UNIT 9
ASSESSMENT OF THE ATHLETE

Not Fitness Testing Again!

By Peter Hastie.

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Australian sport in the 80s has witnessed improvements in athletic performance and an increase in the professionalism and accountability of both coaches and competitors. With these advances have come improvements in the measurement and testing of sporting performances.

The advances in athletic measurement have produced a wealth of information.
-With this data, coaches have been able to evaluate training programmes, make necessary adjustments to training routines and direct competitors to specific areas
of need. The recent article by Pyke (1987) outlined many of the important features of
physiological testing.

Many athletes complain, however, when 'yet another' fitness test is announced. Their discontent is derived from a number of sources, notably a belief that the tests lack relevance, anticipation of little feedback from results, with little or no change to training, and a feeling that the tests are used more as a source of negative accountability than as a guide to progress. This notion of negative accountability arises when the fitness test is used only as a criterion for deciding whether or not the athlete has reached the fitness standard required. Discontent also arises from the infrequency of testing sessions: ticle by Peter Hastie*, aims the initial test is the only one given, yet without further testing, there can be no measurement of progress.

This aims to heighten coaches' awareness of this discontent. It also discusses ways in which these problems may be overcome and presents examples of how data from fitness tests can be presented. He's called it...

Not Fitness Testing Again!

Athletes fail to see the relevance of fitness tests. To them they frequently seem totally unrelated to their particular sport and require actions which do not resemble any performed in actual play. While sports science has improved its ability to outline energy and performance requirements, the development of field tests to measure these parameters has been less productive.
When presenting test results to the athletes, the coach should therefore provide a rationale for the test carried out, and discuss which facet of performance is being measured.

Feedback
Athletes are not often provided with their test results. Instead, the coach is likely to receive the data and make decisions concerning changes to the athlete's training regime without consulting the athlete. If the athlete is ignorant of the test results and is unaware of the need for change, confusion may result. Since he or she performed the test, it seems only reasonable that the athlete be issued with his or her results.

In all cases the athlete should be given information about:

- What the score represented. Was it a good, average or poor performance
- How did it rate with his/per previous score for this test?
- How did it rate for other athletes in his/her group or reference group?
- What are the consequences of this score….what adjustments, if any, should be made to the athlete's training.

Accountability

In many cases, the score attained on a fitness test is used as a "pass mark"; that is, the athlete or player cannot make the team until the criterion score is reached. While this is a legitimate use of fitness testing in some cases, consistent use of testing for this purpose neglects the dimension of change in performance and the capacity for continued improvement.

In many cases, fitness tests can in themselves become a positive motivational challenge to improve. This is especially so for junior athletes.

"One off' tests
In many cases, tests are well conducted, rationales explained, and results pre-sented. The problem, however, is that some tests are never repeated. An average score is of little consequence unless there is the future opportunity to reassess for progress.
Perhaps the most common form of testing misuse of this kind occurs in school physical education units. Dozens of school children are tested in the first term of the year, their scores are recorded, compared against norms and presented to them. But there is often no follow up.

Presenting test data
How, then, to present testing data to athletes? One. idea may be a personal booklet, with follow-up score sheets for updated test scores.
The essential features of this booklet are that it is individual, informative and private. The booklet contains only the athlete's individual score, together with team scores. These are mean scores and can e presented as figures or as graphs. The only other data reported is the "best on record" for that test.

Test Descriptions
For each test performed, there should be information about:
What is being measured
What is a good score
What is the target for the athlete/team

Score Presentation
The booklet should present:
The individual's score
The team average
The range of scores
The best score on record for this test (this can be from team data, or from a wider source)
(An example is available from the Australian Coaching Council — Ed.)
Individual Training Programme

This section tells the athlete what changes need to be made, if any, to his/ her current programme, and should highlight areas of specific concern. here should be careful consultation, however, between sports scientist and coach.

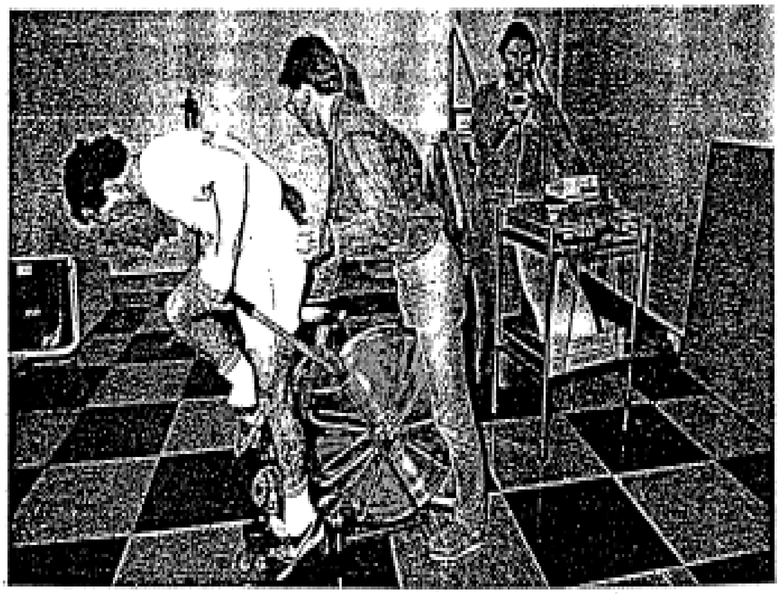
The section may be detailed, or could take the form of a checklist, where training items can be either ticked or crossed depending on which is required. Where possible, there should be information about which training items will produce improvements in which tests or areas of performance.

Details of Next Testing
The dates of the next testing should be given, even if only within a month's range. This lets the athlete know firstly that there will be future tests, and secondly, how much time is available for making improvements. Again, however, this is not always possible in practice for athletes.

Together with the dates, the required levels of performance for the next tests should be listed. For adults, this is often a criterion score, but for juniors, it is recommended that the two scores be given. These scores represent a minimum score that is expected of everyone, and a target score which it is hoped everyone will strive to achieve. Some considerations should be given, however, to determining targets on an individual basis, so as to ensure they are realistic. No competitor can be expected to improve on all parameters tested during all phases of training.

Future Testing Sessions
Where future tests involve the same tests as the initial session, there is no need to repeat much of the paper work. All that is required is a record of the scores, the resultant training programme and details of the next testing. The rationale for the tests need not be repeated. It should be noted, however, the design of the training programme is not the role of the sports scientist.

Summary
Where athletes have misgivings about fitness tests, the reasons are often due to lack of feedback and failure to outline the purpose of the tests. By giving athletes a rationale for the tests being performed, results which indicate their performance or progress, and the desired changes to training, some of these areas of discontent may be minimised.


Feedback from Fitness tests should always be given to athletes.

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The Use of the Repeated Shuttle Run Test for Team Sports – An Alternative to the "Beep Test"

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Abstract
Traditionally the "beep test" or the 20 metre shuttle test has been widely used as a measure of a player's fitness for field team sports. Although being valid and reliable for a measure of a player's aerobic capacity, this test does not provide data on the specific fitness needs of a team sport player. The Repeated Shuttle Run Test (RSRT) provides coaches/conditioners with data concerning the player's anaerobic and aerobic capacities. The RSRT incorporates maximal or near maximal efforts over short distances and changes of direction repeatedly. Anecdotally this test appears to provide more accurate feedback on a player's match fitness level than the "beep" test

My relevant experience is as a strength and conditioning coach in several junior team sports, primarily rugby league. One of the challenges I faced several years ago was finding specific fitness test for team sport athletes. Traditionally the beep (20metre shuttle) test has been widely used test for many team sports to gain a measure of a player's aerobic capacity (an important component in many team sports).

In my early years working with an elite junior rugby league squad I *was* finding that although the beep test was providing me with valid and reliable testing data for aerobic endurance, the results were often inconsistent with a player's individual match fitness and therefore not providing me with the data myself and the coaching staff was really seeing. In most team sports, players are required to perform repeated sprints in varying directions and over varying distances with brief rest intervals throughout the period of match, often a maximal or near maximal speed.

I concluded that a test was required that simulated more closely the demands required of team sport players in competition, incorporating maximal anaerobic efforts, change of direction, over short distances repeatedly.

I found several test that were being utilised by various team sports that aimed at providing data for a player's anaerobic endurance. Most tests were either conducted on a stationery cycle ergometer, not specific for a field sports, or consisted of straight line running.

The most specific test I identified for the demands of rugby league and other similar team sports was the Repeated shuttle Run Test (RSRT).

The protocol for the RSRT follows (Hawley, Burke 1998 pp 72-73):

A ⇔B ⇔ C ⇔D ⇔E ⇔F

Players commence the test at Point A and upon an auditory signal, sprint to cone B, touch the base of the cone, turn, return to Point A, reach down to the base and then spring to Point C.

The player continues in this manner, sprinting to the remaining cones (D, E & F) making sure to return to the start (A) between each outward shuttle.

If a very fit player can run the entire shuttle (A to F and back) in under 30 seconds, then they commence the cycle again.

An auditory signal after 30 seconds of the test indicates the end of that stage of the shuttle run. the number of stages is recorded (in metres) while the player takes a 35 second rest. After 35 seconds they begin the run again. The test is repeated.

The 35 second rest between efforts in the RSRT ensure players do not fully recover the maximal anaerobic effort previously. Whether 35 seconds is the ideal duration for the rest period in this test is probably an area requiring farther study - different sports may have certain rest durations that are specific to the requirements for their sport.

The variables from this test are:

- The total distance covered by a player during the six shuttle runs; and
- A fatigue index, determined from the difference between the maximum distance covered by the player during any single shuttle run minus the shortest distance covered during a run, usually the last shuttle.

The RSRT tests the ability of the player to attain high maximal running speed over a short distance which is obviously a necessary attribute in athletes in most player positions in a variety of team sports. Just as importantly is the ability to perform these maximal efforts repeatedly after short rest intervals throughout the duration of a match the RSRT provides data on the combined measure of the anaerobic and aerobic power systems of the

athletes (Hawley, Burke 1998 Pg73).
Listed below are the pro's and con's for the use of the RSRT for team sports such a rugby league from my experience over the past 3 years.

PRO'S

- More real word valid is obtained regarding the specific fitness of a player, combining both aerobic and anaerobic energy systems
- The movement patterns are specific to league and other similar team sports given the acceleration/deceleration required over short distances
- Test takes 6 ½ minutes to complete, after an adequate warm up

CON'S

- Logistics - for conditioners not familiar with the test, one staff member needs to monitor one player at a time. Given this potentially no more than 5 or 6 players may be able to complete the test at once. For a squad of 20-30 players testing may be spread over a 30-45 minute period, whereas the beep test may be completed for an entire squad at the time within 10 minutes.
- Coaches/Conditioners may take time to become familiar with the test to ensure accurate result, and the calculation of distance is more difficult to perform.
- Due to the new nature of the RSRT extensive normative data are not currently available to compare results against

Although I have not collated any data to prove that players performing better in a RSRT are players with greater match fitness, I can state anecdotally that this appears to be the case. In some cases where I have tested both the beep test and the RSRT, players have shown to excel in one or the other and rarely in both, suggesting they may be measuring different fitness qualities,

Again, anecdotally the players that have excelled in the beep test only are often those putting their hand up for a rest in the first 15 minutes of a game of rugby league. One could conclude that this is not because the aerobic system has been challenged to a great extent early in the game, rather the anaerobic demands have been too much for the player's capacity.

I believe the RSRT provides the essential data that many conditioners for team field sports are seeking - a specific test that addresses the basic speed of the athlete, the ability to turn at pace and accelerate repeatedly (anaerobic capacity) and the ability of the aerobic system to provide rapid recovery between runs.

The data provided to coaches/conditioners from the RSRT is a further tool to provide an overall picture of a player's physiological profile. Comparative results from both the beep rest and the RSRT could well be used to determine the priority in the player's conditioning program. For example, if a player was very good at the beep test but not so good at the RSRT then arguably they may require more short interval alactic training. Conversely, if the player was good at the RSRT but poor at the beep rest, they may require more longer continuous aerobic training, or at least longer interval work.

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About the Author

■ Completed a Bachelor of Science Degree in Sports Coaching at the University of Canberra in 2001.
■ Commence employment at the ACT Academy of Sport in 2001 and worked casually as **a** strength and conditioning coach with several squads, primarily Softball, Basketball and Rugby League.
■ Commenced full-time employment with the Canberra Raiders in 2001 as a development officer (still in that role).
■ Main duties at the club over the past 4 seasons have been *the junior* strength and conditioning coordinator for the junior representative squads competing in the NSWRL competition and
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Predicting 1RM or sub-maximal strength levels from simple "reps to fatigue" RTF tests

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Abstract

The validity of estimating one-repetition maximum (1RM) or estimating repetition performance at levels between 60-100% 1 RM from a table of correction factors was investigated in two studies. In study one, thirty-four (34) male professional rugby league players were tested 1 RM bench press (BP) and repetitions to fatigue (RTF) while lifting an absolute resistance of 102.5 kg. In study two twenty-three (23) male professional rugby league players were tested for 1RM pull-up (PU) and RTF with body mass. The actual repetitions performed by each individual in the RTF tests were correlated to the number of repetitions that were predicted to be performed according to each individual 1 RM and the data from the table. High correlations of r = 0.93 and r = 0.83 were found between the actual repetitions and predicted repetitions performed in the RTF test for the BP and PU, respectively. This result indicates that RTF tests appear to be reliable predictors of strength performance in these two exercises. Consequently RTF tests are recommended for estimating 1 RM performance or repetition performance at sub-maximal resistances. This may be especially useful when dealing with large numbers of athletes, especially inexperienced athletes.

Keywords: strength, 1RM, bench press, pull-up, prediction.

Introduction

When commencing the strength coaching of a new athlete it is often good to have some idea of their capabilities. As a coach, you can interview them regarding their capabilities, implement lengthy one-repetition Maximum (1RM) test procedure(s) or perhaps implement quicker more simple test(s) that estimated 1 RM levels through the performance of a "reps to fatigue" (RTF) test with a given sub-maximal resistance. This last procedure relies on understanding the relationship between maximum and sub-maximum capabilities to estimate 1 RM levels.

The relationship between human power output or performance and time to exhaustion is not a linear relationship, but a hyperbolic relationship (18). Many equations that have been developed do not take this into account and tend to over-estimate1RM capabilities by inferring a more linear relationship (16, 17,20). Also some equations are not gym friendly, requiring a spreadsheet to determine the complicated equations. Simple three-digit correction factors are believed more appealing as they can be used with a simple pocket calculator in the gym to calculate training weights or estimates of 1RM (12), instead of developing another semi-useful equation, I developed a table that allows a coach to extrapolate 1 RM from a RTF effort and conversely, by back-extrapolation, determine how many repetitions could be performed at other sub-maximal resistances in that exercise. Table 1 provides a guide as to the relationship between repetitions performed and % 1RM between 1 to 20 reps with a reconversion factor to estimate 1 RM from a RTF effort or test. This table is based primarily upon my own research (2) and training observations. upon the hundreds of athletes that I have trained, but is also influenced by other research (1, 6, 7, 8, 9,12, 13, 14, 15, 16, 17,20, 21, 22) as well as the tables of renowned strength coaches Boyd Epley (10), Charles Poliquin (19), Nate Foster (11) and the American National Football League (NFL) table (9). The table of correction factors that I developed has been validated before, when between three and six repetitions have been performed (2, 12) but further validation is needed for the higher repetition ranges. Generally correction factors become less accurate further away from 80% 1 RM, when higher repetitions are performed (16, 17, 22). Also very little data has been published concerning the 1RM pull-up strength, RTF and predictive correction factors.

The purpose of this paper is to validate the predictive qualities of the table by comparing RTF results predicted from 1RM test results to actual RTF performance in bench press (BP) and pull-up (PU) exercise (aka chin-up).

Methods

Two experiments were carried out with professional rugby league players as subjects. All were experienced in resistance training and were tested at the completion of a strength development cycle. In study one, thirty-four players were tested for 1 RM bench press (1RM BP) and RTF with absolute resistance of 102.5 kg. In study two, twenty-three players were tested for 1 RM pull-up strength and RTF with an absolute resistance of body mass. In both instances, the amount of repetitions that were predicted to be performed with the designated resistances, based upon an individuals 1RM and the relevant calculations from Table 1, were compared to the actual repetitions that were performed during the RTF tests.

Study One. The average, body mass and height of the subjects was 22.6+3.9 years, 95.5+10.1 kg and 183.3+5.8cm. Procedures for the 1 RM BP testing entailed warming up with sub-maximal resistances and thenlifting progressively heavier resistances until 1RM was achieved (2,3,4,5,). Three days later a RTF test was performed with an absolute resistance of 10.5 kg (this being the NFL 225-lb BP test). In this test, after warming up the players performed as many repetitions as possible with this resistance till fatigue (9). The actual repetitions performed were compared to what was predicted to be performed based upon the calculations from Table 1 (eg. 102.5 kg / 137.5 (1RM BP) = 75% which corresponds to 10 repetitions).

Study Two. The average age, body mass and height of the subjects was 18.8+1.3 years, 89.01.3 years, 89.0+9.6kg and 192.5+5.1cm. The PU 1RM test was rather unique in implementation and required further description. The 1RM was determined by adding the athletes body mass to the attached additional mass to garner the total mass that was successfully lifted during the 1RM PU test. Additional mass was attached to the athletes lifting belt via a rope or light chain. This allowed for the incrementation and calibration of lifting mass during the 1RMPU Test (4). For example a 90kg athlete who could perform a PU with an additional 40 kg attached to the waist would score 130 kg in the 1 RM PU Test.

The PU test was performed with a supinated grip and the testing repetition was preceded by an eccentric phase, as is the case for the BP. For the preceding eccentric phase to occur, the athlete and attached additional mass had to be held by three partners in the starting position of arms flexed and chin in line with the pull-up bar. Other factors must be considered. Firstly, there are obvious individual differences that exist such that some individuals vary greatly from the averages of the table. The table is simply a starting point and over time a coach may develop further information such that they know each individuals variation and in fact develop modified tables for individuals (11). Also it appears that these prediction equations or tables can sometimes be less accurate with untrained people (although this is not unequivocal), less accurate the further away from 80% **1RM** you go (6, 16, 17, 20) and the fact some exercises such as leg press or leg curls do not follow this guide (13). For example, research has shown that about 20 repetitions can be performed at 80% 1 RM in the leg press, but only 11 repetitions at 60% in the leg curl (13). But generally for moderately trained athletes performing multiple-joint, free-weight strength training exercises (or pulley exercises such as lat pull-downs), this table appears as a useful guide for extrapolating what an individuals 1RM would be based upon the maximum amount of repetitions that can be performed with any resistances that allow for the performance of between two and twenty repetitions and/or for back-extrapolating how many repetitions can be performed at any designated sub-maximum resistance in this range.

Conclusion

The data in Table 1 allows a coach to extrapolate what an individuals 1RM would be based upon RTF tests with sub-maximal resistances and also for predicting how many repetitions can be performed at any designated sub-maximal resistance in this range. This could save time when dealing with large numbers of athletes and when coupled with a spreadsheet application, could also allow for very accurate individualised training weight prescriptions.

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Table 1. Guide for determining 1RM from varying repetitions performed to maximum effort. An estimate of 1RM is made when the weight lifted is multiplied by the reconversion factor according to the number of repetitions that were performed with that weight.

Guide for 1 – 10 reps			Guide for 10-20 reps		
1	100	N/A	11	73	1.36
2	95	1.05	12	71	1.40
3	92	1.08	13	69.5	1.43
4	89	1.12	14	68	1.47
5	86	1.16	15	66.5	1.5
6	83	1.20	16	65	1.53
7	81	1.23	17	64	1.56
8	79	1.26	18	63	1.58
9	77	1.29	19	62	1.61
10	75	1.33	20	61	1.64

*To convert, multiply the reconversion factor by the resistance lifted to garner an estimate of 1RM. For example. If someone can lift 100kg for ten repetitions, then the estimated 1RM would be 133kg (100kg x 1.33). To determine the 5RM for this athlete, then 133 x .86 = 115 kg or for 15 RM, 133kg x .665 – 87.5 kg.

Table 2. 1RM strength levels, actual and predicted repetitions performed while lifting the standard 102.5 kg mass during the bench press and correlation between actual and predicted reps (n=34). Mean ± SD

1 RM Bench press (kg)	102.5kg As % 1 RM	Actual Reps	Predicted Reps	Correlation Co-efficient
135.6 ± 16.3	76.6 ± 8.8	10.1 ± 4.8	9.8 ± 5.1	R=0.93

Table 3. 1 RM strength levels, actual and predicted repetitions performed while lifting body mass during the pull-up and correlation between actual and predicted reps (n=23). Mean ± SC

1RM Pull-up (kg)	BM As % 1RM	Actual Reps	Predicted Reps	Correlation Co-efficient
120.6 ± 12.0	74.0 ± 7.1	11.5 ± 4.3	11.1 ± 4.3	R=0.83

A simple method for evaluating the strength qualities of the leg extensor muscles and jumping abilities

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Introduction

The assessment of strength qualities is a valuable part of the coaching process for the strength and conditioning coach. It allows strengths and weaknesses of individual athletes to be identified as well as the monitoring of training progress. One popular method of assessment of the function of the leg extensor muscles and jumping ability utilizes a contact mat system (Bosco et al, 1983). Although such a system has been available for many years, it is not well known in Australia, and is relatively expensive to purchase "off the shelf from overseas. Therefore a cheap alternative contact mat system and test protocols were developed at the Sports Science and Sports Medicine Centre and Computing department at the Australian Institute of Sport (AIS). This system has been "packaged" and made available to coaches and scientists for $200.00, as a non-profit making service. The use of the test protocols and

How the system works

A 78 X 52 cm contact mat is specially wired so that it can be connected to any computer. When an athlete jumps, the computer clock is started, at the instant ground contact is lost and is stopped at the instant of landing back onto the mat. The on-off switch mechanism is also used to record ground contact time to 0.001 seconds. The height of rise of the centre of gravity (C of G) or jump height is calculated by computer from the flight time of the jump, according to the following equation (Bosco et al, 1983):

Jump height (m) = g t2 / 8

Where:
G=acceleration due to gravity (9.81m/s/s)
T=flight time of the jump (sec)

The equation can be simplified and the jump height expressed in centimeters:

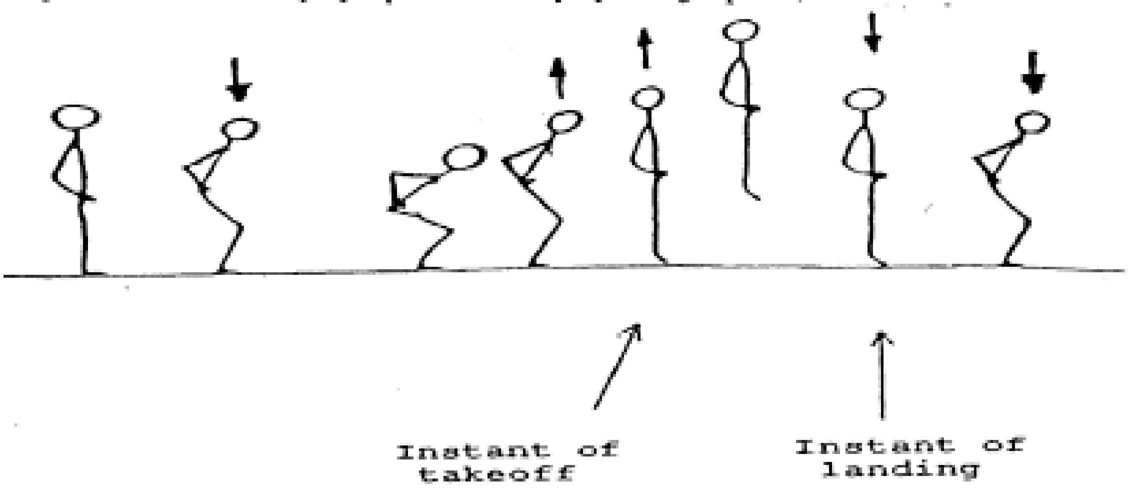
Jump height (cm) = 122.625 t2
Where t = flight time of the jump (sec)

For this method to be valid, an important assumption is made; i.e. the body positions at the instant of takeoff and the instant of landing are the same. Therefore athletes are instructed to land on the balls of the feet in an upright extended position; i.e. full extension at the hips, knees and ankles (Figure 1).
Once contact with the ground is regained, the knees are common deviations from the correct landing position include flexed knees, hips and ankles, and loss of control leading to a foward lean of the trunk or entire body. All of these positions cause the C of G to land at a lower level than the position of takeoff, thereby prolonging the flight time and overestimating the jump height. For example, calculations that were done to predict the degree of error caused by a relatively flat foot landing (dorsi flexed ankles) revealed a 16 % overestimated jump height! Therefore it is crucial for the tester to control the landing position and eliminate "incorrect" trials so that results are valid.

Another consideration is the positioning of the arms during a jump. The simplest way to ensure that the body positions at takeoff and landing are the same is to keep the hands on the hips throughout the jump (Figure 1). Another possibility would be to hold a light stick on the shoulders during a jump. If the arms are allowed to swing as they naturally do in many jumping activities, it is extremely difficult to ensure that they are in the same positions at takeoff and landing. Therefore testing with an arm swing is not recommended- and the validity of test results obtained this way with no effort to control arm positions is questionable.

The main advantage of the contact mat system for the coach or sport scientist is its

Figure 1. Countermovement jump sequence. N.B. The jump is straight upwards, not fowards.



portability. With the use of a laptop computer, the system can be taken to the training venue rather than the laboratory for testing, which has obvious appeal to coaches. In addition the system is quite inexpensive.

Test protocols

There are three tests or options that can be run from the software developed at the AIS.

<u>1. Countermovement jump (CMJ)</u>

This is simply a vertical jump without an arm swing (Figure 1). This test has been used widely in research using force platforms (eg. Komi and Bosco, 1978; Viitasalo and Bosco, 1982) and for monitoring training (e.g. Hakkinen, 1993). The CMJ is used at the AIS as one test of the speed-strength qualities of the leg extensor muscles, and for talent identification purposes.

The arm swing in the traditional vertical jump and reach test (VJ) has been shown to contribute approximately 10 % to jump height (Luhtanen and Komi, 1978). Strength training of the shoulder muscles that swing the arms has also been shown to improve VJ performance (Narita and Anderson, 1992). These findings indicate that improvements in the VJ score may not be entirely due to the function of the leg extensor muscles. which is what the VJ test is thought to measure. By taking out the arm swing, *it* is intended that the CMJ reduces the skill/co-ordination requirement of the test and focuses the effort on the leg extensor muscles. Therefore the CMJ is preferable to the VJ as a test of leg power and for monitoring the effects of strength training programs that target the leg muscles.

The athlete is instructed to jump for maximum height and execute a dip or countermovement immediately before the upward propulsion. No specific instructions should be given regarding the depth or speed of the countermovement which could influence the results. However, athletes should be encouraged to "experiment" during warm-up/practice trials to find his or her optimum countermovement conditions. Generally, a very shallow or deep or slow countermovement doesn't produce the best jump height

As soon as the athlete returns to the mat from a jump, the height attained is immediately displayed on the computer screen, which should be conveyed to the athlete as feedback. An unlimited number of trials should be allowed to reveal the true best performance of the athlete. This usually requires4-8 jumps, using a complete recovery (15 sec or more) between trials. To enhance the reliability of the test (test-retest consistency), it is recommended that the athlete displays a "reasonable" level of consistency e.g. variation of less that 1.5 cm between the top three jumps. The score used as the athletes performance is the mean of the best three jumps. An alternative is to retain only the single best jump as the score, but this may not be as reliable. The method that is preferred should always be used for the purposes of standardization.

<u>2. Drop jump (DJ)</u>

A drop jump (DJ) involves jumping vertically immediately after landing from a fall or drop from a predetermined height.

This activity has been widely used as a plyometric training exercise (eg. Miller, 1981; Schmidt-bleicher, 1992), and as a test of leg extensor function (eg. Komi and Bosco, 1978; Hakkinen and Komi, 1985). The way in which the DJ test is conducted using the AIS system is somewhat different to the traditional method of jumping only for height. The athlete is instructed to jump for maximum height and also for minimum ground contact time. Performance is calculated as jump height (cm) divided by contact time (sec). To achieve a good score on this test, the athlete must be able to quickly Reverse the downward velocity from the fall and generate good upward propulsion. This form of DJ test is considered as a measure of reactive strength.

Although both the CMJ and DJ are vertical jumping activities; they have some clear differences. The CMJ typically involves a deep knee bend (approximately 90 degrees), and therefore a relatively long4akeoff time (> 400 ms). The eccentric or stretch load that is placed on the leg muscles during the countermovement is relatively low. On the other handle- DJ involves a relatively small knee bend, and short contact time (,200 ms), which imposes higher stretch loads on the leg extensors. Testing conducted as the AIS has revealed that athletes that are relatively good at the CMJ are not necessary good at the DJ and vice-versa. This means that the two tests may be measuring different qualities.

The CMJ appears to be quite specific to jumps from a standing position eg. block in volleyball, rebound in basketball. The DJ contains features that are more specific to the characteristics of a jump from a run-up eg. high jump. As might be expected, AIS test results have shown that the CMJ is a relatively good predictor of vertical jumping ability (from a standing position), whereas the DJ is a relatively good predictor of the ability ;to jump from an unlimited run-up. The conclusions to draw from this are that jumping abilities are quite specific, and the selection of the appropriate test should depend on the specific nature of a particular sport.

Description of the DJ protocol,
DJ are performed from a variety of drop heights eg. 30,45,60 and 75 cm. As soon as a jump is completed, the jump height, contact time and reactive strength performance is displayed on the computer screen. Feedback should be provided so that the athlete can easily determine the optimum combination of jump height and contact time that produces the best performance. An example of a test result from a male gymnast is shown in Figure 2.

The test result provides three sources of information.

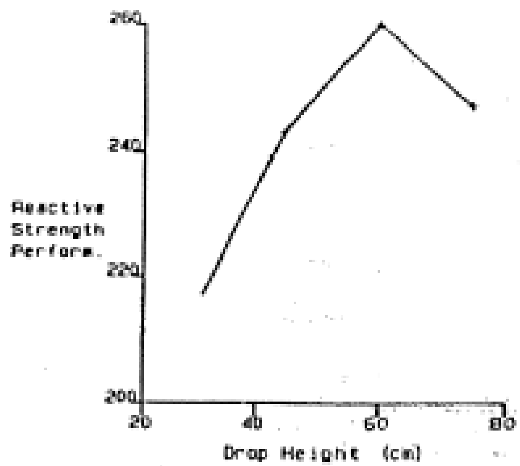
1. The maximum reactive strength performance across all drop heights (260 in Fig.2) is compared to athlete norms to determine the need to further train this component The reactive strength ability should be considered in conjunction with other physical components of performance contained in the athlete profile, before any modifications to the training program are made.
2. The drop height that produces the best performance (i.e. 60 cm in Fig.2) provides information about the ability to tolerate stretch loads (Le. the greater the drop height, the better the ability). If this quality can be improved through training, an athlete may be able to utilize a faster approach run and convert this to vertical height with less risk of the takeoff leg "collapsing".
3. The drop height producing the best performance may be prescribed as the height to use for drop jump training. It is likely that the lower drop heights producing submaximum performances (i.e. 30 and 45 cm in Fig.2) produce an inadequate training stimulus. On the other hand, the 75 cm drop height produced an excessive stretch load that could not be tolerated, possibly due to a neuro-muscular inhibition. The 60 cm drop height is assumed to be the individual optimum training height for this athlete because it probably produces the most powerful muscular contractions. Although the benefit of this method is yet to be proven, it offers a rationale for the selection of training drop heights which is lacking in alternative methods.

Although drop heights of 30, 45 60 and 75 cm are recommended for the majority of athletes, elite performers may produce their best performance at 75cm.In this case, additional drop heights should be added in 15cm increments until it is clear that the reactive strength performance has declined. On the other hand, poor athletes may produce a progressively deteriorating performance from 30 to 45 to 60 cm. In this situation, the 75 cm drop height should not be used, since the drop height producing the best performance has already been observed.

Figure 2. Example of a drop jump test result.

Reactive Strength (Drop Jump)

Drop Height (cm)	Jump Height (cm)	Contact Time (sec)	Reactive Strength Performance (Jump height/time)
30	36.0	0.166	217
45	39.6	0.163	243
60	42.4	0.163	260
75	41.3	0.167	247



This form of DJ involves relatively high impact forces (as with jumping from a run-up), and tend to increase with increasing drop height Athletes at risk of injury should not be exposed to this test, especially individuals with a history of calf muscle, achilles tendon or shin problems.

3. Contact time

This option is intended to simply display contact times (in milliseconds) so that plyometric exercises can be monitored during training. It is often desirable to instruct an athlete to either minimize the contact time or use a contact time that is as close as possible to a competitive movement Experience has shown that this form of feedback is very motivational and useful for controlling the desired contact times, even for athletes experienced in jump training.

This application is ideally suited to vertical jumping exercises eg. hurdle jumps, and although it can be used for horizontal jumps, it is not recommended for movements involving a large horizontal component eg. sprinting.

Field *tests* of jumping ability

Although the CMJ and DJ involve jumping, they are primarily intended to provide information about the function of the leg extensor muscles. The elimination of the arm swing makes them significantly different to jumps that are performed in different sports. Therefore, it may also be useful to conduct field tests that are specifically designed to measure sport specific "jumping abilities**. An example of such a test used at the AIS is a VJ performed from a single step approach. This test was selected to simulate as close as possible the skill of some jumps used in basketball. A jump using a single leg takeoff from an unlimited run-up would be an example of a specific test for a high jumper. Such a test could not be performed practically using a wall to mark the highest reach, due to the horizontal movement of the body. Therefore a special jumping device such as a Vertec is recommended. This device is portable, free standing and has plastic vanes that are displaced by the fingers during a jump, thereby revealing the highest reach.

By using a combination of the contact mat system to evaluate the leg extensor muscles and sport specific field tests, it is possible to isolate the source of any training-induced gains in jumping ability. For example, if a field test indicates improvement in jumping ability without a corresponding gain in a muscle function test (CMJ or DJ), the improvements would have been largely due to development of jumping skill rather than leg extensor abilities. In this case, the effectiveness of any leg power program would have to be questioned.

Figure 3 is a guide for selection of tests for sports requiring jumping abilities.

For example, if a sport involves jumps that utilize a relatively fast run up, it will contain a relatively short contact time and high stretch load characteristics. Therefore possible tests could be a sport specific field test to evaluate jumping ability (test 3), and the DJ test to evaluate the muscular qualities associated with this type of jump (test 4).

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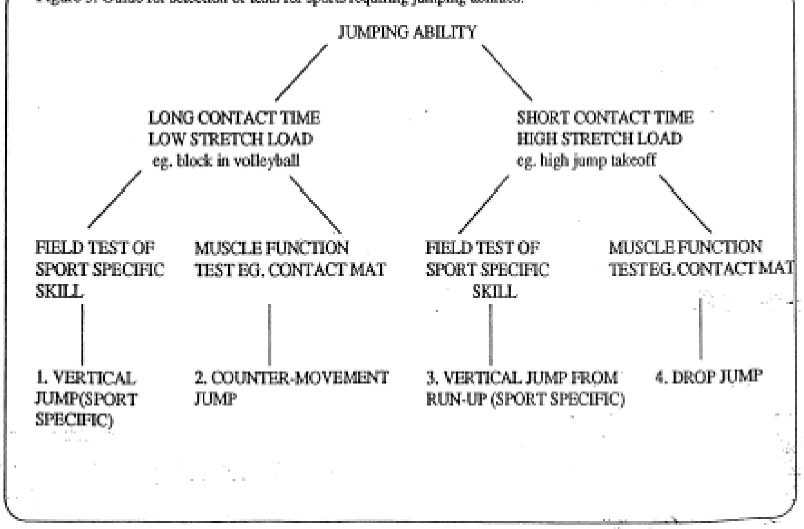
Figure 3. Guide for selection of tests for sports requiring jumping abilities.



Fitness Testing and Assessment of the Athlete – A Review

By Derek Gibbins BASc (Sports Science)

Testing provides coaches with a means of assessing the attributes required by an athlete in order to succeed in a particular sporting endeavour. Having identified the necessary physical skills, and physiological requirements, testing can continue to serve as a tool to evaluate the effectiveness of the specific training programs used to develop the appropriate athletic qualities. (3,17,7).

The assessment of athletes can be carried out as either a series of laboratory procedures, using highly specialised and sophisticated equipment, or as a group of field tests, selected for their close correlation with the actual motor skills required for a particular sport.

Field testing has become one of the most widely used diagnostic tools in modern coaching because of the relative ease with which it can assist the conditioning specialist in achieving the following vital tasks:

a) Talent identification
b) Quantification of specific strengths and weaknesses.
c) Screening athletes for potential health risks.
d) Establishing training goals.
e) Measuring the effects of specific training programs.
f) Evaluation for position placement and ranking.
g) Motivating the athlete
h) Collection of normative data.

Selecting Appropriate Tests

The first step in the process of selecting an appropriate battery of tests with which to assess the capabilities of an individual, or group of athletes, is to identify the physiological parameters that are required to perform the particular activity in a superior fashion and to then find a relevant test for each one. (2)

When evaluating the tests to be used for the physical assessment of athletes the major criteria are:

Relevance

Tests selected should be sport specific and mimic actual movement patterns as closely as possible. (5)

Validity

The tests must measure what they claim to measure. (5)
Reliability Test results must be consistent and reproducible. (5)

Acceptability

The tests used should have a sound scientific base and be accepted by your peers. (2)
Feasibility It must be possible to effectively complete the number and type of tests within the selected protocol given the availability of time, resources and facilities.

Within a single sport the dominant physical characteristics (Eg., Strength, speed, endurance, etc.) required to become an elite performer may change from one playing position to another, and therefore the rank order of tests may need to be varied. (4)

The following list contains some of the most commonly identified physiological parameters, together with examples of both laboratory and field tests normally used by conditioning specialists when assessing athletic abilities. (1,2)

Cardio-respiratory Endurance
These tests normally measure heart rate response to exercise, but can also assess the efficiency and capacity for oxygen extraction and utilisation (V02 max.), given the availability of sophisticated gas analysis equipment.

Treadmill (Ohio State University Method [*])
Ergometer (Astrand {5}, PWC 170 {5}, Tri-level {18})
Step Tests (Queen's College {5}
Distance Runs (Cooper's 12 minute run {5})
20 metre Shuttle Run {11{

Anaerobic Endurance

The athlete's ability to sustain high intensity activity is measured during this type of assessment.
Tri-level (18)
Shuttle Run (10)
Line Drill (15)

Muscular Strength
These tests can be used to highlight specific strengths, weaknesses or imbalances and relative improvements in response to appropriate training.

Isokinetic [Cybex (8)]
1RM or 3 RM (8,9)
Dynamometer (5,8)
Kneeling Overhead Throw (12)

Muscular Endurance

This type of test normally involves repetitive movements designed to stress a particular muscle or group of muscles, and typically uses the athletes own body weight as the major source of resistance.

Pushups(13)
Situps(6)
Chins
Dip

Power (Force x Velocity)

These tests are designed primarily to assess the athlete's ability to utilise energy and strength to produce rapid and powerful movements.
Vertical Jumps, Triple Jump and
Broad Jump (16)
Margaria-Kalamen Test (8)
Tri-level Test (18)

Speed (Displacement/time)

Tests in this category are designed to measure the athlete's ability to accelerate to maximum velocity in the shortest possible time frame and to be able to maintain that speed over a preset distance.
Stationary Start 10-100m Dash (1)
Flying Start 40-100m Dash (1)
Stride Length (1)
Stride Frequency (1)

Agility/Reaction Time

These tests reveal the athlete's ability to perform a series of rapid movements in opposing directions.
T-Test(14)
Illinois Agility Run

Body Composition

Measurements of Body fat and assessments of lean body mass can be a valuable guide to the success of specifically designed weight loss/gain programs.

Hydrostatic Weighing (8)
Skinfolds (5)
Body Weight
Circumferences
Ultra sound

Flexibility

Tests of range of motion at the various joints recruited during the performance of particular sport specific activities can provide the coach with an insight into muscle rigidity, length imbalance and injury susceptibility.

Leighton Hexometer (8) Sit and Reach Test (5)

Other types of assessments are also used to complement the data obtained from the fore mentioned physical evaluations including Nutritional Status, General Health and Injury Potential.

Test Administration

The reliability, accuracy and ultimate validity of any testing protocol is dependent on the strict adherence to carefully designed and standardised administration procedures.

The following points should be considered during the design of an effective test protocol (5):

1. The order in which any battery of physical evaluations is performed should be carefully considered to ensure that the physical demands of one test do not compromise the results of subsequent evaluations. (A safe sequence to adopt would be body composition, aerobic capacity, flexibility, strength, speed and finally power.
2. Recovery intervals between *tests* should be carefully planned and rigorously enforced to ensure that the risk of injury to athletes is kept to an absolute minim
3. It is vital that athletes warm up and stretch adequately prior to the commencement of any test protocol
4. The pretest condition of all athletes in terms of food and fluid intake, recent training intensity, state of health and pre-evaluation rest must be carefully controlled to ensure that test results are comparable.
5. The test environment, time of day and equipment used should be standardised to limit the possible corruption of results. The practice of always using the same person to administer a particular test to all athletes will also help to ensure comparability of output data
6. Every test procedure should be fully documented and carefully explained to all parties

involved to ensure that the reasons, relevance and outcomes of testing are known, and clearly understood.
7. Test results should be compared to existing norms and rate of progression according to age, sex, sport, position, etc.

Integration of Testing

Testing is an integral element of any training program, and as such should be written into the periodisation plan from the outset, and not 'Bolted on' as an after thought One-off evaluations are of little use, and therefore all assessments should be on a test/ retest basis.

Recommendations concerning testing frequency range from once per fortnight to once per year, with the ideal lying somewhere between these two extremes. (2) In practice, testing normally takes place at one or more of the following instances:

1. Pre-season
2. End of Program Macrocycle
3. Post-season
4. Special Program Completion

Testing need not be time consuming, and with the availability of portable equipment can easily be done in the field To minimise disruption of training, reassessments should be scheduled to coincide with low intensity, low volume periods in the normal training cycle.

Testing may be used to motivate athletes and, to this end, test days should always be scheduled as 'special events'. But this in no way precludes the use of test procedures as regular training drills. (7).

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