determinants), and lateral displacement of the pelvis. A patient with an intact control system can lose one or two determinants and still maintain an even passage of the common center of gravity without rise in energy consumption. Loss of two or more of the determinants makes full compensation impossible. Patient will walk with exaggerated displacement of the common center of gravity and accompanying increasing energy demands.

Dr. Basmajian: A patient who has lost four of the determinants has to decide whether he prefers a wheelchair.

Dr. Stein: One must accept the fact that you have a system which is optimized originally with regard to consumption of energy.

Dr. Simon: Although your statement may be correct, it remains to be proven whether the final goal any individual with a pathological disorder or any treatment program initiated to correct such disorders strives to achieve is an optimization of energy consumption. Someone who has a disability may be incapable of achieving the normal minimal levels of energy expenditure when walking. It is possible that he may be trying to optimize his total

energy to the best of his ability. Nevertheless, this attempt is not as good as the normal and clearly may be defined as an impairment. But, it is also to be noted that there are other impairments present. Pain, loss of motion, overall stability, and balance are just some of the other impediments present in an individual's pathological gait. The individual must deal and compensate in some way for all of these if he is to walk. Under such circumstances, it is not clear which factor he "optimizes" or gives priority to. Loss of stability may stop the individual from taking one step. Pain may stop the individual from walking after two or three steps. But, increase energy cost may only stop an individual from walking after some distance is traveled; when further progression becomes extremely fatiguing. The item of acceptability then is the one that achieves maximum forward progression (in distance). Energy expenditure may, therefore, be the significant factor only in the case of normal subjects. Clinically, we are subconsciously aware of this situation all the time in prescribing different treatments. Braces are used to achieve stability even though they may be increasing energy expenditures. To then relate the situation in normal subjects to that which exists in subjects with pathological disorders may be like mixing apples and oranges. It remains for us to ascertain in each disorder which are the prime factors optimized and how the situation is altered by treatment. The item of the acceptability of the method of progression is significant. Otherwise, the minimum oxygen consumption for all is a motorized wheelchair, and yet we don't choose it. We're mixing apples and oranges, and we do that clinically all the time. We make different optimizations as it were, for different patients, because of their own reactions to their disabilities.

Member: I think there's more to it than that. There's evidence that we do have a good hand on it--the things the patients are happy with when we do optimize them. They do like to have a certain rate of progression; they do like to be able to minimize energies. One can see these things as satisfying. They may be arbitrary, but they certainly solve some of the problems.

Dr. Simon: Certainly, in many cases, either because of the nature of the disease or the treatments available, energy expenditure becomes the rate limiting factor. With oxygen consumption studies, we have an objective method of measuring one aspect of energy expenditure. It is, however, an incomplete measure since it only reflects the aerobic metabolism of the body during walking. Nevertheless, it does provide us with a good indicator in some patients of their walking ability. At certain institutions such as Rancho Los Amigos Hospital where studies of O₂ consumption have been performed, it has been found that once we start increasing our O₂ consumption, we find there is a point at which an adult ceases to walk. Clinically, we are aware of this phenomenon occurring with various disabilities. As young children they may walk but with growth as their body mass increases and energy cost rise, they stop walking.

Dr. Perry: The rate of progression is important for the slower a person goes the longer time he must expend his energy. Hence energy cost per meter becomes a significant functional measure. Further with more severe limb impairment the person cannot exercise sufficiently to develop his energy

production system. That is to train heart, lungs, and muscles for oxygen delivery in extraction. With a limited energy production capability a "normal" minute energy cost becomes relatively higher.

Dr. Basmajian: The time, ladies and gentlemen, has come for thinking about some kind of summation, and I would like to suggest that we spend the remaining time discussing the possibility of some national priorities for gait laboratories and gait research, to act as a stimulus for further growth in this area. First, can priorities be set? Is there any way in which we can agree that there are priorities? Is there anyone who has a strong feeling there are no priorities?

Dr. Burstein: We have assembled here people who are deeply interested in the outcome of gait studies, and who have been deeply involved in this area for quite a while. If one can generalize and offer a useful outcome, I would suggest certain things. For example, when we look at gait laboratories and gait studies, I might suggest that we've been developing them using the patient for approximately 30 years. We've reached the stage in development where there is a wide range of instrumentation available, at a wide range of costs, and certain degrees of sophistication, and that we probably, at least in my opinion, should consider developing new instrumentation only if we can show that it serves the needs in reaching some goals that are not yet available to us. If you want to talk about a priority, then the development of new conceptual instrumentation should be based on an established need to go over and above the capabilities of existing instrumentation. I'm not talking about number of facilities. That's an entirely different question, but my personal feeling, from the point of view of one involved in instrumentation, is we have more capabilities now than we have uses for it.

Dr. Basmajian: But Al, that's sort of a negative priority.

Dr. Burstein: I didn't get to the positive ones. I just wanted to throw this umbrella idea over the whole area. What about the direct measurement of muscle force? I don't think that one has to worry at this point about developing a kinematic system that can resolve at intervals of let's say, greater than two millimeters. I don't think it is worth the cost, in light of other things we have mentioned. But, if one could measure muscle force, and there's a demonstrated need to do that, because there are clinical questions that have to be answered directly...

Dr. Basmajian: Direct, clearly on-line measure of muscle force...

Dr. Burstein: ...that certainly would be an interesting extension of our instrumentation capability. There possibly are one or two others--and I'm not saying, don't develop them, but I think we should be critical in the expenditure of time and effort at this point. You can become too caught up in the ability to measure things more precisely and more quickly and more rapidly. It doesn't always lead to more progress.

Dr. Basmajian: Can we debate this concept that the state-of-the-art of gait studies in man is now sufficiently developed so that we need not be encouraging major developments--major improvements--in instrumentation?

Members: Pros and cons.

Dr. Basmajian: We agree then that the state-of-the-art in human gait studies is sufficiently advanced so that a major investment to improve upon them is not a top priority. So can we say that reducing the complexity of clinical diagnosis and prognosis, is needed?

Dr. Burstein: I'd put it more strongly than that. I would say right now we have almost no clinically-useful diagnostic tools that can be taken outside of the very heavily-financed research laboratory. There's a complete imbalance between capabilities in a research center...

Member: ...where you may very well do clinical work, but that's not the question. But outside of the heavily endowed research center (with few exceptions) you do not have the capabilities of doing gait analysis/or research.

Dr. Basmajian: What about the need for and understanding of normative data?

Dr. Burstein: Requests to support the procurement of normative data should be evaluated on the basis of individual merit. I think the only thing to establish (in terms of priority) is if somebody sees an area of normative data that is missing and it's related to their clinical interests--then the priority on that is as high as the clinical need or the area of associated investigation. Normative data is necessary in any basic science--especially in the medical and biological sciences. We always talk in terms of studying the abnormal and that inherently implies that we need normative data.

Dr. Perry: All gait laboratories are equipped with multipurpose systems. Many are put together in rather a prototype fashion which requires repeated calibration and adjustment by the staff. For wider application of gait analysis clinically reliable dedicated systems are needed. This should be one objective in improving the development of gait instrumentation. The fact that most gait laboratories are not regularly providing clinical measurements identify that all these laboratories are not set up to do so. Also all laboratories do not measure the same factors. There still needs to be interpretations that will identify which data proves useful guidelines for physicians and therapist.

Dr. Stein: If we say that human gait labs are well set up and well instrumented, then the question is, what are the related studies on animals and when can they begin? In animal studies the idea of looking for general principles, by looking at a broad spectrum of animals, needs to be pursued.

Dr. Childress: Dr. Chaq brought up an important point which I should like to emphasize. This is the need for cooperative efforts among the existing gait laboratories. Funds are limited and progress will be slower if the 20-25 laboratories in this area work independently.

We know from such fields as molecular biology and high energy physics that great strides can be made through tightly drawn communication channels. Would an internal sharing of data and information before it is published be beneficial or feasible in this small field?

Dr. Basmajian: That is almost an outcome of the decision that if the state-of-the-art is good, then obviously we move to the situation where we need cooperation. And how do we get that cooperation? Do we have one group acting as a clearing-house? If not necessarily a coordinating center, a clearing-house. And would, for example, NIH accept a grant application for a department to be a clearing-house for information on gait studies? It might not be a very attractive job, but it is a possible way to proceed. Do we then feel that cooperative effort is a high priority, by any technique?

Member: In a meeting with Dr. Fredericksen (Director, NIH) one of the things he pointed out was that in the future we may have work with less in grant funds, and that more cooperation between institutes and between agencies of the government, will have to be developed to best utilize available funds.

Dr. Basmajian: A substantial number of Mickey Milner's list of gait centers are outside the United States, of course, and are doing work as impressive as that which is being done in the U.S. Something could be worked out, surely. So I gather that we see the state-of-the-art as satisfactory for human-based studies in locomotion but that the future emphasis should be on cooperation and sharing. I might ask Dr. Burstein about sharing efforts; he was in a group that tried to get together and standardize techniques some time ago. Did anything ever come out of that as far as gait studies are concerned?

Dr. Burstein: The activity itself was useful. It occurred in 1969 to 1972. The report finally appeared about two years ago. But the activity itself was very useful to all of us in gait, and considerable standardization was achieved. The standardization was probably of secondary value for the fact that during that time we all learned a tremendous amount and were able to keep fully apprised of what was going on. There is, by the way, a publication that is circulated to people doing gait analysis.

I might also mention another whole group who uses gait laboratories but who are not represented here, that is the people involved in athletics. There are probably more of those facilities than now represented on our lists. Their activities are useful; unfortunately, they do have to be supported, but the benefit that you obtain from their work far exceeds support costs.

Dr. Basmajian: Did you have them in your earlier group? Did any of the athletic researchers...

Dr. Burstein: No.

Dr. Basmajian: Does CPRT sponsor most of their work?

Dr. Burstein: Yes.

Dr. Basmajian: And SRS used to sponsor some things, and the Veterans Administration also is interested. So there are some agencies who have shown interest.

So we're talking about state-of-the-art, not about individual devices. The state-of-the-art is sufficiently developed so that small variations are not as important as they once were and they should be interchangeable; the emphasis should be on interchangeability.

Member: Just on that point could I say that, as more and more people go into the field and need equipment, a lot of time and effort will go into acquiring and standardizing it.

Dr. Buskirk: In the same vein, Simons described the standardization with respect to the techniques for making the measurements--but you also need to standardize terminology. Then if you put these two together, it seems to me that you're going to know whether you're talking about the same measurements.

Dr. Stein: I was wondering whether the other side of the coin of your projection about the state-of-the-art and technology meant that applications for the establishment of a gait lab would be looked upon with disfavor by funding agencies?

Dr. Basmajian: That implication might be read into it by outsiders, but I don't think that really is the inference we should take here. Probably what we've been saying is that if someone comes along and says, "I want \$100,000 to improve upon a forceplate" or some such thing, that wouldn't be looked at with great enthusiasm. But if someone decides to conduct research using current methodologies, preferably in an existing lab, that would be looked upon with more favor. But we're not really discussing grant applications at this workshop.

Member: Is any priority being put on human work, rather than animal? Or is research to be judged entirely by the merit of the questions being asked?

Dr. Heiple: There is no question that the Applied Physiology and Orthopedics Study Section has both approved and given high priority scores to meritorious proposals involving animal models, if they looked at important questions in relation to fundamental problems in gait or locomotion.

Dr. Basmajian: I think that the tendency to consider human gait work came out strongly today. I doubt whether this Study Section can afford to look at it simply because it has to do with human gait, but rather to look at its value and the questions that are being asked. I don't know how to put a priority figure on that. I imagine that's always been one of the NIH's requirements--that the questions being asked are valid. You are suggesting that good questions have priority--I think that's automatic, we expect that.

Dr. Buskirk: Just for our enlightenment here, and since I do not know what is going on in the area, what training activities are available, and how do you set these up, and is there a priority that needs to be established? What's the optimal mix in personnel? I see looking at the programs in the Milner list, that the basic interests appear to be locomotion. That is about the only common feature that you see.

Dr. Basmajian: Good question. Are there some other kinds of priorities, such as training?

It seems to me over the several years that I've watched the growth of gait labs, that half of them result from someone moving to a new institution where he or she has to have a gait lab. They do not seem to spring up otherwise; they are a shift, the result of people leaving and going somewhere else. There's one now, for example, in Waterloo, Canada--it moved from Winnipeg to Waterloo; there's one now at McMaster because Mickey Milner moved to McMaster, and Dave Sutherland moved here, (i.e. San Diego) so there's one here now. Do we need some sort of national priority for training people in this area, or have we reached saturation point even in the number of persons, let alone saturation in the state-of-the-art? There are some 20 such centers now with two, three, or four people at each center. Anybody have any views?

Members: Considerable discussion (not recorded).

Dr. Basmajian: Wayne, would you like to tell us what you have on the blackboard, and what you think is the consensus?

Dr. Akeson: This Workshop has produced a useful compilation of the techniques and facilities which are available for the analysis of gait abnormalities. It is clear that there has been an extensive effort to bring modern technology to bear on the analysis of gait. The variety of sophisticated techniques which have been described offer an ample selection of tools for a study of locomotion disorders. While deficiencies in most of these techniques can be identified, the techniques are adequate for application to most neuro-musculo-skeletal research which requires motion analysis.

The question of research priorities in this field has been raised repeatedly during the Workshop. The most obvious existing need in terms of application of existing technology to clinical analysis, is to develop additional normative data of a variety of types. This effort deserves high priority in the near term for obvious reasons. Coordination between laboratories would reduce any redundancy of this effort.

Another priority which has come up several times during the Workshop is the need for direct measurement of muscle force. This problem does require the development of additional sophisticated instrumentation, an exception to the general statement that the gait laboratories do not require a great deal of more advanced technology for their application to neuro-musculo-skeletal research.

More complex questions arise with respect to the evaluation of results of application of gait analysis in scientific investigation. As Dr. Burstein has pointed out, good scientific questions are being asked by some of the investigators using these laboratories, but many of the laboratories have become bogged down in problems of technology, data management, and redundancy of description. These difficulties are expected to some degree in an era of expanding technology. But they also probably reflect a low order of collaborative effort between the principals: bioengineers and orthopedic surgeons or physiatrists on the one hand and neurophysiologists or neurologists on the other. Dr. Leith has charged during the Workshop, with some justification, that an inordinate gap exists between applied clinical science and basic science which has seriously hampered quality gait laboratory productivity. This is probably the most serious charge which can be leveled at a burgeoning field, and is surely the basis of much of the criticism which has been directed at research utilizing gait analysis in the recent past. It is self evident that critical focus of the scientific method in this complex field in which neurophysiology, neurology, orthopedic surgery, physiatry and engineering overlap requires a multi-disciplinary input, but because of the realities which have been noted, the point must be stated and emphasized. Furthermore, gait analysis is not a discipline, but rather simply a tool which can be used by those interested in malfunction of the neuromuscular control apparatus to obtain specific objective measurements. Gait analysis is but one type of motion analysis which is a necessary element of the data gathering process in projects where there is interest in abnormalities of physical performance. Its effective use requires the effective collaboration of members of each of the scientific disciplines listed above.

Many applications of the locomotion analysis techniques have been suggested today, not only to study control mechanisms, motor activity, and energy expenditure, but also sensory input and response to biofeedback. Applications of gait analysis to animal research is equally appropriate as it is to human locomotion studies and applications from primates through tetrapods have been quoted by Drs. Houk, McMahon and Basmajian which attest to this fact.

As several Workshop members have pointed out, instrumentation already available can provide most of the measurements asked of a locomotion analysis laboratory. The question of the appropriate number of laboratories which should be supported by Federal agencies hinges on specific requirements. Are sound teams of collaborators working together who can develop appropriate hypotheses for testing with this method? The utility of this tool, as others, hinges entirely on the scientific merit of the investigations proposed. Hence, it is folly to attempt to describe the optional number of laboratories or dollar amounts of funding. Rather, one senses a certain amount of urgency about getting on with the appropriate application of the technique rather than further refinement or addition of more complex techniques. If anything, a priority item in locomotion research is the development of techniques simpler to understand, less expensive, less technologically complex and with more discriminating data output which can find application in everyday clinical practice. The elegant refinements from Dr. Perry's laboratory serve as an outstanding example of this approach.

In brief, technology has arrived, but appropriate application has lagged largely through insufficient collaboration between investigators using gait laboratory tools and neurologists or neurophysiologists. Additional collaboration between existing laboratories is also a priority concern which has been emphasized by Dr. Chao and Dr. Childress. Key among near term priorities is closer communication between workers in the field. Improved communications and supplementary meetings of this relatively small group would seem easy to accomplish.

Dr. Basmajian: What remains is to tell you that our time is up, and also to conclude by thanking all of you--especially the guests who came and joined us. We hope that they got as much out of this Workshop as the members of the Study Section obviously did. This session will, I am sure, enable the members of the Study Section to view grant applications with considerably more knowledge and more understanding in the future. Thank you for coming.