BIOMECHANICAL FOUNDATIONS FOR EXERCISE PRESCRIPTION

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During the school year, 1970-'71, a group of faculty members from the Department of Physical Education, University of Maryland, gathered to make plans for a new undergraduate bachelor's degree program. The motivation for this action centered on an understanding which became increasingly more obvious each year. That is, there were a large number of students who were intensely interested in the subject matter of our department, but who were unwilling to join us as physical education majors with the attendant requirements to prepare to teach in the public schools. Our single bachelor's degree program had teacher preparation and state certification as its central goals, and no other path was possible. We felt that our offering was truly one-dimensional and that we could broaden our contributions substantially by inaugurating a new curriculum to be known as Kinesiological Sciences (10). This program is concerned with what we refer to as the human movement sciences and sport. It has been in operation since early 1973.

The number of students that have chosen to study with us in this program has grown steadily to a present total of approximately 150. During this same period our teacher training program ranks have changed in an inverse manner to a point where we expect Kinesiological Sciences majors to outnumber their teaching counterparts perhaps within the next two to three years. As a result of observing the two programs and their students over these years, several interesting differences are clear. Among them are:

1. In general, because of the differing goals of the two programs, the Kinesiological Sciences students seem to be more highly motivated in terms of scholarship.

2. Since the Kinesiological Sciences program is organized after a "liberal arts" model, with no avowed professional mission, its students are more discipline oriented with a large percentage planning to continue their studies at the graduate level.

3. Since public school work is neither sought nor available to the Kinesiological Sciences students, they see other sectors of society as sites for their life's work, sectors dominated by adults rather than those under the age of 19.

It is not the purpose of this discussion to describe this program to any great extent. What is of interest is that the graduates of this program, with their keen interests in sport and other exercise related matters, are seeking employment where adult sensitivities, adult values and adult scrutiny are the norm. In addition, increasing numbers of teacher preparation graduates are doing likewise because public school teaching and coaching opportunities appear to be dwindling to smaller numbers. They all wish to be involved with human movement activities in a wide variety of forms, but in particular, that vigorous kind known as exercise.

A recent article (12) in JOPERD has pointed out that "...adults tend to pay strict attention to the claims for and outcomes of the work our graduates perform. Many see this development as a boon to the profession because it broadens markedly the scope of our influence upon society. But it is clear that the broader the influence, the closer the scrutiny." Our traditional work in the public schools has not received the evaluative scrutiny to be expected from adult clientele. With this closer attention it is reasonable to expect a greater display of dissatisfaction and a greater willingness to resort to litigation to settle grievances. Other professions, especially the medical profession, have had to contend with this problem by purchasing staggering quantities of insurance protection (1, 7). We should expect similar developments in the world of sport and exercise.

The graduates of our programs have always been involved with exercise in ways which require its prescription. In fact, this practice is expected of us to the extent that we are continually being asked to suggest redemptive means to reestablish some lost physical proficiency, particularly in sport activities. With decades of experience with such requests, it is clear now, as it should always have been, that we must better understand the nature of prescriptive practice. We must better understand the programs of which the exercises are a part. We must better understand the broad goals of such programs, such as:

1. physical and emotional fitness
2. sport and dance training
3. lifetime skills development
4. weight control
5. behavior modification
6. injury/illness prevention
7. injury/illness rehabilitation

PRESCRIPTIVE PRACTICE

Exercise is prescribed to decrease resting heart rate, blood pressure, stress and tension, appetite and body size to look better. Exercise is prescribed to increase flexibility, endurance, strength, the sense of well-being, regularity, and body size to look better. It is prescribed at one time or another by practically everyone who takes a serious interest in these and other specific outcomes, real or imagined, because they are seen as desirable. When exercise is self-prescribed, each individual must shoulder responsibility for the outcomes, good or bad. When it is prescribed for others to engage in, quite serious problems of accountability can arise.

The number of agencies within our society which are involved with exercise prescription is considerably larger than one would at first expect. In fact, the number of individuals serving these agencies as practitioners of exercise prescription is immense. Table 1 lists a number of these involvements.

TABLE 1 SITES AND INDIVIDUALS INVOLVED IN EXERCISE PRESCRIPTION

1. SCHOOLS AND COLLEGES: Teachers; coaches, trainers.
2. YOUTH ORGANIZATIONS (Little League, YMCA, Scouting, Etc.): Physical training instructors; volunteer coaches; parents.
3. ARMED FORCES: Drill instructors; physical training instructors; trainers.
4. MEDICAL PROFESSIONS: Physiatrists; cardiologists; orthopaedists; pediatricians; obstetricians; physical, occupational and corrective therapists; opthamologists; psychotherapists, exercise specialists; exercise program directors; osteopaths; chiropractors; and podiatrists.
5. CORPORATE-INDUSTRIAL ORGANIZATIONS: Fitness instructors; program directors; trainers.
6. PROFESSIONAL ATHLETICS: Coaches, trainers, sports medicine practitioners, strength specialists.
7. DANCE PROGRAMS (Classical, Aerobic, Therapeutic, Etc.): Teachers; dance therapists.
8. COMMERCIAL EXERCISE AND FITNESS CENTERS: Instructors; program directors; strength specialists.
9. MUSIC-VOICE-THEATER DISCIPLINES: Teachers; coaches.
10. RITUALISTIC AND WELLNESS ORGANIZATIONS: Yoga instructors; stress management directors.
11. CIVIC RECREATIONAL ORGANIZATIONS: Teachers; therapists; recreation leaders.
12. INDIVIDUAL ENTREPRENEURS: Charles Atlas; Jacki Sorensen.
13. MASS MEDIA (TV, Radio, Newspapers, Magazines, Etc.): Exercise entertainers; writers (identified and anonymous).

Noting the large involvement, it would be reasonable to ask:

1. Where were these people trained for such practices?
2. What was the nature of the programs involved in their training?
3. What evaluative mechanisms are brought to bear in terms of monitoring their practices? and,
4. Where may we turn to gain assistance in dealing with these matters?

It would seem logical to approach the medical profession for guidance about prescriptive matters since its practitioners have been doing it for centuries. Such an inquiry will yield little in the way of formalized policies or principles to guide one's action. We are told that prescriptive practice is not dealt with formally in medical school curricula. Thus, the individual medical practitioner is essentially cast adrift, nearly alone in making prudent choices, and depending heavily upon the good faith of those on who's behalf their prescriptions are enacted. Very little is different when examining the dilemma faced by those of us who aspire to exercise prescription outside the medical professions. This state of affairs can and should be improved in our profession as well as in medicine.

The preceding comments would hasten one to believe that the medical profession has not faced the problems of exercise prescription in any way. This is not the case. One interesting approach to exercise prescription comes to us from the American College of Sports Medicine, an organization which counts many of us as its Fellows. In "Guidelines for Graded Exercise Testing and Exercise Prescription" Chapter Three is entitled "Guidelines for Exercise Prescription." This approach divides the prescription process for asymptomatic adults into four components:

1. Type of Exercise
2. Intensity of Exercise
3. Duration of the Exercise Session
4. Rate of Progression

In this context, exercise is broadly portrayed as being leisure activities; including sports (ranging in activity level from fishing to cross country skiing), exercise classes, dancing, and games. These activities are quantified with respect to intensity and duration in METS, to establish a narrow system of graded exercise dominated primarily by concerns for energy expenditure and cardiovascular functioning. There is much here to be commended, but surely there is more to be considered in the prescriptive process.

A broader approach would include the identification of what the exercise prescriber is expected to know and do for their clients. "To prescribe positively means to give direction by setting down a course of action whose outcomes are considered desirable. Whether clients come to us by their own free will or are ours by some captive process, they <u>expect</u> to be party to prescriptive regimens involving exercises in pursuit of such outcomes. Within this interaction, prescribers are expected to:

-know what these desirable outcomes are:
-understand and be able to explain all cause and effect relationships involved;

-knowledgeably prescribe the substance and course of the program directed toward these outcomes;
-avoid all contraindicated elements which could jeopardize achieving them, and
-evaluate the results of the program with an eye toward maintaining the benefits achieved" (12).

If the operations listed above are to prove successful, knowledge of considerable breadth and depth is required. Certainly one of the most important areas of knowledge to support such a practice is biomechanical in nature. Furthermore, there is always a strong educative element involved with programs of this sort which points at assisting the client to develop, some degree of self-direction for the future. With the practical examples which follow, a number of the operations of exercise prescription are developed with emphasis placed on a biomechanical knowledge base that can help support enlightened practice. No attempt at completeness was intended, for the participants at this conference are more than capable of filling in the gaps with their own extensive experience.

An Example Involving Flexibility and Strength

As people pass from the physically active times of their early lives to their more sedentary later years, joint mobility and muscular strength often decrease by substantial amounts. This adjustment of functional abilities can be said to be habituation-controlled; that is, patterns of use dictate the ranges of abilities maintained. For those in late middle age and beyond (5, 14, 18) reaching overhead to change a light bulb can identify perplexing shoulder joint movement limitations. Removing a tightly secured jar lid can show the decrement of hand and arm strength that comes upon us gradually. Who among us has not observed the problems faced by elderly drivers. Because the seat back restricts trunk rotation, and because scanning movements of the head-neck region are often very limited, little or no attempt is made to see behind the car for approaching traffic when departing a parallel parked position. Out the window goes the arm, signalling all to take heed of the car's slow entry into the traffic stream -- all the while struggling with the strength demands of the steering wheel.

These lost abilities carry with them other burdens beyond the physical in the form of embarrassment, annoyance, and fear that these formally, easily accomplished tasks are now beyond our comfortable means. From such dilemmas often come firm resolutions to rectify these difficulties through the time honored method of physical training. The urge is justified for much can be accomplished through such means to improve the sense of ease and control we have over our physical lives.

It would be valuable for those prescribing exercise for these outcomes to have substantial knowledge of the mechanisms of joint mobility, muscular strength dynamics, and the developmental changes accompanying aging which result in impaired function. Background in the elastic and distensibility properties of muscle and connective tissues would be very useful when establishing the methods used to gradually increase joint mobility (20) and muscular strength, which, of necessity, must have protracted natures.

Knowledge of joint capsule and bursal involvements, bone responses to mechanical stress (2, 9) with their attendant mineral changes, are also important. Some knowledge of the piezoelectric-like mechanism which is thought to control cellular growth in the region of the stress, whether achieved through intertissue stress or through artificial application, would be helpful with the elderly client.

The protracted nature of such programs cannot be overstressed when applied to elderly clients. Remarkable improvements in flexibility and strength may be achieved. The general problem faced is that there is a clearcut parallelism between motivation (enthusiasm to continue) for such a program and the energy levels available to these clients. If energy demands are not increased in carefully planned progressions, discomfort will not be held to acceptably low levels. As with most members of the animal kingdom, if you hurt them beyond reasonable limits, they are not likely to return to you for additional agony.

An Example Involving Weight Control

Probably the most interesting area where biomechanics and exercise physiology interface is with the concerns of energetics. The methods of measuring energy dynamics differ for these two areas of study, the former depending upon the careful analysis of observed movements, with the latter depending upon careful analyses of gaseous exchange and thermodynamics. These latter elements are essentially invisible to the biomechanics analysis procedures. Consequently, the physiological approach is usually the method of choice because it requires less in the way of assumptions and estimations. Even so, there is much to be gained from the biomechanics of energy useage when it comes to weight control programs which involve exercise as well as food intake control.

With some risk of oversimplification, the liberation of heat energy sufficient to be equivalent to that contained in a pound of body fat is a central issue in the standard quantitative approach to weight control. Vigorous exercise is often prescribed to produce the energy loss. The dietetic calorie (kilocalorie) is equivalent to approximately 3,087 foot pounds of mechanical work. The loss of one pound of fat tissue is equivalent to approximately 3,500 kilocalories. The product of these two quantities, between 10 and 11 million foot pounds of equivalent mechanical work, must be undertaken to reduce body weight by one pound if no change in food intake is instituted. Now all would agree that this is a large amount of physical work to be done. Such a negative balance between input and output can be accomplished in a number of time frames. Efficiency matters aside, power generation abilities of human beings dictate that conservative prognosis for weight loss be instituted to avoid disillusionment in clients.

Foremost in basic considerations here is an understanding of the mechanical constraints imposed by an organism which cannot develop high power levels and in addition, cannot maintain the levels which can be achieved for long. Exercise pacing then is the controlling factor because, when pushed too hard, the body simply shuts down because of severe fatigue. Secondly, it is essential not to paint exercise as a panacea for the problems of weight control. Useful as it is, the metabolic energy exchange model does not answer all the questions that arise concerning weight control.

Perhaps the most intelligent approach to controlling weight with programs including exercise is that recommended by deVries (6) which he calls "The Long-

Haul Concept of Weight Control." A combination of food intake control and exercise stimulation on a regular basis over protracted periods of time will set up behavior modifications that can be tolerated and sustained. Crash programs are contraindicated. We have heard it time and time again, but moderation is a principle that serves us well in most endeavors.

An Example Involving Joint Pain

Pain and exercise are well known bedfellows. Ranging from simple residual muscular soreness to the agonies of bone fractures and loose bodies in joint cavities, pain can nag at us or it can immobilize swiftly. The knee joint has probably been studied more than any other in the human body. Damage to it, and the accompanying pain, has brought many a sterling athletic career to a sad close. Situated as it is in the lower extremities, with their weight bearing and shock absorption duties, the knee joint can serve as a focus for our discussion of joint pain.

The burgeoning interest in jogging and competitive running, even at rather advanced ages, has at one time added much to our understanding of what these structures can endure, and at the same time, confirmed how much more we need to know. As an example, let us examine the pain that is often experienced in the front of the knee joint, seemingly behind the patella (4). This pain can range from a minor annoyance requiring mostly rest, to a hobbling response to even limited use of the lower extremities (8, 16).

Faced with this kind of problem with a client, caution is certainly called for because symptoms can be very misleading. Of course this is a situation where referral is in order so that proper medical attention may be provided (17). Certainly the admonition to run through the pain to make it go away is not an appropriate response. One outcome of medical consultation might be the diagnosis of a problem called chondromalacic patellae (13). This condition, which can result from persistent overuse, results in the development of a preternatural softening of the articular cartilage which lines the interacting bone surfaces. This softening often gives an impression of shredded crabmeat filaments billowing from the articular surfaces which would normally be very smooth and regular.

Some background in tissue biomechanics and histology would be valuable for the budding exercise prescriber so that soft and rigid tissue responses to stress could be appreciated. In this case, articular cartilage must undergo continuous contact interaction. The special characteristics of this homogeneous, granular-matrix tissue and its encapsulated, synovia-bathed environment, are not difficult to understand. This information is almost never covered in introductory kinesiology and biomechanics courses for undergraduates. In fact, most biomechanics courses at this level focus on sport with external mechanics receiving by far the lion's share of attention; a practice that overlooks many of the mechanisms which explain how the athlete accomplishes the fine control which is so easily recognized externally.

Another biomechanical mechanism which would be of significant assistance in understanding many joint problems is that of bone-on-bone force dynamics as related to external loading and muscular contractions. In the case of patello-femoral pain, prescribed rehabilitation exercise should avoid knee positions which involve substantial flexions. If bicycle exercising is prescribed to improve the strength of the extensor musculature for example, careful seat

positioning is mandatory. Similarly, the use of isometric and isotonic exercises must be chosen with great care. Even with maximum attention paid to joint use in exercise, some cases respond to the exercise negatively, resulting in worsening pain.

Knowledge of the developmental stages passed through in joint maturation would be useful in understanding that unusual, congenital structures may also contribute to similar painful symptoms. For example, two related structures known as medial petallar shelf and synovial plicas (3, 11) can impinge upon the articulating patella and femur in ways that mimic chondromalacic pain and which appears to be relieved only through surgery. Fortunately today, artheoscopic diagnosis and surgery (11) techniques markedly reduce the trauma placed upon the joint by the surgery itself. After surgery, as expected, exercise is once again prescribed to rehabilitate the repaired joint by gradually increasing muscular control and range of motion which are always early casualties of joint pain.

A SERIOUS PROPOSAL

An upper division, undergraduate course, perhaps entitled "Exercise Prescription and Practice," should be developed and incorporated into the curricula of departments of physical education and those with similar goals and functions but differing names. This course should occur late in the program's progression of courses so that it may use completed courses as background to avoid repetition and needless review. As the title suggests, its focus should be on exercise as a prescriptive entity and the practices which are commonly encountered. In this writer's view, it should have three primary subject matter emphases, namely, biomechanics, exercise physiology, sport psychology, with time available at the end provided for coverage of accountability, liability, and litigation matters. It would need to be assigned a minimum of four credits so that laboratory and clinical experiences could be incorporated. Ideally, it should be team taught to gain the benefits of experts in each of the central emphases. To save time, the use of innovative audiovisual learning methods which evaluate as well as instruct, would be valuable.

Courses of this sort are in short supply in typical undergraduate programs presently offered. There are some programs which accumulate varying amounts of the suggested subject matter from other courses, and from individual instructors whose backgrounds allow them to embellish the usual content with practical examples relating to exercise practice. The picture at the graduate level is somewhat better with the more recent development of Master's degree programs which have highly defined goals of a practical nature such as the preparation of fitness and rehabilitation practitioners. According to their catalog, the Department of Physical Education, University of Wisconsin at Madison, offers a graduate course, 543-Clinical Exercise Physiology, which places exercise prescription as a high priority component of its content. But in general, our profession has not taken exercise prescription serious enough to be able to point to a large number of examples which could be emulated.

IN CONCLUSION

Historically there seems to be evidence that our profession cannot make up its mind as to how it perceives the importance of exercise and how it should include exercise practice in the curriculum. These perceptions seem to change regularly, depending on the tenor of the times. Seward C. Staley's writings and teachings can be used to illustrate this ambivalence. In the late 1930's (19) he wrote that "An objective is something which one deliberately aims at. A concomitant, on the other hand, is something which one comes by inadvertently." When referring to exercise he wrote, "A half century ago when the curriculum here under discussion finally gained general recognition in the schools, and for two or three decades thereafter, exercise was held to be one of the more prominent objectives. At this time the school curriculum was devoted almost exclusively to subjects that were essentially passive in nature . . . . The program in gymnastics in vogue at this time was looked upon as a release from confinement. Exercise was accepted as an objective of this program."

While discussing the relationships between exercise and the development of health, Staley continued, "It has been demonstrated over and over again, however, that the average individual will not engage in exercise for exercie's sake, that is, for the sake of health alone, in any case not for long. . . But it will be noted the exercise which is gained here is gained incidentally. Exercise is not the objective of either the teacher or the student. It is merely a concomitant of the teaching-learning procedure." Because he believed at that time that exercise as an objective would not be supported by individuals, Staley concluded, "The exercise factor must be submerged. This suggests that for psychological reasons if for no others, it would be better to exclude exercise as an objective and consider it simply as a by-product of the program."

Points of view change over time and it is apparent that Staley's view changed significantly over approximately the next decade. During the summer of 1946, in a graduate course titled Philosophy of Sport, Staley discussed at length the concepts of what physical education was, and was not. During this discussion he made it clear that "The main business of physical education is exercise prescription and sport." * It seems that we will cross the same bridges many more times as we struggle with the place of exercise and its prescription in our profession.

POSTSCRIPT

In a reported interview with writer George Steiner, carried in the Washington Post newspaper, May 13, 1982, Steiner and the interviewer were discussing the functions and symbioses of critics and artists, and the writer-as-critic. Perhaps Steiner's sentiment contains a message for us all. Steiner

*Quote from Marvin H. Eyler, sport historian and member of the Philosophy of Sport course in the summer of 1946. At that time, Dr. Staley was Dean, College of Physical education, University of Illinois.

concluded, "At my best, I hope I am that curious bird which I have seen in nature films. It sits on the rhinoceros and does two very interesting things. It cleans the ticks off. . . and it flies a little ahead and gives warning of the beast's approach. I take that to be the greatest thing I can do -- to help prepare the audience for new ideas. So that when (the) rhino comes, people aren't too frightened." Food for thought for all of us interested in using exercise properly. BE PREPARED. The rhinoceros is coming! For some, one could say the rhino has already arrived.

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