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Constructing Z-Profiles for Triathletes

Introduction

The creation of a z- score profile for an athlete allows interpretation of a fitness profile with regards to the theoretical issues that underpin fitness in specific sports. It states the implications for the subject as a competitive sports person. Constructing z-profiles allow comparisons between athletes of that sport, often highlighting the inadequencies, weaknesses or areas of improvement.

In order to begin this process, the optimum z-profile must be constructed and the components that make up this profile must be first understood.

Fitness Components

Foran (2001) describes *'many diverse factors that have been considered important for sports fitness…the degree of reliance on each component is completely dependent on the specificity of each sport or in some cases within the sport.'*

1. Aerobic Fitness
2. Anaerobic Fitness
3. Speed
4. Strength
5. Power
6. Flexibility
7. Local Muscular Endurance

8. Body Composition

Aerobic fitness involves a number of areas of adaptation such as neuromuscular, metabolic, cardio-vascular and respiratory. '*…the enhancement of the cardiovascular system increases the overall physiological function of the athlete.'* Foran (2001)

Anaerobic fitness comes into to play where oxygen supply does not meet oxygen demand and *'…levels of lactic acid in the blood and muscle begin to rise expontentially.'* Town (1985)

'Speed is the quickness of movement of a limb' MacKensie (2004) MacKensie (2004) notes that speed is an integral part of every sport and may be expressed as a combination of maximum, elastic (power) or endurance. This study refers to speed as being a maximum, the ability to move muscles as quickly as possible.

'Strength is the ability of the neuromuscular system to produce force' Stone (No Date)

Power is defined as *'The exertion of a force through a given distance in as short a time as possible.'* Beckenholdt and Mayhew (1983)

'Flexibility or mobility is the ability to perform a joint action through a range of movement.' MacKensie (2004)

Local Muscular Endurance is *'A single muscle's ability to perform sustained* work' MacKensie (2004)

'Your total weight is a combination of bone, ligament, tendon, organs, fluids, muscle and fat …Exercise scientists have coined the term "body composition."' Wolkodoff (No Date) This study took skinfold measurement to assess body fat.

Laboratory testing limits validity, failing to take into consideration the environment the athlete will be competing, in this example we will take the triathlete.

Foran (2002) suggests that there are three questions that need to be addressed before testing in order to interpet results accurately and to assess weaknesses and strengths. He states that the particular sport needs to be understood in terms of functional movement quality, functional performance quantity and sport specific skills.

Relation of Fitness Principles to Triathlon

Bompa (1999) outlines a number of characteristics for talent identification for swimming, cycling and middle distance running. Combining these will create an ideal triathlete profile:

- High VO2max per kilogram body weight and high capacity overall
- High resistance to fatigue
- High aerobic capacity
- High anaerobic threshold
- Ability to cope with stress
- Perseverance and motivation

High VO2max, cardiac volume and aerobic capacity will all help improve triathlon performance. *'The aerobic system…is of great importance to the triple sport athlete...The amount of energy produced from a molecule of glucose by the glycolytic system is only 5% of what could be produced by the same molecule if processed aerobically. In a sport where so much*

of one's success or failure hinges on the energy available for muscle contraction, this comparison becomes of key importance.' Town (1985)

A high anaerobic threshold will allow a pace to be held longer and faster before fatigue sets in. (Town, 1985)

Weighting was applied to the tested components:

- Aerobic Fitness 25%
- Anaerobic Fitness 15%
- Speed 15%
- Power 15 %
- Strength 10%
- Flexibility 10%
- Local Muscular Endurance 5%
- Body Composition 5%

Methods

Subjects

A cohort of second year female (n = 4) and male (n = 25) students enrolled on the Undergraduate Scheme in Sports Studies at the University of Wales, Institute Cardiff, with a mean (±4SD) age of 21 and 22 years, respectively, took part in the study.

General Protocol

Prior to the initiation of testing all subjects completed a pre-test health questionnaire and signed form of informed consent (see Appendix A). A general warm-up was carried out before each testing session.

Basic Anthropometric Procedures

Stature

Data for stature and body mass of all students was collected by a single observer to ensure accurate and reliable data prior to initiation of the first practical session.

Stature measurements were obtained using a Harpenden stadiometer (Holtain Ltd, Crosswell, Crymmych, Dyfed, Wales) calibrated in millimetres. Subjects stood barefoot and upright, with heels together and arms hanging naturally by the sides. Heels, buttocks, upper back and head were in contact with the vertical upright of the stadiometer. The subject's head was placed in the Frankfort plane, whereby the orbitale and tragion are aligned horizontally, thus ensuring the vertex of the head to be uppermost and in contact with the Brocca plane. Measurements were recorded to nearest 0.1 cm.

Body Mass

Body mass measurements were obtained using digital weighing scales (SECA weighing scales, Birmingham, UK) calibrated in grams. Subjects stood in minimum clothing, upright and still over the centre of the weighing scale platform with feet slightly parted and body mass evenly distributed. Measurements were recorded to nearest 0.1 kg.

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Physical Fitness Assessment Procedures

Aerobic Fitness: Multi-Stage Fitness Test (MSFT)

A distance of 20m was measured accurately with a tape measure. Both 0m and 20m were marked with cones. The subject was instructed to stand at the start of the shuttle run in preparation for the start of the test. They were asked to reach each marker on the sound of the beep. When this was no longer achievable on three consecutive attempts, the test was terminated. When the test was terminated, the level and shuttle number achieved were recorded.

Anaerobic Fitness: 40 Metre Maximal Shuttle Run Test

The 40m Maximal Shuttle Run Test was used to assess anaerobic fitness. The course was measured with a tape measure and marked out with cones at 0m, 10m and 30m. The subject was instructed to start at the 10m cone, run towards the 0m cone, run then to the 30m then return to the 10m line. (SEE APPENDIX) On a five second countdown the subject was instructed to sprint the course maximally. This was repeated 8 times with 20 seconds recovery in between each sprint. All 8 times were recorded and fatigue index calculated.

Speed: 20 Metre Sprint Test

Speed was assessed using the 20m Sprint Test. Timing gates were positioned at 0, 5, 10 and 20m intervals. A line was marked at the start (0m) and finishing position (20m) The subject was instructed to when ready (to eliminate reaction time) sprint as fast as possible run through the 20m finish line to prevent speed drop-off. The subject was allowed a maximum of two practice trials with adequate rest in between the first and second trial. Ensuring timing gates were

reset; the subject was instructed to perform the third and final trial recording split times at 5m, 10m and final time at 20m to the nearest 0.01seconds.

Strength 1: Hand Grip Strength

Strength was assessed using two tests, hand-grip dynamometer for upper body and a leg strength dynamometer for lower body.

The size of the grip was adjusted so that the second phalanx of the subject's middle finger of the dominant hand was at an approximate right angle. The subject was instructed to maintain an upright posture with their hand by their side. Holding the dynamometer in their dominant hand, approximately 10cm lateral to the thigh, the subject was instructed to slowly exert as much force as possible by squeezing the hand grip dynamometer. The subject was reminded to fully extend the arm and remain in this position throughout the test. Two practice trials were allowed with 30 seconds rest in between each trial. After an interval of 1 minute the third trial was recorded to the nearest 0.1kg.

Strength 2: Leg Strength

The leg strength test required the subject to stand on the dynamometer platform with the trunk upright and knees flexed at an angle of 130 to 140 degrees. The subject held the hand bar using a pronated grip with elbows fully extended. The chain length was adjusted accordingly so that there was no slack and bar rested comfortably across the subject's thighs. The subject was then instructed to exert slowly as much force as possible by extending the knees, ensuring the trunk remained perfectly upright. Two practice trials were allowed with 30 seconds rest in between each trial. After an interval of 1 minute the third trial was recorded to the nearest 0.1kg.

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Power: Vertical Jump Test

A Vertical Jump test was used to assess power. The subject was instructed to stand in the centre of the base mat and place the jumpometer cord around the subject's waist. The counter was then set to zero. Standing with their feet approximately shoulder width apart, the subject bent their knees to 30 degrees approximately while swinging the arms backwards. The arms were then thrown forwards and upwards while the legs were straightened as fast as possible in an attempt to jump as high as possible. During the highest point of the flight phase, the subject placed their hand against the jump board meter and the observer recorded the height reached. In the interest of safety the subject was instructed to absorb the landing by bending the legs when coming back into contact with the ground. Three attempts were permitted with the best result being used to calculate power in W.

Flexibility: Sit-and-Reach Test

The sit and reach test was used to measure flexibility. Thorough warm-up was carried out with passive stretches specific to lower back and hamstrings. The sit and reach box was placed against a wall to prevent it moving during testing. The subject was instructed to remove their shoes and place the soles of the feet against the front of the box. The subject then bent slowly forwards, sliding their hands along the measuring scale while maintaining fully extended legs, a straight back and without curvature of chest. Three attempts were allowed with the third being held for 2 seconds and recorded to the nearest cm.

Local Muscular Endurance: Abdominal Curl Test

An Abdominal Curl Test was used to assess local muscle endurance. The subjects were instructed to sit on the floor with their knees bent at an angle of 70-90 degrees with their feet approximately 5-8cm apart and forearms folded in an 'X' position across their chest. The rhythm was then set 1 full sit-up every 2 seconds. Partner subjects held their feet down and terminated the test on missing three consecutive sit-ups. Verbal encouragement was provided and the number of sit-ups was recorded by the partner.

Body Composition: Anthropometry

Body composition was assessed using skinfold measures (SFM). Skinfold callipers were placed on either side of the skinfold and gently gripped the fold and then gently released then moved.

Male SFM were taken on the chest, abdomen and thigh. The Chest SFM was taken on the mid-point between axillary border and nipple. The Abdomen SFM was taken approximately 5cm lateral of the omphalian. The Thigh SFM was taken at the mid-point of the distance between inauguinal fold and superior border of the patella parallel to long axis of the femur (subject seated).

Data Collection, Management & Analysis

Raw data was recorded on a data proforma designed specifically for the present study (See Appendix B) and subsequently entered into a computer data file. Descriptive statistics (mean ± SD) and z-scores were calculated for all variables. The subject's z-score fitness profile

was graphically illustrated. All necessary mathematical calculations, data transformations, statistical computations were performed in Microsoft Excel for Windows.

Development of Individual Physical Fitness Profile

While both male and female data were collected, due to the nature of the study that aims to develop a sex specific individual fitness profile, only male/female data are reported in the results section.

Results

The subject of study (PD) was 20yrs, below the mean (22yrs) of the group. PD was smaller in stature (171cm) than the group mean (180.50yrs) and outside one standard deviation (± 1SD) of the group (5.98cm). The subject was lighter in body mass (61kg) than the average of the group (78.99kg) and outside ± 1SD (8.09) of the male group mean (78.99kg). This is shown by green bars in Figure 1. and Table 1.

Table 1. Descriptive summary [Mean (± *SD*)] of the male study sample general characteristics and case study (PD) raw scores

Variable	Male Study Sample Mean (*SD*)	Case Study (PD) Raw Score
Age (yrs)	22 (*4.55*)	20
Stature (cm)	180.50 (*5.98*)	171.00
Body Mass (kg)	78.99 (*8.09*)	61.0

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PD's VO2max was 60.20ml.kg^{-1}.min^{-1}, better than the male group average (56.53ml.kg^{-1}.min^{-1}), and higher than ± 1SD (2.86ml.kg^{-1}.min^{-1}) of the male group (z=1.28). PD was ranked joint highest VO2max.

PD's fatigue index (FI) of -0.04% was better than the male group mean (-0.09%) and within ± 1SD (0.07%). The z-score (z=0.71) described PD as better than the male group mean. PD fatigued little throughout the test, ranking 2nd lowest fatigued.

The speed of 3.48secs for PD was slower than the average of 3.20secs for the male group and higher than ± 1SD (0.18secs). The z-score (z=1.56) described PD as slower than the male group mean, 2nd to last slowest.

The total strength of 201kg for PD was lower than the mean of the male group (231.34kg), but was within ± 1SD (36.23kg). The z-score (z=0.84) described PD as less than the male group mean. PD was ranked 18th (n=22). When relative strength was taken into account PD ranked 7th (n=22), and z-score of 0.80 better than the male mean (2.95kg.kgBM).

Power values for PD (8986W) were lower than the mean of the male group (12025.19W) and ± 2SD below the mean (1261.97W). A Z-score described PD as ±2.41SD less than the male group mean.

PD's result of 33cm of flexibility was better than the male group average (22.95cm) and higher than ± 2SD (4.69cm). The z-score (z=2.14) described PD as better than the male group mean. PD's power value was last in the group, ranking 22nd (n=22).

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Local muscular endurance (LME) of PD (58sit-ups) was lower than the average of the male group (81.19sit-ups) and within ± 1SD (28.01 sit-ups). The z-score (z=0.83) described PD as less than the male group mean. This ranked PD as 18th (n=22).

The body fat percentage for PD (8%) was lower than the average of group (9.48%) but within ± 1SD (2.88%). The z-score (z=0.51) described PD as less than the male group mean, joint 9th lowest of the male group.

Table 2. Descriptive summary [Mean (± *SD*)] of the male study sample physical fitness assessment results and case study (PD) raw scores

Variable	Male Study Sample Mean (*SD*)	Case Study (PD) Raw Score
VO_2max (ml.kg^{-1}.min^{-1})	56.53 (*2.86*)	60.20
FI (%)	-0.09 (*0.07*)	-0.04
Speed (secs)	3.20 (*0.18*)	3.48
Total Strength (kg)	231.34 (*36.23*)	201
Power (w)	12025.19 (*1261.97*)	8986
Flexibility (cm)	22.95 (*4.69*)	33
LME (number of sit-ups)	81.19 (*28.01*)	58
Body Fat (%)	9.48 (*2.88*)	8

Table 3. Descriptive summary [Z-Score] of physical fitness assessment results of the case study (PD) with ranking

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Variable	Z-Score	Ranking	Number in Male Group
VO_2max (ml.kg^{-1}.min^{-1})	1.28	Joint 1st highest	23
FI (%)	0.71	2nd lowest fatigue	16
Speed (secs)	1.56	21st fastest	22
Total Strength (kg)	-0.84	18th strongest	22
Relative Total Strength (kg)	3.30	7th strongest	
Power (W)	-2.41	22nd most powerful	22
Flexibility (cm)	2.14	1st most flexible	20
LME (number of sit-ups)	-0.83	18th most LME	22
Body Fat (%)	-0.51	Joint 9th lowest Body Fat %	25

Figure1. Z-Score Profile of physical fitness assessment results of the case study (PD)

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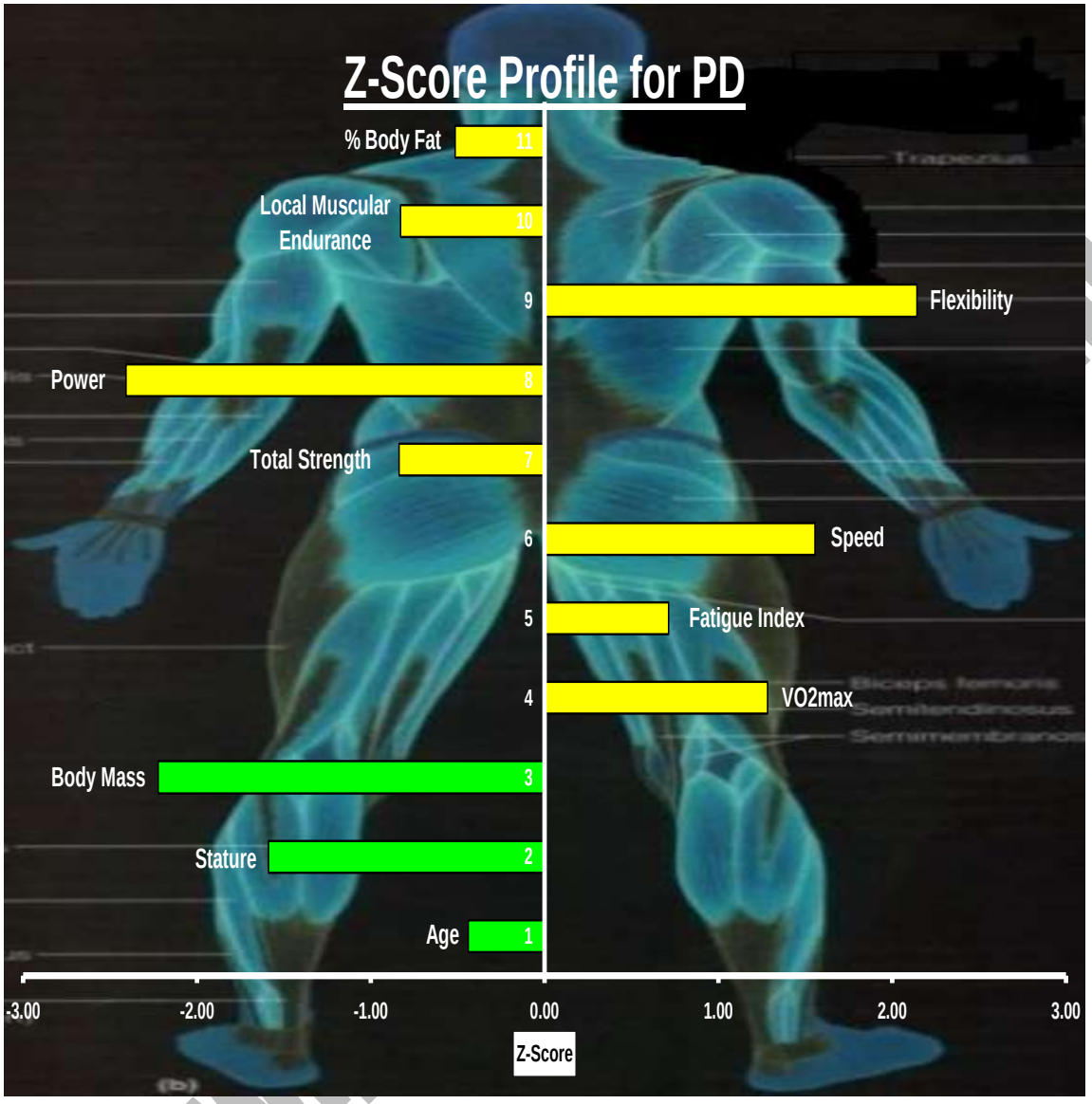

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Discussion

The subject of study (PD) was 20yrs, below the mean (22yrs) of the group. PD still has a number of years before he will reach his physical peak. *'Men tend to maintain their peak levels of muscular strength and endurance and CR fitness until age 30.'* Jallic (2003) PD was considerably smaller in stature (171cm) than the group mean (180.50yrs) and lighter in body mass (61kg) than the average of the group (78.99kg) allowing PD to carry less weight in bone mass.

The maximum amount of oxygen uptake in one minute is incredibly important to the triathlete. High VO2max values raise the lactate threshold, pushing upwards the point at which lactic acid is produced (Bompa, (1999). This is a contributing factor in the limiting of fatigue onset. PD's high VO2max of 60.20ml.kg^{-1}.min^{-1} was the joint highest value within the male group, demonstrated with a z-score of 1.28 and is the most important quality for a triathlete (Town, 1985).

The 40 Metre Maximal Shuttle Run Test involved many changes of direction. This is not an important element to triathlon. Although PD did not expect to show fast times, PD was predicted to show little decrease from the first to the last measure. PD's fatigue index (FI) of -0.04% and z-score profile of 0.71 confirmed this assumption. This endurance level will benefit the triathlete as PD will fatigue little during efforts. The ranking of 2nd lowest fatigued suggested that greater emphasis is placed on of this component in triathlon than those of other sports within the male group. Together with high VO2max values PD has demonstrated high resistance to fatigue, essential to the sport of triathlon. Recovery may also increase and allow PD to train longer and harder (Town, 1985).

PD expected to perform poorly in the 20 Metre Sprint Test as speed endurance is considered more important. Speed is necessary to all sports in some form (MacKensie, 2004) but there is a greater need to remain aerobic throughout triathlon racing. PD was a lot slower than the mean of the group as expected. A majority of the male group came from games backgrounds such as football or rugby. This group may have exhibited exceptional values as speed is a vital component games sports. This may explain poor performance and the 1.56 z-score.

Average performance was expected in both the Hand Grip Strength and Leg Strength test. This could be affected by the triathlete's stronger events. A swimmer would expect to score slightly higher in the hand strength test due to use of the arms than for example a cyclist. However, this test is not specific to swimming or use important swimming muscles. The Leg Strength test would expect to favour those who cycle or run. During a triathlon the athlete must carry their own weight around the course. Therefore what muscle they carry must be efficient and effective. As a result, PD's absolute strength was of less importance than relative total strength. PD's total strength was poor (18^{th}, n=22). However total strength in relative terms brings PD into the top third of the male group (7^{th}, n=22). This reverses PD's z-score from less than the mean (z=-0.84) to more than the mean (z=0.80).

The Vertical Jump Test should have scored a triathlete around the average power. The value (8986W) recorded for PD suggests that performance is very much lacking in this area. PD's values are significantly lower than the male group (z=2.41). Swimming, cycling and running demand the '*…exertion of a force through a given distance in as short a time as possible.'* Beckenholdt and Mayhew (1983). However, it is this repeated action of power, power endurance, which is more important. Further investigation into the male group suggests the group is biased towards power-based sports such as rugby. Nevertheless, these values seem too

low, especially for entering the competitive phase of the triathlon season. Improvement is needed in this area.

PD's flexibility result (33cm) is exceptional (z=2.14) for a triathlete and for this male group (ranked 1st). The Sit and Reach test concentrates on lower leg flexibility, namely the hamstrings. Arguably, inclusion of shoulder flexibility values would be of greater importance to PD due to extensive use of upper limbs during the swimming section. High flexibility of the arms should in turn increase mobility therefore increasing range of movement and the amount of water available to catch.

Local muscular endurance (LME) of PD (58sit-ups) measured abdominal endurance. Abdominals are very important for core stability (Foran, 2001) where a repeat action or movement is required. Triathletes should have developed good core stability to support their cycling position. *'Balance between left and right sides is crucial for good performance…'* Foran (2001) Although little emphasis was initially placed on this component, this area needs improvement here. Further investigation into PD showed a recent long-term chest injury. This may have adversely affected the score (z=0.83).

The low body fat percentage for PD (8%) demonstrates the need for useful body mass. *'Excess fat provides useless weight…'* Foran (2001) As expected body fat was lower than others in male group (ranked 9th, n=25). However, testing was deemed inaccurate as some subjects measured 4%, well below normal levels of 6-8% for male subjects. Outside these levels are deemed *'…unhealthy even for athletes.'* Foran (2001).

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Conclusion

Laboratory testing and some test protocols limit the validity of data to the sporting environment of triathlon. However taking into consideration previously determined weightings of components, PD lacks in Speed and Power. These elements provide a combined 30% performance to triathlon. Further specific sprint and power testing is required. Further training may be needed to limit these weaknesses to optimise performance in triathlon. PD possesses many promising qualities to build upon and has a number of years to reach his potential.

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