The Value of Sports Profiling

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Athletic performance is influenced by a multitude of variables that can be divided into physiologic, neuromuscular, psychometric, and environmental factors. One method of determining the relative importance of these factors in the performance of sports is profiling. Profiling is simply the gathering of information about the physical attributes of athletes. The value of profiling lies in its many applications to successful participation in sports. We consider the performer to include anyone who participates in any type of sports activity, regardless of age or handicapping condition.[4] A typical profile might include measurements of an individual's cardiac performance, muscular strength, flexibility, body composition, pulmonary function, and coordination. As well, it can be expanded to include tests of reaction time and balance.

One application of profiling is to determine if an individual possesses the attributes necessary for participation in sports activities. There are variables that must be appreciated when profiling individuals for sports. First, there is no such thing as a truly "average" man or woman. Every individual has a unique set of physical attributes that can be utilized during athletic endeavor. Profiles, however, can be used to find the average value of any given physical attribute for a group of athletes. None of the athletes, however, will "meet" all the specific average values for all of the profile's variables.

Second, over the years, pathology, either occult or found on "stress" musculoskeletal performance testing, will become readily apparent during participation in sports. Therefore, screening is valuable because it can uncover pathology not obviously present. The number, location, and severity of pathologic findings then determines the likelihood of injury in playing certain sports.

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Once profiles are completed on a large number of participants in a given sport, averages or ranges can be determined for any given level of performance. In this manner, profiling provides us with the means to determine and evaluate performance characteristics. For example, strength is of prime importance for a football lineman but may be less important to a dancer who relies on flexibility and coordination. Once the attributes are delineated, the profile can be applied to many uses. For the individual who is sedentary and wants to begin participation in sports or simply an exercise program, preparticipation profiling can provide a means of determining whether the individual possesses the ability to participate without excessive risk. These risks would include all potential areas for problems. Specifically, the cardiac system must be evaluated to rule out heart disease or simply a diminished cardiac reserve. The orthopedic examination is a valuable tool for diagnosing current and past injuries and abnormalities, thereby preventing future orthopedic problems. Musculoskeletal strength, joint motion, and nerve function are also evaluated. The somtatotype and body composition (lean muscle mass in relation to fat) are used to identify ideal weight for participation; pulmonary testing may be of value to the individual with lung disease.

TEAM APPROACH

Although some profiling measurements can be done by any of a number of health care professionals, to fully complete a profile, it is necessary to conduct medical and orthopedic examinations. Thus, the team approach is necessary to obtain a complete profile. This is particularly true because of the multidisciplinary nature of sports performance. Hence, physicians and other health care professionals involved in sports medicine must not have a "tunnel vision" approach to the body. The cardiologist must consider the effects of sport beyond its effector, the "pump," and the orthopedist must not look simply at the knee. Close contact between individuals working together to perform each part of a profile permits an exchange of ideas. After all, profiling is simply the application of the basic medical sciences to an athlete. Anatomy, pathology, physiology, and biochemistry form the basis of the clinical areas of cardiology, neurology, and rehabilitation. The study and application of profiling depends on the use of both basic science and clinical medicine. Hence, without the teamwork approach, profiling would not be worthwhile.

USES OF PROFILING

The profile may be used to guide individuals to play only at levels of skill in which they can meet the imposed demands. For example, if an individual is found to have diminished cardiac reserve, the physician can provide advice concerning the activities or sports that are appropriate, or a training program could be developed to improve the person's capabilities. Similarly, findings from the musculoskeletal examination may also be the

Table 1. *Sports Classification*

Strenuous Contact Sports
Football
Ice hockey
Lacrosse
Rugby
Wrestling
Field hockey
Strenuous Noncontact Sports
Bicycling
Crew
Running (especially cross country)
Dance (ballet/modern jazz)
Fencing
Skiing
Swimming
Tennis
Track and field
Nonstrenuous Noncontact
Golf
Bowling
Archery
Riflery

basis for directing an individual to an appropriate sport. For example, individuals with tight heel cords would be well advised to do intensive stretching of the lower leg muscles prior to playing racquet sports. This form of sports medicine counselling is extremely important because it represents preventive medicine by reducing the potential risk of participation in sports. In this simple application of profiling, the goal is to decide which sports an individual can play or what can be done to prepare someone to meet the demands of the activity.

A useful sports classification ranges from strenuous contact sports to nonstrenuous noncontact sports. Examples of each category are seen in Table 1. Having been examined and profiled, an individual is matched to a sport, based upon the judgment of the physician and the patient. The match of sport and individual is made according to the classification of sports and the results of the profile. In the case of persons wishing to participate in strenuous contact sports, an orthopedist generally determines the fitness of the individual. With noncontact and highly aerobic activity, the cardiovascular component may play an important role, so the exercise physiologist, cardiologist, and orthopedist may all be important in rendering the final decision.

A simple model can be outlined that gives an approximate idea of how athletes or would-be athletes can be categorized following a profile examination. We are enthusiastically advocating this model because we have demonstrated its effectiveness in our Institute.

1. *Priority A Individuals.* Profiles of these athletes conform well to previously determined profiles of other athletes in a particular sport. These athletes could participate as long as they desire to participate within their fitness level. In this category would be individuals whose fitness profile

places them on a professional level or who have no demonstrable defects. It is quite likely that athletes in this category can, when injured, undergo repair more quickly, complete rehabilitation more readily, and return more enthusiastically to their sport. This is possible since these individuals have not sustained their injuries on top of previous injuries. Not everyone in Priority A may excel in his or her sport; indeed, quite the contrary, but since no apparent risks have been determined by profiling, the individuals are deemed free to play.

2. *Priority B Individuals.* These individuals may have minor defects in their overall profile, yet can be recommended for their desired sport. They are expected to perform in their sport reasonably well. However, because of the variation in their profile from the average, they are potentially at risk for certain injuries. At the professional level, these individuals probably would not be limited by their defect, since to reach this high level of achievement, adaptation in performance can be accomplished. An example would be someone with visual problems who is otherwise physically fit for the sport. Many of these individuals are people seeking resumption of play in their 30s and 40s after a lapse since high school or college sports.

3. *Priority C Individuals.* These athletes, both at the amateur and the professional level, have various defects in their profile, particularly in the musculoskeletal make-up, that place them at particular risk for injury during participation. These individuals cannot be allowed, in all good conscience, to play because of their abnormal findings. This group is likely to suffer repeated injuries, a shortened career, and disrupted performance capacity due to their particular physical shortcomings. Nonelite athletes who fall into this group can generally be guided into a sport that would better suit their capabilities. People in this category are usually 35 years old or more and have chronic musculoskeletal problems. Elite athletes in this group have generally been participating in high level competition since childhood, and at 30 are simply physically burnt out. Typical problems placing athletes in this group include patellar pain due to a poorly tracking patella, subluxating shoulders, low back problems, or discogenic disease of the cervical spine with symptoms. Residual difficulties from previous injuries also place individuals in this category. Individuals with excessive laxity in the ankle from chronically recurring sprains or a painful hallux rigidus from recurrent acute inflammation would be included in this group. Many are deconditioned and have cardiac risk factors without symptoms.

4. *Priority D Individuals.* These individuals cannot, in the opinion of the profiling team, play sports because of the great risk of further injury. For example, individuals who are diagnosed to have unstable angina, severe aortic stenosis, or severe idiopathic hypertrophic subaortic stenosis should not be given clearance to exercise except with strict levels of tolerance determined by an expert cardiological work-up.

It is generally possible by profiling individuals to rank all people within these four categories. The groups are not absolute, and often an athlete may actually fall into the criteria for two adjacent groups. For example, a football player who has undergone a successful repair of a dislocating shoulder might be considered to fall between groups A and B. Moreover, for some sports, it is possible with treatment to move a person up from

Table 2. *Discriminant Analysis of Performance Factors in Three Sports**

	SOCCER	BASKETBALL	HOCKEY
SA	1.941 ± 0.02	2.317 ± 0.035	2.132 ± 0.022
$\dot{V}O_2$	52.7 ± 1.3	47.9 ± 0.9	49.3 ± 1.3
$\dot{V}m$†	122.9 ± 3.4	133.8 ± 4.2	139.4 ± 4.3
TLS	728.8 ± 27.4	857.7 ± 28.0	847.1 ± 26.9
HAB/TLS	16.2 ± 0.4	15.8 ± 0.4	12.9 ± 0.3

*From Gleim, G., Marino, M., Best, L., et al.: Pro sports profiling by discriminant analysis. Med. Sci. Sports Exerc., *14*:151, 1982, with permission.

†$\dot{V}m$ = minute volume; TLS = total leg strength; HAB/TLS = ratio of hip abduction to total leg strength.

Priority D to C or even B, with removal of, for example, a symptomatic lumbar disc.

Another use of profiling is exemplified by our experience working with professional athletes for almost 25 years. Each year we conduct preseason examinations as a means of determining baseline information. This becomes particularly valuable when a player is injured because it provides the medical team with some criteria for return to play. In addition, a baseline profile aids the rehabilitative process by providing a goal for a player to work toward.

Although the profiling of athletes can provide us with information about individual performance factors, it is generally agreed that participation in sports entails multiple performance factors. A technique for measuring these multiple performance factors is discriminant analysis.[6] Basically, this technique allows one to distinguish between groups by analyzing select variables in which the groups are supposed to differ. Variables are weighted and combined linearly so that the groups are as distinctly different as possible. The raw variables of an individual are inserted into the equation for each group and compared. Individuals are assigned to the group in which their raw variable produces the largest value. The probability that an individual belongs to this group is then assigned. In our laboratories, Gleim et al. employed discriminant analysis on data obtained from preseason screening of professional soccer (n = 26), basketball (n = 19) and hockey (n = 21) players.[1] Specifically, discriminant analysis was applied to the following variables: surface area (SA), maximum oxygen consumption ($\dot{V}O_2$), minute volume ($\dot{V}m$), total leg strength (TLS = knee extension + knee flexion + hip adduction + hip abduction + hip flexion, as tested on a Cybex at 10 RPM), and the ratio of hip abduction to total leg strength (HAB/TLS).

The means and standard deviations were as shown in Table 2.

These data revealed soccer players to be shorter and lighter than hockey or basketball players. However, soccer players had especially strong hip abductors, as evidenced by the HAB/TLS ratio of 16.2, which was the highest of the three groups. In addition, soccer players had the highest $\dot{V}O_2$, 52.7 ml per kg per minute, which may be attributed to the large field, continuous running, need for agility, and cardiovascular demands of the sport.

Since basketball, especially on the professional level, is usually played by tall individuals, it is not surprising that this group displayed the greatest surface area, 2.317 m^2. The fact that basketball players had the highest TLS, 857.7 ft. lbs., and the second highest HAB/TLS may also be attributed to their large surface area, which results in longer lever arms.

One major area in which hockey differs from basketball and soccer is that the players skate rather than run. However, since it has been illustrated that $\dot{V}O_2$ measurements taken during running and skating are comparable,[2] it is not surprising that hockey players had the lowest HAB/TLS, 12.9, although this may be due to the decreased resistance of skating.

Using the variables SA, $\dot{V}O_2$, $\dot{V}m$, TLS, and HAB/TLS, the technique of discriminant analysis correctly classified 84.8 per cent (56 of 66) of the players. In summary, discriminant analysis places a value on each variable and adds up the individual attributes. However, since each attribute is assigned an appropriate value based on the sport, it is possible for an individual to succeed in a given sport without scoring high on all of the variables measured.

THE LIMITATIONS OF PROFILING

The so-called "exercise response" occurs when one participates in professional sports or plays simply for recreation. It occurs whether an athlete is young or old, sick or well. However, the way a person reacts physiologically to the stress of athletics goes beyond the simple observation that the neuromuscular and skeletal systems are active and the heart is working harder. Certain difficult-to-quantitate skills are required in all sports and these factors also play a role in athletic performance. Rhythm, timing, and coordination are skills required in many activities.[3] All of these skills require complex interaction between systems of the body. The organization and activation of these processes are just beginning to be defined in the normal state. In the athlete with pathology, occasionally, we can only marvel at the adaptations made to allow performance. It is remarkable to see how some people play sports with obvious pathology and succeed, regardless of the demands of the sport. Individuals, such as an adult with a hip deformity from a slipped capital femoral epiphysis, have played successfully in sports, as have others with handicapping conditions. Nonsymptomatic spondylolisthesis is often seen in those playing rough contact sports. Older individuals, 70 and over, have completed marathons; some of these people have had bypass surgery. People with multiple joint replacements of the shoulder, knee, hip, and hand have been active in sports, such as golf, aquatics, and tennis.

LINKING TRAINING AND PROFILES

In athletes with pathologic conditions, the opportunity arises to study the effects of abnormalities in one system on another system. For example, one cannot yet determine what effect various physical defects have on

cardiac function. Problems in athletes, such as unilateral leg weakness, may cause restrictions in training. Thus, aerobic capacity may be limited. During the profiling of athletes or would-be athletes, data are being generated that may eventually yield answers to these problems. We are intensely studying these relationships, as well as the relationship of complex tasks, isometric exercise, abdominal and trunk linkage and the biomechanical effects of work of such regions, and the physiologic costs to the individual's energy output from such demands.

SPECIFICITY AND PROFILING

What makes the sports profiling examination unique? The profiling examination embraces the specificity concept. This is inexorably linked to the demands of sport. Specificity can be shown by comparing a 110 pound, 4 foot 11 inch jockey, suited for riding a horse, to a 6 foot 10 inch center playing professional basketball, who requires that height to reach baskets. The profile seeks to uncover variations that may be affected by the demands of one sport or another. Discriminant analysis clearly shows variations between muscle strength, body composition, and flexibility of athletes involved in different sports. The concept of specificity can also be applied to pathologic findings. A ballet dancer with claw toes and hallux rigidus will not be able to dance without pain, no matter how otherwise perfect her body is. For another sport, such as swimming, hallux rigidus would not be a problem.

SUMMARY

In his presidential presentation to the American Orthopedic Association in 1975, Inman said, "Man is a machine that moves . . . and expends energy." He was all too ahead of his time. Profiling, by recognizing that the body is a machine with links, studies the biophysical, biochemical, and biomechanical links of the body's systems. These studies, carried out on athletes and potential athletes of all ages, yield data with useful clinical and research applications. The continued use and study of profiling data will certainly enhance performance, increase enjoyment of athletes for years to come, and, we believe, prevent injury.

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