Performance Requirements and Capacity Profiles in Triathlon

- Sprint and Olympic Distance Triathlon -

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1.1 Introduction

This report is part of the course Träningslära I (7.5 Credit Points) within the Trainer program at Gymnastik- och Idrottshögskolan in Stockholm. That report focuses on Performance Requirements and Capacity Profiles in Triathlon. In the first part Capacity Profiles will be stated and actual tests and measurement methods of several capacities within club, regional and national level for elite, junior and youth athletes in Germany are going to be presented. The second part contains the performance requirements both on national and international level in Triathlon, extracted from scientific articles. While there is a great variety in Triathlon referring to the distances this report is subject to Sprint and Olympic Distance.

1.2 Background

Mostly, Triathlon is seen in a very wrong way that it is a sport which is assembled of three different sports. But, as in all sports, it is much more complex. Triathlon is one sport that contains three disciplines: swimming, cycling and running. It needs different training methods than just to adopt the training of each individual sport, and a combined training of all disciplines which is highly complex in its demands. Additionally, the shorter the distance in the competition is, the more important become the transitions from swimming to cycling as well as from cycling to running. For example, a very good swimmer may come out of the water leading the race, but with a poor transition he may be in last position of the group or he may even loose contact to the first or main group in the cycling part exiting the transition zone. Following, he has to use too much energy to get back up to the front again or, in worst case, falls further back and looses time what will lead to worse results than possible. So, the transition parts have very great values in Sprint and Olympic Distance Triathlon. Therefore, it could be seen as a fourth "discipline". Swimming, cycling and running as well as transition have high demands on aerobic, anaerobic capacities, strength, technique and flexibility which will be focused on in this report within the capacity profiles in the first part and the performance requirements in the second part.

Tests and measurements as well as their methods play an important role for monitoring performances, controlling and adjusting the training, to give possible prospective achievements respectively realistic aims as well as for talent selection in sports. Therewith, it is a challenge to choose the correct testing and diagnosis for each sport, to interpret their results correctly and also to make them part of the training process, i.e., on the one hand, to use them as training and, on the other hand, to choose the best time within the season.

As already mentioned above, Triathlon has a great variety on distances. Main competition distances are Sprint, Olympic/Short, Long Distance and Ironman. Table 1 shows the length and age groups it refers mainly to. Furthermore, there are some other distances but those are either shorter due to young ages (till 15 years) or longer, e.g. Triple Long Distance.

Table 1 – Age groups, ages, distances and main competitions for German Triathletes (Distances: Swim – Bike – Run)

Age Group	Age	Distance [km]	Distance Name	Competitions
Schüler A	8/9	0.2 – 5 – 1	Novice Sprint	Regional
Schüler B	10/11			
Schüler C	12/13	0.2/0.4 – 5/10 – 1/2.5	(Novice) Sprint	Regional, NC
Jugend B	14/15	0.4 – 10 – 2.5	Sprint	GC, NC
Jugend A	16/17	0.75 – 20 – 5	Sprint	GC, EC, WC
Junioren	18/19	0.75 – 20 – 5	Sprint	GC, EC, WC
U23/Elite	19+	1.5 – 40 – 10	Olympic/Short	WCS, OG

NC = National Cup, GC = German Championship, EC = European Championship, WC = World Championship, WCS = World Championship Series, OG = Olympic Games.

This report concentrates on both Sprint and Olympic Distance Triathletes (0.75-20-5km and 1.5-40-10km respectively) because the Short distance is part of the Olympic Games since 2000 and the Sprint is essential in the youth and junior age groups as well as a preparation for Olympic Distance both when entering the Elite/U23 age group and in advance of the main season. But, e.g. during the last season, also giving triathlon another new competition format, there were Team World Championships in Lausanne held over the Sprint distance. So it becomes obvious that Sprint and Short distances have an important compound within Triathlon that can't be neglected.

1.2.1 Issues

The purpose of this report is to create a profile of physical performance demands (Part 2) and capacities (Part 1) for Triathlon, specifically Sprint and Olympic Distance Triathlon. The focus lies on five physiological attributes: Aerobic and anaerobic Capacities, Strength, Technique and Flexibility.

1.3 Method

In this part of the report I contacted different trainers, scientists and athletes who are involved in Triathlon as well as to a physical education teacher from the Sportgymnasium Leipzig. Furthermore, I also looked for task-related information on the homepages of the national union (Deutsche Triathlon Union – DTU), regional federations (Sächsischer Triathlon Verband – STV & Triathlonverband Mecklenburg-Vorpommern – TVMV), clubs (SC Neubrandenburg – SCN, SC DHfK Leipzig, TV Dresden – TV DD) and the Institute of Applied Training Sciences, IAT Leipzig.

I wrote messages to 5 persons from the DTU: Roland Knoll (national head coach), Matthias Zöll (competitive sport consultant), Ralf Schmiedeke (juniors' coach) and Nina Eggert (womens' coach) and Thomas Moeller (Head of Department Triathlon at IAT Leipzig); messages and phone calls to different trainers and athletes: Frank Heimerdinger (regional and club coach TVMV/SCN), Cornelia König (juniors' coach TV DD), Gregor Niemann (regional coach STV & club coach SC DHfK Leipzig), Andreas Beudt (performance and youth sports director STV & PE Teacher) and Holm Grosse (youth coach & athlete TV DD).

1.4 Results

Although, it wasn't possible to get an answer from everyone I wrote to and to every question, I could get some important information on what tests are examined and what the contents are. The few answers I received are mainly due to the fact that the training for the season 2012 started some weeks ago what means, e.g. that trainers and scientists are involved in first training camps and/or important preparations for the up-coming season, or problems occurred which have to be solved, so that some of them have less time and possibilities to answer. Due to the complex structure of triathlon this part of the report is divided into five sections, which describe the tests and test procedures in general, the tests referring to each capacity for each discipline and also the summary of athletic tests.

1.4.1 General Description

Tests for triathlon that include scientific evaluation are examined for each discipline. The test procedure consists of either running and swimming parts or running, swimming and cycling tests. The testing takes place on two days, successively. The first day includes an incremental and a mobilization test for running, followed by an incremental swimming test and, if scheduled, an additional incremental cycling test on the second day. Scientific performance diagnoses are done two or three times per season.

Competitive tests in order to obtain aerobic and anaerobic capacities as well as to be nominated into regional or national teams are examined on one day. These tests include only swimming and running. Those are scheduled two (STV) or three (TVMV) times per season (November/March and October/January/March respectively). The running parts take place inside and outside. Criteria and distances referring to the swim and run nomination competitions for the different age groups, within both STV and TVMV, can be seen in the Attachments 3 and 4.

1.4.2 Swimming

1.4.2.1 Aerobic Capacity

Scientific tests for the swimming part on national level are examined for all age groups as gradually tests or incremental tests, so-called Stufentest (Mohammed, 2002, p. 65). These tests include a gradual increase of performance swimming 4x400m in the swimming pool (50m-pool). Starting at a lower load, individually adjusted depending on the personal best time, the speed and therewith the load is increased gradually with each repetition up to the maximum performance.

Aerobic capacity is determined by calculating the lactate performance curve after recording heart rate and lactate concentration at the end of each load level. Following, the respiratory efficiency and capacity can be evaluated and training can be adjusted. Especially the duration of the whole test requires a good aerobic capacity.

Additionally, simple swim tests in the form of competitions are examined on each national, regional and club level. Distances lie between 200 and 1500m, depending on the test level and age group. Only times are measured there and compared primarily to preset values for possible nomination into the national and/or regional team. Secondary, the achieved performances are compared to previous results, if possible, and between other athletes.

1.4.2.2 Anaerobic Capacity

Especially the anaerobic capacity is measured and evaluated with the above mentioned incremental test (Stufentest; Mohammed, 2002, p. 65). The performance time for the maximum try lasts mostly between 04:10min until 05:00min, depending on age and performance ability/status. As already stated, heart rate and lactate concentration is measured, followed by the calculation of the lactate performance curve and the evaluation of the metabolic efficiency.

Contents of the competitive tests that may evaluate anaerobic capacities are 50m Freestyle, 50m Backstroke or Butterfly and 50m Freestyle legs. Also the longer distances up to 1500m still need a good anaerobic level in order to perform on a very good level.

1.4.2.3 Strength

There were no specific tests found on strength capacity for the swimming part in Triathlon.

1.4.2.4 Technique/Coordination

With the incremental tests it is not possible to measure coordination or technique abilities in swimming. The swimming technique is analyzed only by filming the athlete. The only coordination and technique test, which is evaluated just by time comparison to preset values, is 50m Freestyle legs within the competitive testing. There couldn't be found any other specific tests on coordination or technique for Triathlon swimming.

1.4.2.5 Flexibility

There are not run specific flexibility tests for the swimming part.

1.4.3 Cycling

1.4.3.1 Aerobic Capacity

The only scientifically evaluated test for the cycling discipline is a gradual test on a cycling ergometer with on-line measurement of various values. The athletes start at a resistance load of 100 W (women) resp. 130 W (male), riding 5 minutes on each load level before the resistance load is increased by 30 W each time. The athlete is supposed to ride at a cadence of approximately 90 RPM. The test ends when complete exhaustion occurs, the rider is at its maximum, cadence is decreasing gradually respectively the rider aborts the test either because of exhaustion or unease. Lactate at the end of each load level, heart rate, respiratory gases, cadence and tangential forces on both right and left side are measured. The measurement of respiratory gases in combination with the other values makes it easy to evaluate the aerobic capacity.

1.4.3.2 Anaerobic Capacity

Anaerobic capacity is also measured with the above mentioned test and the obtained values. The tests on the bike could differ only in the value of the increase of resistance load and/or the increased amount.

1.4.3.3 Strength

The only specific strength on the bike is measured with the above mentioned test including tangential forces on right and left side. Yet, it has a great influence on evaluation of the cycling performance concerning also technique/coordination.

1.4.3.4 Technique/Coordination

Technical and coordinative measurement is done by recording pedalling cadence and the course of tangential forces on right and left side.

1.4.3.5 Flexibility

There are no flexibility tests found referring to specific bike tests.

1.4.4 Running

1.4.4.1 Aerobic Capacity

A laboratory incremental test and a mobilization test are examined to evaluate the aerobic capacity in running. Depending on age and performance ability the first run test includes 4x3000m or 4x4000m on a treadmill. The increase between every try is 0.25 m/s while the last run should be examined approximately at the 5 resp. 10km race pace. Heart rate, lactate, respiratory gases as well as stride length, frequency, support and air time are matters to be measured.

After this incremental test (including an according rest) a mobilization test is run. Starting at a velocity of 4.0 m/s and 4.25 m/s for female and male triathletes respectively, velocity is increased every 30 seconds by 0.25 m/s until complete exhaustion occurs. This test makes it possible to measure and evaluate specifically VO_2max values. Respiratory gases, heart rate and all other measurements as for the incremental test are included.

Competitive tests include 1000m, 3000m or 5000m running tests on outside (400m lap) or inside tracks (200m lap), also depending on age group and testing level. Only times are measured.

1.4.4.2 Anaerobic Capacity

Anaerobic capacity is measured scientifically by the incremental test described above by evaluating lactate concentration, heart rate and all other obtained values mentioned before.

For the nomination (competitive) tests 60m and 100m sprints are decisive for the evaluation of anaerobic capacities (time measurement).

1.4.4.3 Strength

No specific strength test on running is examined. The only evaluation basis could be built by the recordings of stride length, frequency as well as support and air time.

1.4.4.4 Technique/Coordination

Stride length, frequency, support and air time is recorded during above mentioned tests. These values build a good basis to work on technique and coordination. In addition, a video recording is made for analyzing the running technique (from the side and from behind).

1.4.4.5 Flexibility

Flexibility could maybe only be seen indirectly in stride length and frequency. Specific tests for running are not examined.

1.4.5 Athletic Tests

On regional level and only among athletes till 14 years of age, a specific athletic test is run for all capacities whereas the aerobic capacity is more likely to be the endurance over the complete athletic test. 7 exercises are included which measure mainly strength, flexibility and coordination.

1.5 Discussion

Triathlon, including the disciplines swimming, cycling and running, is an individual sport that has its beginning of the season not just with starting competitions but much earlier, when the training for the upcoming season begins. For Sprint and Olympic Distance Triathletes this mostly means a season start in the end of October, with aiming for highest performances between June/July and August/September. Due to this fact it was not an easy task to get as much useful answers from all contacted persons because of previously in this report mentioned problems.

Still, I could gather a lot of important information through the combination of contacting relevant persons, looking for relevant material on the homepages and also my own experience as a triathlete on a higher performance level.

Triathlon is an endurance sport that places high demands mainly on aerobic and anaerobic capacities for a best possible performance, including competition durations of 54 to 64 minutes for Sprint distances on junior level and of 1h45min to 2h05min for Olympic distances on Elite level (both genders considered). Therefore, the main tests include measurements for evaluation of aerobic and anaerobic capacities. Scientific tests for triathletes were primarily adopted from performance diagnoses of the individual sports (disciplines). Therewith, it is possible even to compare the gathered values with those from the individual sports' athletes (swimmers, cyclists and runners).

Direct Measurement of aerobic capacity is included in the incremental tests for Cycling and Running, but also additionally, as a VO_2max test, in the mobilization running test. The necessary values are obtained through capturing respiratory gases. Swimming has no direct measurement of aerobic capacity. The testing of two or three disciplines with different test variations takes a long time which means not only stress and load for the athlete but requires also capacity from the institution to examine the test. A swimming diagnosis in the swimming flume could only be done by one athlete at a time, so it becomes more effective but still worth it by testing the athletes in the swimming pool. The direct measurements within cycling and running parts could indicate an approximate level of aerobic capacity for the swimming part in combination with the obtained heart rates, even if the disciplines differ fundamentally in the structure and demands.

But still direct measurements of anaerobic capacities are carried out for all three disciplines within scientific performance diagnoses. Those include lactate concentration and heart rate measurements.

Indirectly measured or only an indication is given by the times achieved in the competitive tests for the aerobic and partially anaerobic capacities on the longer distances for running and swimming. These tests are primarily examined for nomination into regional or national teams but, besides and in combination with that, they are still used for evaluating the performance level. Specifically anaerobic capacities are obtained by the short distance tests like 50m sprints in swimming and 60/100m sprints in running.

Although triathlon is a sport that places very high demands on those two capacities, it is important to have an efficient technique and coordination in each discipline; flexibility improves furthermore the performance abilities, and strength is a main factor to stability and balance. Swimming requires a great range of flexibility and good coordination of technique what is, on the one hand, judged by video analysis and also indirectly gathered by obtaining times. The latter is used as an indicator for the efficiency, whereas the 50m Freestyle legs test was specifically introduced to force trainers and athletes to involve leg exercise into swim training. In my opinion, this is an important part of the test because triathletes start to neglect leg exercises due to the use of wet suits which give the athletes not only coverage from cold water but also a flotation effect.

In cycling it is important to have the combination in evaluation of cadence and the course of the tangential forces on right and left side. The latter can indicate whether the technique and coordination as well as power output is optimal and efficient or not. An optimal coordination is achieved when the course of the tangential forces is homogeneous concerning both pulling and pressure phase while maintaining at a constant high cadence (90 RPM) and has high amplitudes which indicate a high force and power production transferred into bike acceleration and high velocity.

At laboratory tests it is difficult to evaluate the best cycling technique referred also to individual positions on the bike. Therefore, in my opinion, video analysis should be done from time to time with the athletes using their own bikes. An opportunity builds the velodrome where the athlete can be seen from close position all the time. Another possibility is a flat, closed road which should then be used for every filming. Also advices during training from experienced athletes or trainers should be given to avoid maladaptation of cycling technique. During my time at youth and junior stage our training group, even on regional level, has almost never experienced any advices from the trainer referring to technique. But this seems to be a general problem among triathletes because you can see a great difference in technique and coordination (also drafting) comparing cyclists and triathletes. Only on Elite level technique training is included, even if rarely, but it should be started much earlier in young ages.

Cycling tests on competitive and nominative level had been removed approximately nine years ago in Germany. This step had been done, in the first place, because another costly and additional test would have to be carried out, and, moreover, triathlon changed in its performance and competition structure, so that the priorities for training and competition were set towards swimming and running.

Technique training is a very important factor for running as well which is involved, more or less, depending on the trainer, within the training process. Therefore, it is necessary to include technique evaluation into scientific testing in the way it is done at the IAT Leipzig, with video analysis combined with measurement of stride length, frequency, support and air time. Also those factors should always be considered relative to height of the athlete and not as absolute value because there are always differences in the athletes' constitutions. The values are not only indicators for efficient or non-efficient technique, also the times for support and air phase give a direction towards strength efficiency.

However, the only measurement of absolute strength is done by recording the course of tangential forces within the bike test. But this only capturing of strength is caused again by the factor that triathlon is an endurance sport that places mainly demands on aerobic and anaerobic capacities. Those recordings of forces during the bike testing are important because the athlete needs a high amount of strength to produce high and efficient load for accelerating the bike and maintain at high velocities.

No specific flexibility tests are examined for each discipline during scientific tests. Flexibility, in general, leads to better performances, and plays an important role especially for swimming and running. Therefore, the athletic test includes seven different triathlon-specific exercises which measure flexibility, strength and coordination, i.e. those capacities which are not specifically tested during the competitive tests and also for those athletes who don’t attend scientific tests.

I think, the athletic test is therewith a necessary part of the test procedure for triathletes. Because of the importance, maybe the athletic tests should be scheduled for athletes up to 16 years of age (actual till 14 years) to avoid neglection of athletic and strength training, which still should be related to specific motion patterns and muscle groups used in triathlon.

All in all can be said that the main scientific tests in Germany, referring to regional (STV and TVMV) and national team members (U23/Elite and Juniors), have a standardized, valid and reliable procedure because those are examined at the Institute for Applied Training Science (IAT Leipzig). With obtaining knowledge and experience through several other sports on a very high scientific level within the institute, it is even possible to interact with other departments and sports to develop triathlon as well as to foster and support the athletes.

Yet, the nominating or competitive tests play an extremely important role throughout the whole development process of the athlete, both for nomination and development observation. Therefore, it is necessary to keep up and improve/develop those tests.

2 Performance Demands Analysis

2.1 Background

To develop one's own performance it is essential in Triathlon to gain high capacities on every level. The combined training process, i.e. 'cross-training' where the disciplines swimming, biking and running are trained within the same training session, is important in Triathlon because high demands are placed on physiological attributes of the athletes. Furthermore, not only the cross-training plays an important role. Although Sprint and Olympic Distance Triathlon is an endurance sport, where best performances are achieved by having high aerobic and anaerobic levels, still the factors technique/coordination, flexibility and strength have to be included as main points during the training and competition process. Only in the combination of all this it is possible to improve up to World Class level.

2.1.1 Issues

This part of the report highlights the physiological demands for Triathletes who compete on world class level, internationally, on Sprint and Olympic Distances. The focus lies on aerobic and anaerobic capacity as well as flexibility, technique/coordination and strength.

2.2 Method

For this part I looked for scientific reports and articles on the internet. Within the searching machines SportDiscus, PubMed, SpoNet, Spowis and also Google I found several relevant articles concerning the physiological demands for Sprint and Olympic Distance Triathletes. Also, the homepage of the GIH Biblioteket and previous reports from other students gave me the opportunity to gather all necessary articles and data.

2.3 Results

2.3.1 Aerobic Capacity

Researches about treadmill running and cycle ergometry for triathletes gave the results that VO_2max values appeared to be significantly higher in the running than in cycling tests (68.9 ± 7.4 vs. 65.6 ± 6.3 $ml \cdot kg^{-1} \cdot min^{-1}$). Other studies showed the same results with higher values (75.4 ± 7.3 vs. 70.3 ± 6.0 $ml \cdot kg^{-1} \cdot min^{-1}$) (Millet, Vleck, Bentley, 2011, p. 6-7).

The maximum heart rate HR_{max} has shown mostly lower values for cycling than for running (6-10 bpm). However, Millet et al. presented also studies on the level of elite female triathletes that reveal no significant differences for HR_{max} between cycling and running parts.

The review article from Suriano et al. presented following values on VO_2max for running and cycling, also comparing the aerobic capacities with those from runners and cyclists:

Table 2 – VO_2max of national level (elite) triathletes, runners and cyclists (Suriano & Bishop, 2010, p. 342)

Sport/Discipline	Sex	Competition Level	VO_2max ($ml \cdot kg^{-1} \cdot min^{-1}$)	
			Running	Cycling
Triathlon	Male	French National Team	78.5 ± 3.6	75.9 ± 5.2
	Male	South African Nation Team	74.7 ± 5.3	69.9 ± 4.5
	Female	South African Nation Team	63.2 ± 3.6	61.3 ± 4.6
Marathon	Male	French & Portuguese Olympic Teams	79.6 ± 6.2	-
	Female	French & Portuguese Olympic Teams	61.2 ± 4.8	-
Road Cycling	Male	Professional Team	-	78.8 ± 3.7

Furthermore, Suriano et al. stated reports comparing VO_2max scores of running (100%) with swimming (74-86%) and cycling (94-97%) tests. In the same report physiological profiles of young athletes who began triathlon as their first sport revealed VO_2max values that didn't differ significantly comparing the results on a cycling ergometer and a treadmill run (69.1 ± 7.2 and 70.2 ± 6.2 $ml \cdot kg^{-1} \cdot min^{-1}$ respectively).

The below shown tables show physiological variables for both laboratory testing on a cycle ergometer and of cycling-running combination. The latter was examined with two runs, one isolated and one after an exhaustive cycling portion what should reveal results on what extent of exhaustion a hard cycling part causes prior to running in triathletes.

Table 3 - Physiological variables from a laboratory running test for junior and senior male and female triathletes (Millet et al., 2004, p. 194)

	Male		Female	
	Juniors	Seniors	Juniors	Seniors
V_{run} ($km \cdot h^{-1}$)	17.6 ± 0.4	18.1 ± 9.2	14.9 ± 0.4	15.3 ± 0.6
EC_{run1} ($ml \cdot kg^{-1} \cdot km^{-1}$)	178.7 ± 13.5	172.9 ± 8.6	174.7 ± 16.4	176.4 ± 20.4
EC_{run2} ($ml \cdot kg^{-1} \cdot km^{-1}$)	183.9 ± 11.2	177.4 ± 8.6	184.6 ± 18.0	173.7 ± 23.3
ΔEC (%)	3.1 ± 6.4	2.6 ± 2.0	5.8 ± 5.6	-1.6 ± 4.7

V_{run} = velocity sustained during the two treadmill runs; EC_{run1} = energy cost of isolated run (before cycling); EC_{run2} = energy cost after an exhaustive cycling exercise; ΔEC = percentage change in energy cost from run 1 to run 2.

Table 4 - Physiological variables from a laboratory cycling ergometer test for junior and senior male and female triathletes (Millet et al., 2004, p. 194)

	Male		Female	
	Juniors	Seniors	Juniors	Seniors
VO_2max ($ml \cdot kg^{-1} \cdot min^{-1}$)	74.7 ± 5.7	74.3 ± 4.4	60.1 ± 1.8	61.0 ± 5.0
VO_2max ($l \cdot min^{-1}$)	4.98 ± 0.44	5.21 ± 0.34	3.55 ± 0.23	3.67 ± 0.42
HR_{max} (bpm)	195.0 ± 8.5	187.6 ± 8.9	193.3 ± 7.9	184.3 ± 7.1
PPO (W)	354.3 ± 20.9	384.7 ± 50.2	268.3 ± 19.4	292.8 ± 20.9
PPO ($W \cdot kg^{-1}$)	5.41 ± 0.51	5.47 ± 0.57	4.55 ± 0.37	4.83 ± 0.39
VT (%VO_2max)	74.4 ± 10.0	83.9 ± 4.5	77.0 ± 11.1	80.5 ± 7.9
Economy ($W \cdot l^{-1} \cdot min^{-1}$)	72.5 ± 4.5	73.8 ± 4.3	75.6 ± 4.5	79.8 ± 9.8

VO_2max = maximal oxygen uptake; HR_{max} = maximal heart rate; PPO = peak power output during the incremental cycle test; VT = ventilatory threshold.

2.3.2 Anaerobic Capacity

Several studies that are presented by Millet et al. showed both similar and significantly different values for the anaerobic threshold relative to VO_2max for cycling and running (78.8 vs. 79.3% resp. 66.8 ± 3.7 vs. 71.9 ± 6.6%). For the latter, only the absolute values were stated to be similar for cycling and running. In isolated incremental running and cycling tests the anaerobic threshold occurred "…at a different exercise intensity…" (90 vs. 85% of VO_2max) (Millet et al., 2011, p. 7).

Heart rates corresponding to the anaerobic threshold are shown in Table 2 below.

Table 5 – Heart Rates at Anaerobic Threshold and corresponding percentage relative to maximum Heart Rate for cycling and running parts (Millet et al., 2011, p. 7)

HR at AT - Bike	HR at AT - Run	HR at AT in % of HR_{max} - Bike	HR at AT in % of HR_{max} - Run
145.0 ± 9.0 bpm	156.0 ± 8.0 bpm	80.9 ± 3.4%	85.4 ± 4.1%
148.2 ± 3.4 bpm	164.7 ± 4.0 bpm	79.7 ± 1.5%	87.3 ± 1.6%
149.9 ± 18.0 bpm	169.6 ± 15.7 bpm	-	-
166.4 ± 7.6 bpm	174.6 ± 4.5 bpm	-	-

The anaerobic threshold, in Suriano et al. referred to as ventilatory threshold, showed similar relative values for running and cycling parts (65 to 85% and 61 to 84% of VO_2max respectively) but lower ones for swimming (Male: 71.8 ± 2.0%; Female: 75.8 ± 4.2% of VO_2max). Compared to trained cyclists and runners the observed values within individual disciplines for triathletes appear to be similar. Also it became obvious from further investigations, although there are only few reports on the swimming part, that triathletes have lower anaerobic threshold values in swimming than in cycling, while both being lower than running.

2.3.3 Strength

Landers et al. referred to the proportional segmental length of body extremities to be an important factor that "…significantly predicted swim time." (Landers et al., 2000, p. 397). In this report the authors stated "…low levels of body fat and proportionally long levers [as necessary to realize a] superior endurance performance." (Landers et al., 2000, p. 397). Adequate strength is essential for a triathlete in order to use the levers as efficient as possible with creating a biomechanical advantage in the water. In addition, a certain strength amount is needed in the cycling part, depending on course profile, physical characteristics of the athlete and race performance (Landers et al., 2000, p. 397f).

Many triathletes have a problem to choose the correct strength training. Lavin reports, in order to prevent injuries as well as to produce more strength and as efficient as possible it is important to train the trunk, to do balance and single-leg exercises. For triathletes it is necessary to have a balanced ratio on hypertrophy and intra- and intermuscular coordination for not gaining to much muscle weight but still be able to produce power most efficient (Lavin, 2007, p. 15-17).

A report about elite open-water swimmers revealed efficiency of strength training for both general muscular endurance and specific shoulder strengthening (Van Heest, Mahoney, Herr, 2004, p. 304-305).

2.3.4 Coordination/Technique

Bentley et al. stated in their article from the year 2002 that elite triathletes have a less efficient technique and coordination in swimming compared to elite swimmers. Referring to the front crawl, observations could be made by calculating the differences of energy cost (21 to 29% lower for swimmers) and propelling efficiency (36.4% higher for swimmers). Although there is a similar stroke rate, the main difference lies within the distance per stroke (D_S) at the same relative velocity. The D_S-to-height-ratio, where the height of the athlete is included, is much lower in triathletes than in swimmers.

Also drafting is mentioned in the work of Bentley et al. They showed that the passive drag of following behind leading swimmers is decreased by 10 to 26%. Also blood lactate concentration and rating of perceived exertion (RPE) are reduced by 31 and 21% respectively. Performance improvements of 3.2 to 6% at submaximal and maximal velocities are related as well to a 5 to 10% decrease in oxygen uptake (VO_2). At high velocities like in a 400m swimming part that may lead to a performance improvement of 9 to 12 seconds. Greater efficiency is furthermore achieved by increasing the distance per stroke which occurs when drafting (Bentley et al., 2002, p. 349).

Additionally, technique changes are suggested through previous investigations. That means the first 400m in a triathlon, still depending on the full length of the swim stage, should be swum using a 6-beat kick at a higher velocity for good positioning. Later at the swim stage it is suggested to use a 2-beat kick for less lower limb movement.

Another important factor concerning technique and coordination is drafting during cycling inn triathlon. Although there are much more influences (athletes' physical and bicycles' biomechanical characteristics) on how much drafting effect occurs than, e.g., in swimming, there is evidence that the athletes experience highly significant metabolic savings which may influence the running part in draft-legal triathlon events. In turn, the lower energy expenditure allow the athletes to perform at a higher velocity at the same relative exercise intensity and/or an improved running stage. At the same speed there occur savings in oxygen cost and metabolic demands (Bentley et al., 2002, p. 351-352).

Pedalling frequency has two different views to be look upon. On the one hand, the metabolically optimal pedaling cadence (PC) lies between 60 to 80 rpm. On the other hand, also mostly used, is the biomechanically optimal PC at approximately 90 rpm. Bentley et al. also compared it to cyclists' frequency. Those specialists are, in most cases, much more able to maintain at a cadence of 90 rpm over a longer period of several hours while triathletes tend to lower it down to 83 rpm.

2.3.5 Flexibility

Despite search it was not possible to find useful information on flexibility demands in triathlon on international level. This may be due to the fact that triathlon is an endurance sport and has been investigated mainly on aerobic and anaerobic level.

2.4 Discussion

Performing on World Class level (Elite) in Olympic Distance triathlon places high demands especially on aerobic and anaerobic capacities. Therefore, Millet et al. (2011) described a 'contemporary' viewpoint on physiological level that connects traditional parameters with performance determinants which are primarily required to achieve best results on elite level.

The "…'traditional' parameters of physiological function interact with the kinetics of VO_2…" (Millet et al., 2011, p. 2), so that certain 'intensity domains' can be described by the determination of the captured time course of VO_2. Figure 1 describes the role of VO_2 kinetics in exercise tolerance intensities which can be performed over a period of 30 Minutes to 4 hours.

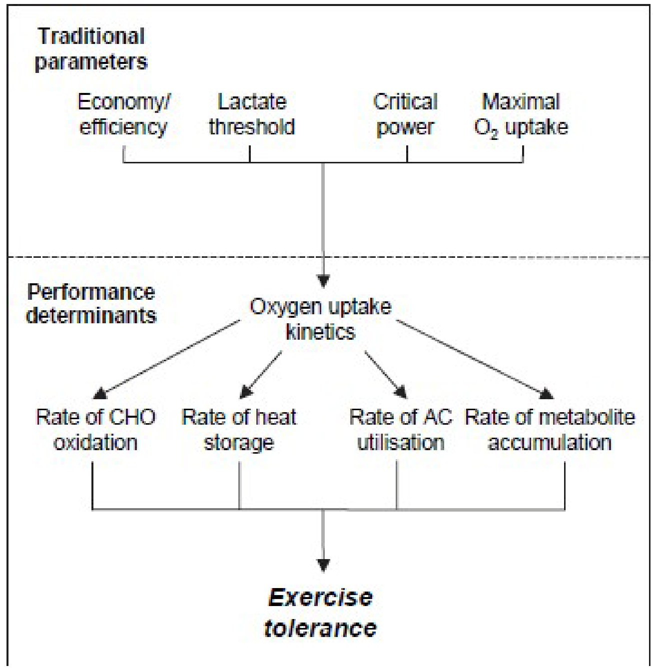


Figure 1 – The role of VO_2 kinetics in heavy- and severe-intensity exercise tolerance (Key: CHO carbohydrate, AC anaerobic capacity) (Millet et al., 2011, p. 3)

Looking at the distributions of maximum oxygen consumptions for all three disciplines, isolated, it appears to be that athletes achieve the highest VO_2max values in running. Comparing the triathletes' maximum oxygen consumptions, based on running having the highest ones (100%) in cycling a slightly lower (94% - 97%) and in swimming a much lower maximum oxygen uptake (74% - 86%) is achieved. Such basic differences of performance attributes are also seen in the comparison of professional triathletes with professional cyclists and swimmers. Figure 2 shows that triathletes achieve lower VO_2max values than runners but still have higher ones than cyclists.

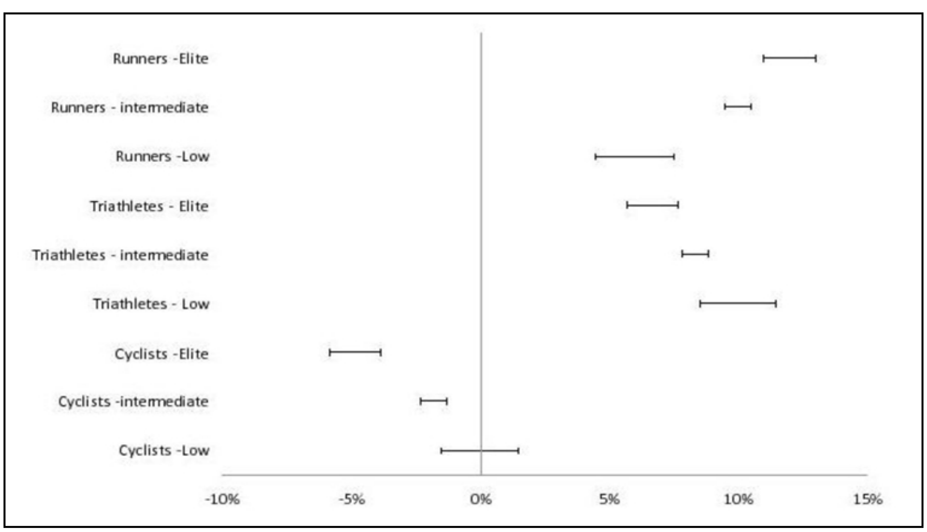


Figure 2 – Differences between running and cycling: VO_2max (Suriano et al., 2010)

A reason for the highest maximum oxygen uptake during running, suggested by Suriano et al. (2010), may be the larger muscle mass which is recruited compared to swimming and cycling.

A connection between the anaerobic threshold and maximum oxygen consumption was concluded by Suriano et al. Triathletes with a higher anaerobic threshold in running than in cycling and swimming had also achieved higher VO_2max values within the discipline. In the same way, similar values for anaerobic threshold for running and cycling correlated with similar VO_2max values between this disciplines.

Very good adaptation and training efficiency for Elite triathletes, older than 23 years, was evaluated by gathering and calculating energy cost differences between an isolated run test and a run test following an exhaustive bike ride to simulate the bike load during a triathlon, all examined on scientific, valid and reliable level (Millet et al., 2004). It showed lower energy cost differences for male and female Elite triathletes compared to those from junior triathletes competing on international level (see Table 4). Although the junior athletes achieve more or less a low loss of running performance after an exhaustive cycling exercise compared to an isolated run, the Elite triathletes manage to lower that loss during their career. That means they are able to achieve almost the same performance in the running part of a triathlon as in a single run, what indicates good training quality and efficiency of combined training, also called cross-training (Suriano et al., 2010, p. 341).

A higher peak aerobic output was obtained for cyclists than for triathletes. That fact combined with the ability to maintain much longer at a biomechanically optimal cadence of 90 rpm indicates a greater efficiency for cyclists during a bike ride (Suriano et al., 2010, 343). That increases the necessity of video analysis and technique/coordination training for the cycling part as well as keeping up the scientific evaluation with additional attention to the technique for triathletes.

The problem of choosing the correct strength training is common between triathletes. The conflict between gaining enough power in order to produce high forces during the bike part and the body mass that influences the running performance inversely proportional forces the athlete to train a compromise of both. Especially trunk and pelvis stability as well as balance and single-leg exercises should be examined for a basic strength and stability, mainly referring to swimming (stable position in the water for optimal hydrodynamic load) and running (trunk and hip stability for an efficient stride). Besides that, shoulder and arm strength is important to perform efficient swimming strokes. Therefore, it is not only necessary to do strength training but also to train all swimming styles. This leads to a greater strength together with a variable ability what is important to perform at best levels. That means triathletes should combine strength training, specified to the motion structure of triathlon, with varying exercises within specific triathlon discipline training. Inter- and intramuscular coordination plays an important role for using the best possible and efficient power production.

In the end, Triathlon is still an endurance sport with main demands on aerobic and anaerobic capacity for Sprint and Olympic Distance. But only in combination with specific strength training, a good flexibility and a high amount on technique and coordination training a development towards Elite stage competing on international level can be achieved. Especially the latter is neglected often within the training process due to the training and combination of three different disciplines. That is a field of subject that necessarily has to be paid attention to in the future to gain better performance.

Summarizing can be said that Triathlon has mainly scientific evaluations (international) on aerobic, some on anaerobic capacities but still there is a lack of research for the other subjects and actual investigation is missing or still in process which is due to the age of the sport that developed mainly during the last ten years, since it became part of the Olympic Games. Therefore, it will be very interesting to see, especially after the Olympic Games in London 2012, how the demands for World Class Triathletes developed.

3 Literature and Sources

- R. Suriano & D. Bishop (2010). Physiological attributes of triathletes. *Journal of Science and Medicine in Sport*, 13, 340-347.

- G. Millet, V. Vleck & D. Bentley (2011). Physiological requirements in triathlon. *Journal of Human Sport & Exercise*, 6 (2).

- J. Zinner, B. Pansold & R. Buckwitz (1993). Computergestützte Auswertung von Stufentests in der Leistungsdiagnostik. *Sportmedizin*, 2, 21-26.

- D. Bentley, G. Millet, V. Vleck & L. McNaughton (2002). Specific Aspects of Contemporary Triathlon: *Implications for Physiological Analysis and Performance*. *Sports Med*, 32(6), 345-359.

- D. Bentley, G. Cox, D. Green & P. Laursen (2008). Maximising performance in triathlon: Applied physiological and nutritional aspects of elite and non-elite competitions. *Journal of Science and Medicine in Sport*, 11, 407-416.

- G. Millet & D. Bentley (2004). The Physiological Responses to Running After Cycling in Elite Junior and Senior Triathletes. International Journal of *Sports Medicine, 25*, 191-197.

- G. Landers, B. Blanksby, T. Ackland & D. Smith (2000). Morphology and performance of world championship triathletes. *Analysis of Human Biology*, 27(4), 387-400.

- Lavin (2007). Strength Training for the Triathlete: *Tradition versus Function. Strength and Conditioning Journal*, 29(5), 15-17.

- J. Van Heest, C. Mahoney & L. Herr (2004). Characteristics of Elite Open-Water Swimmers. *Journal of Strength and Conditioning Research*, 18(2), 302-305.

- B. Roels, L. Schmitt, S. Libicz, D. Bentley, J. Richalet & G. Millet (2005). Specificity of VO_2max and the ventilator threshold in free swimming and cycle ergometry: comparison between triathletes and swimmers. *International Journal of Sports Medicine*, 39, 965-968.

- A. Chapman, B. Vicenzino, P. Hodges, P. Blanche, A. Hahn & T. Milner (2009). A protocol for measuring the direct effect of cycling on neuromuscular control of running in triathletes. Journal of *Sports Sciences*, 27(7), 767-782.

- Y. Mohammed (2002). Spiroergometrie im Strömungskanal: Vergleich metabolischer, kardiozirkulatorischer und respiratorischer Parameter bei Schwimmern unterschiedlicher Leistungsstärke. *Dissertation*, Universität Hamburg.

Homepages:

- http://www.dtu-info.de/
- http://www.triathlon-mv.de/
- http://www.triathlon-dresden.de/
- http://www.iat.uni-leipzig.de/
- http://www.triathlon-sachsen.de/

Attachment 1 – Description of the athletic test within regional level

Handreichung
Athletiktest des STV

Sächsischer Triathlon Verband e.V.

INHALTSVERZEICHNIS

Handreichung

Athletiktest des STV

Sächsischer Triathlon Verband e.V.

Ziel des Athletiktests

Die vorliegende Sammlung athletischer Übungen und deren Durchführung und Auswertung soll im Wesentlichen eine Orientierung für alle Trainer und Übungsleiter sein, die sich dem regelmäßigen Training mit Nachwuchsathleten widmen. Nach Absolvieren und Analyse der Testaufgaben werden die Trainer und Übungsleiter das Ausmaß an Fähigkeiten ihrer jungen Nachwuchsathleten einschätzen können.

In der Wissenschaft gilt das Trainingsprinzip des langfristigen Leistungsaufbaus. Hierbei müssen in bestimmten Entwicklungsphasen der motorischen Ontogenese bestimmte Fähigkeiten trainiert werden. Werden diese sensiblen Phasen in der Leistungsentwicklung nicht genutzt, ist eine spätere Ausprägung auf dem erforderlich hohen Niveau nur noch sehr schwer bis nicht mehr zu realisieren. Der Verband möchte und muss für die erfolgreiche Ausbildung von zukünftigen Spitzensportlern die altersadäquate Fähigkeitsausprägung fördern. Mit den angegebenen Orientierungen ist es den Übungsleitern und Trainern möglich zu überprüfen, ob und inwieweit die fähigkeitsspezifischen Leistungen dem erforderlichen Niveau entsprechen.

Die Leistungsstruktur des Triathlonsports ist vor allem geprägt durch konditionelle Fähigkeiten (Kraft und Ausdauer). Neben den psychischen und materiellen Bedingungen muss ein zukünftiger Spitzenathlet zudem Schnelligkeitsfähigkeiten, Beweglichkeit und koordinative Fähigkeiten in hohem Maße ausgeprägt haben. Diese zuletzt genannten werden im Nachwuchstraining zugunsten einer (zu) zeitigen Spezialisierung und eines frühzeitig entwickelten hohen wettkampfspezifischen Ausdauerniveaus gern vernachlässigt.

Schnelligkeitsfähigkeiten, vor allem die Frequenzschnelligkeit, sind in hohem Maße genetisch determiniert und nur in dem Altersbereich von 8-12 Jahren wesentlich zu trainieren (HOLLMANN & HETTINGER, 1998). Daher wird in der vorgelegten Sammlung der Abtestung von Schnelligkeitsfähigkeiten eine hohe Priorität beigemessen.
Die Phase des besten motorischen Lernalters wird von MEINEL & SCHNABEL (2002) dem Altersbereich zwischen 10 und 12 Jahren zugeordnet. Hier kommt es durch die enorme Plastizität des Gehirns bei entsprechender Förderung, also einem altersentsprechenden Training (Vielseitigkeit und Variabilität sowohl in derÜbungsauswahl und deren methodischen Gestaltung), zur wesentlichen Ausbildung koordinativer Fähigkeiten. Diese bilden wiederum eine Grundlage sportartspezifische Fertigkeiten (Schwimm- und Lauftechnik) zu erlernen und letztlich diese Fertigkeiten für einen maximalen Vortrieb möglichst effektiv zu gestalten.
Das Niveau der Beweglichkeit beeinflusst deutlich die Ausprägung sportartspezifischer Fertigkeiten. So ist es bei unzureichender Beweglichkeit im Schultergürtel kaum möglich die Kraultechnik effektiv zu gestalten („entspannte“ Überwasserphase beim nach vorn führen des Armes). Involutionsprozesse (rückgängige Entwicklung) beginnen beim Menschen die Beweglichkeit betreffend ohne dem entgegenzuwirken schon im späten Kinderalter. Demnach müssen die Übungsleiter und Trainer besonderen Augenmerk auf die Förderung der Beweglichkeit von klein auf an legen.

Das Niveau der allgemein athletischen Ausbildung ist des Weiteren stark durch die Kraft(-ausdauer)fähigkeit der großen Muskelgruppen (Glutaen, untere und obere Rückenmuskulatur, Bauchmuskulatur) bestimmt. Diese Fähigkeiten lassen sich zwar auch in höherem Alter noch sehr gut ausbilden, sind aber im Sinne der Prävention von muskulären Dysbalancen, Verletzungen und Gesundheitsschädigungen, schon in jüngstem Alter auf einem hohen Niveau auszubilden.

In folgendem Abschnitt werden die Übungen bezüglich ihrer Validität für den Triathlonsport kurz erläutert.

Stationen des Athletiktests

Kasten-Bumerang-Test

Dieser Test, von TÖPEL 1972 entwickelt und vorgestellt, prüft vor allem das Niveau der Bewegungsschnelligkeit und der koordinativen Fähigkeiten unter Zeitdruck ab. Gleichgewichts-, Kopplungs- und Orientierungsfähigkeit sind die leistungsbestimmenden koordinativen Fähigkeiten.
Die Auswertung der Ergebnisse lässt dem Übungsleiter und Trainer also eine genaue Aussage über das Niveau der oben aufgeführten koordinativen Fähigkeiten und der Bewegungsschnelligkeit zu.

Seilspringen

Das Seilspringen ist für Sportler bis zum Jahrgang Schüler A zu absolvieren. Hierbei werden vor allem die Rhythmisierungs-, die Kopplungs- und die Differenzierungsfähigkeit überprüft. Des Weiteren testet diese sportliche Übung das Niveau der Sprungkraftausdauer. Möglichst kurze Kontaktzeiten müssen hierbei über den genannten Zeitraum aufrecht erhalten werden. Die Auswertung der Ergebnisse lässt dem Übungsleiter und Trainer also eine genaue Aussage über das Niveau der oben aufgeführten koordinativen Fähigkeiten und der Sprungkraftausdauer zu.

Banküberspründe

Die Banküberspründe werden von Sportlern ab der Jugend B absolviert. Hierbei werden vor allem die Rhythmisierungs-, Gleichgewichts- und die Differenzierungsfähigkeit überprüft. Des Weiteren testet diese sportliche Übung das Niveau der Sprungkraftausdauer. Möglichst kurze Kontaktzeiten müssen hierbei über den genannten Zeitraum aufrecht erhalten werden. Im Vergleich zur Übung „Seilspringen" ist das Anforderungsniveau an die koordinativen und konditionellen Fähigkeiten deutlich erhöht.
Die Auswertung der Ergebnisse lässt dem Übungsleiter und Trainer also eine genaue Aussage über das Niveau der oben aufgeführten koordinativen Fähigkeiten und der Sprungkraftausdauer zu.

Liegestützbeugen

Diese bekannte Athletikübung testet vor allem die Kraftfähigkeiten der Brustmuskeln und der Oberarmstrecker. Bei Einhalten der angegebenen Durchführungsbestimmungen werden beide Muskelgruppen abgetestet. Diese Muskelgruppen sind beim Schwimmen leistungsbestimmend und haben im Radfahren Stützfunktion. Durch eine Übungszeit von 120s wird meist die maximale Anzahl an Liegestützen abgetestet. Eine Verkürzung der Übungszeit würde die Athleten gerade in den oberen Altersklassen zu unsauberer Arbeitsweise animieren. Auch ein angemessenes Niveau an Körperspannung (Bauch, Rücken) ist notwendig um über den genannten Zeitraum die Liegestützposition in geforderter Weise zu halten.
Die Auswertung der Ergebnisse lässt dem Übungsleiter und Trainer also eine genaue Aussage über das Niveau der Kraftausdauerfähigkeiten der Brustmuskeln und des Oberarmstreckers zu.

Rumpfheben aus der Rückenlage

Die im angloamerikanischen Sprachraum auch als Situps bekannte Übung testet das Niveau der Kraftausdauerfähigkeiten der gesamten Bauchmuskulatur ab. Bekanntermaßen sind beim Situp die Hüftbeuger entscheidend an der aufrichtenden Bewegung beteiligt, dennoch handelt es sich hierbei um eine Übung mit höchster Beanspruchung für die Bauchmuskulatur bei EMG-Untersuchungen (BOECK-BEHRENS & BUSKIES, 2002). Die Position der Arme hinter dem Holzstab garantiert ein Üben ohne Schwungbewegung.
Die Bedeutung der Rumpfkraft für den Triathleten soll hier nicht näher ausgeführt werden (enorme Beeinträchtigung der Radleistung bei geringem Abfall der Leistungsfähigkeit der Bauchmuskeln, aufgrund des fehlenden Widerlagers zur Pedale; typische „Triathlonhüfte“ beim Lauf aufgrund mangelnder Bauchmuskeln; schlechte Wasserlage durch fehlende Körperspannung beim Schwimmen).
Die Auswertung der Ergebnisse lässt dem Übungsleiter und Trainer also eine genaue Aussage über das Kraftausdauerniveau der Bauchmuskulatur zu.

Klimmzüge (im Schrägliegehang)

Erst ab der Altersklasse Schüler A müssen die Klimmzüge freihängend an der Stange durchgeführt werden. Bis zu diesem Alter wird die vereinfachte Form im Schrägliegehang durchgeführt. Für Sportler der AK Schüler A, welche noch keine freihängenden Klimmzüge schaffen, gibt es in der Normtabelle entsprechende Werte für die Ausführung im Schrägliegehang. Diese komplexe Übung überprüft die Kraftfähigkeiten der gesamten Rückenmuskulatur (vor allem breiter Rückenmuskel) und des Armbeugers. Im Schwimmen sind die Kraftausdauerfähigkeiten der genannten Muskulatur leistungsbestimmend.
Die Auswertung der Ergebnisse lässt dem Übungsleiter und Trainer also eine genaue Aussage über das Kraftausdauer-/ bzw. Maximalkraftniveau der Rückenmuskulatur zu.

Rumpf-/ Hüftbeugen

Die Beweglichkeit der ischiocruralen Muskulatur ist Leistungsvoraussetzung für eine entsprechende Lauf- und Radleistung. Der erforderliche Kniehub beim leichtathletischen Lauf kann durch eine verminderte Beweglichkeit wesentlich beeinträchtigt sein. Noch wichtiger erscheint eine ausreichende Beweglichkeit allerdings für eine gesunde Becken-/ Hüftstellung im Zusammenspiel aller beteiligten Muskelgruppen.
Die Auswertung der Ergebnisse lässt dem Übungsleiter und Trainer also eine genaue Aussage über das Niveau der Beweglichkeit im Hüftgelenk (Dehnfähigkeit der hinteren Oberschenkelmuskulatur - Beinbeuger) und in der Lendenwirbelsäule zu.

Schulterbeweglichkeit

Die Beweglichkeit im Schultergürtel vor allem der Oberarm-Rumpf-Winkel ist Eignungskriterium im Schwimmsport. Eine verminderte Beweglichkeit führt zu einem erhöhten Muskelaufwand bei bestimmten Bewegungsausführungen. Das Nach-vorn-führen des Arms bei der Kraularmbewegung gestattet bei ausreichender Beweglichkeit eine kurze Phase der Erholung während der Überwasserphase.
Die Auswertung der Ergebnisse lässt dem Übungsleiter und Trainer also eine genaue Aussage über das Niveau der Beweglichkeit im Schultergelenk (u.a. Dehnfähigkeit des Großen Brustmuskels) zu.

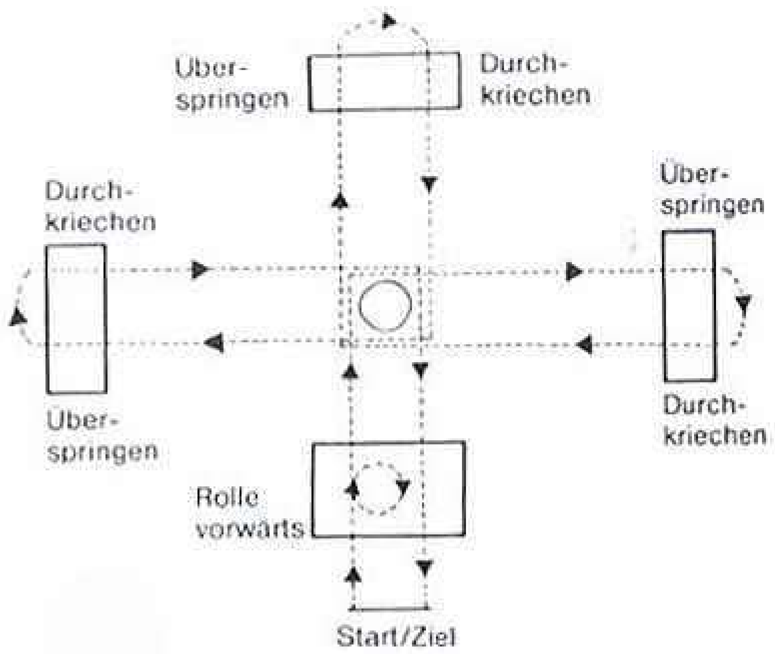
Testbezeichnung: Kasten-Bumerang-Test (nach Töpel, 1972)

Testdurchführung:
Nach einem Startsignal erfolgt von der Startlinie eine Rolle vorwärts auf der Matte. Danach wird im rechten Winkel um den Medizinball zum Kastenteil 1 oder Kastenteil 3 gelaufen, das Kastenteil übersprungen und in Richtung Medizinball durchkrochen. Jeweils mit rechtwinkligem Umlaufen des Medizinballes müssen alle Kastenteile in angegebene Reihenfolge absolviert werden. Die Reihenfolge des Überwindens von Kastenteilen ist durch entsprechende Zahlen (1 bis 5) angegeben.

Testparameter:
Gewertet wird die Zeit, welche vom Startsignal bis zum überqueren der Ziellinie benötigt wird.

Testmaterialien:
1 Turnermatte (2 m lang)
1 Medizinball (5 kg)
3 Kastenteile (145 cm breit, 45cm hoch, 20 cm tief)

Aufbau:
Je 2 m Abstand vom Medizinball zum Rand der Turnermatte und den Kastenteilen 2m



Testbezeichnung: Seilspringen / Bankübersprünge

Die Nachwuchsathleten bis zur Altersklasse Schüler A führen die Übung „Seilspringen (A)“ aus. Athleten ab der Altersklasse Jugend B ersetzten die Übung durch das „Banküber-sprünge (B)“

(A) **Testdurchführung:**
Das Seil wird in 60s so oft wie möglich mit beiden Beinen übersprungen. In der Ausgangsposition ist das Seil an jedem Ende mit der jeweiligen Hand gefasst, wobei sich das Seil hinter den Fersen/ Füßen befindet. Es werden alle „Überschreitungen“ des Seils als Durchschläge gezählt (z.B. bei Unterbrechung des Bewegungsflusses).

Testparameter: Anzahl der Durchschläge in der vorgegebenen Zeit.

Testmaterialien: Stoppuhr, Seil

(B) **Testdurchführung:**
Die Sportler stehen seitlings neben der Turnbank und überspringen diese in 60s möglichst oft. Bei einem gültigen Übersprung darf die Bankoberfläche mit den Füßen nicht berührt werden und die Bank muss mit beiden Beinen (gleichzeitig, parallel geschlossen) ohne Absetzen eines Fußes überquert werden.

Testparameter: Anzahl der erreichten Übersprünge über die Turnbank in 60s

Testmaterialien: Turnbank, Stoppuhr

Testbezeichnung: Liegestützbeugen

Testdurchführung: Der Sportler befindet sich im Liegestütz, die Hände sind in 1 1/2facher Schulterbreite, Füße gegen einen festen Halt gestemmt und die Arme durchgestreckt. Die Hände befinden sich unter einer Matte und mit dem Kinn bzw. der Nase muss beim Beugen die Matte (oder ähnlichem, ca. 5 cm dick) berührt werden.

Testparameter: Anzahl der Liegestützbeugen in 60s

Testmaterialien: eine Matte bzw. einen ca. 5 cm dicken Gegenstand, Stoppuhr

Testbezeichnung: Rumpfheben aus der Rückenlage (Rumpfbeugen)

Testdurchführung: Der Sportler liegt auf dem Rücken und stellt mit angewinkelten Beinen die Füße auf den Boden. Der Kniewinkel beträgt etwa 90°. Die hinter dem Kopf verschränkten Arme halten einen Stab (Besenstiel) im Nacken (Ellenbogen am Stab, Hände hinter dem Kopf). Aus der Rückenlage muss sich der Sportler in 60s so oft wie möglich aufrichten (LWS berührt den Boden nicht mehr).

Testparameter: Anzahl Wiederholungen in 60s

Testmaterialien: Stoppuhr, Stab (Besenstiel), Unterlage (Handtuch, Matte o.ä.)

Testbezeichnung: Klimmzüge (im Schrägliegehang)

Die Nachwuchsathleten bis zur Alterklasse Schüler B führen die Übung „Klimmzüge im Schrägliegehang" (A) aus. Athleten ab der Altersklasse Schüler A führen die Übung „Klimmzüge" (B) aus.

(A) Testdurchführung: Der Sportler hängt mit gestreckten Armen an der Klimmzugstange. Die Hände fassen die Klimmzugstange im Ristgriff etwas mehr als schulterbreit auseinander. Die Füße stehen auf dem Boden/ an der Sprossenwand, so dass der Arm-Rumpfwinkel in der Ruheposition 90° beträgt. Der Sportler beugt die Arme und führt den Brustkorb mit gespanntem Körper zur Klimmzugstange bis der Brustkorb die Stange berührt oder das Kinn über die Stange geführt wurde.

Testparameter: Anzahl der Wiederholungen in 60s

Testmaterialien: Stoppuhr, Klimmzug-/ Reckstange

(B) Testdurchführung: Der Sportler hängt mit gestreckten Armen frei an der Klimmzugstange. Die Hände fassen die Klimmzugstange im Ristgriff etwas mehr als schulterbreit auseinander. Der Sportler beugt die Arme und führt das Kinn mit gespanntem Körper zur Klimmzugstange bis das Kinn über die Stange geführt wurde.

Testparameter: Anzahl der Wiederholungen in 60s

Testmaterialien: Stoppuhr, Klimmzug-/ Reckstange

Sächsischer Triathlon Verband e.V.

Testbezeichnung: Rumpfbeugen/Hüftbeugen

Testdurchführung: Vor einer Langbank wird eine Messskala angebracht, die nach oben und unten jeweils zwanzig Zentimeter umfassen soll. Der Nullpunkt entspricht der Bankoberkante. Die Versuchsperson steht ohne Schuhe mit geschlossenen Beinen auf der Bank. Die großen Zehen schließen mit der Vorderkante der Bank ab. Aus dieser Stellung ist eine Rumpfbeuge/ Hüftbeuge vorwärts mit gestreckten Knien auszuführen.

Die Versuchsperson soll mit geschlossenen Beinen und durchgedrückten Knien auf der Bank stehend eine Rumpfbeuge/Hüftbeuge vorwärts ausführen.

Testparameter: Als Testwert eingetragen wird der mit den Fingerspitzen erreichte tiefste Punkt an der Skala, der mindestens zwei Sekunden gehalten werden muss. Messwerte über dem Bankniveau werden negativ bewertet, unter dem Bankniveau positiv. Jede Versuchsperson hat einen Probeversuch.

Testmaterialien: Bank mit Skala (Lineal)

Schulterbeweglichkeit

Testdurchführung: Der Sportler liegt in Bauchlage auf einer Matte. Beide Arme sind nach vorn gestreckt, wobei beide Hände übereinandergelegt werden. Der Oberkörper und die Stirn berühren den Boden. Die Arme werden bei gestreckter Armhaltung so weit wie möglich angehoben. Die Athleten haben einen Probeversuch.

Testparameter: Maximaler Abstand der unteren Handfläche vom Boden/ Matte in cm.

Testmaterialien: Maßband/ Messstab

Attachment 2 – Announcement of Nomination Testing (STV)

Sächsischer
Triathlon
Verband e.V.

Überprüfungswettkampf Schwimmen/ Laufen des Sächsischen Triathlon Verbandes am 27.11.2011

Veranstalter: Sächsischer Triathlon Verband e.V.

Datum: Sonntag, den 27.11.2011

Zeit: Einlass: 9.00 Uhr, Beginn: 10.00 Uhr, Ende: ca. 18.00 Uhr

Wettkampfort: Sportforum Reichenhainer Straße 154, 09125 Chemnitz

Wettkämpfe:

AK 2009/10	Alter:	Jahrgang:	Kadertest:
Schüler C	8/9	2003/04	50m K + 50m R + 50m KB, 60m + 1km Lauf
Schüler B	10/11	2001/02	50m K + 50m R + 50m KB + 200m F, 60m + 1km Lauf
Schüler A	12/13	1999/00	50m K + 50m R + 50m KB + 400m F, 60m + 1km Lauf
Jugend B	14/15	1997/98	50m K + 50m S + 50m KB + 400m F, 60m + 3km Lauf
Jugend A	16/17	1995/96	50m K + 50m S + 50m KB + 400m F, 100m + 5km Lauf
Junioren	18/19	1993/94	50m K + 50m S + 50m KB + 400m F, 100m + 5km Lauf
U23	20-23	1992-89	50m K + 50m S + 50m KB + 400m F, 100m + 5km Lauf

Meldungen sind nur in den oben aufgeführten Altersklassen möglich.

Ablauf:

10.00 Uhr –13.00 Uhr — Schwimmwettkämpfe (Einschwimmen ab 9.30 Uhr)

14.00 Uhr - 17.30 Uhr — Sprint/ Lauf(Leichtathletikhalle/ Stadion)

Meldung: Bitte als Vereinssammelmeldung mit Name/ Geb.-Datum an Leistungssportwart Andreas Beudt
Email: a.beudt@gmx.de

Meldegebühr: 3,50 Euro zahlbar vor Ort

Meldeschluss: 24. November 2011 **Nachmeldungen sind nicht möglich!**

! Die Schwimmleistungen werden nur in (Dreiecks-)Badehose oder Badeanzug (Oberschenkel frei) als Kaderleistung anerkannt **!**

! Der Ausdauerlauf findet auf Beschluss des Trainerrates in der Laufhalle statt **!**

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Attachment 3 – Nomination Criteria for Regional Team (STV)

Kadernormen des Sächsischen Triathlon Verbandes (Stand: November 2011)

für die Saison 2012 gelten folgende Altersklassen:

AK	Alter:	JG:	Kadertest:
Schüler C	8/9	2003/04	50m + 50m R + 50m KB, 60m + 1km Lauf
Schüler B	10/11	2001/02	50m + 50m R + 50m KB+ 200m F, 60m + 1km Lauf
Schüler A	12/13	1999/00	50m + 50m R + 50m KB+ 400m F, 60m + 1km Lauf
Jugend B	14/15	1997/98	50m + 50m D + 50m KB+ 400m F, 60m + 3km Lauf
Jugend A	16/17	1995/96	50m + 50m D + 50m KB+ 400m F, 100m + 5km Lauf
Junioren	18/19	1993/94	50m + 50m D + 50m KB+ 400m F, 100m + 5km Lauf
U23	20-23	1989-92	50m + 50m D + 50m KB+ 400m F, 100m + 5km Lauf

Normen - weiblich:

Kader	Alter	50m Kraul	200/ 400m Kraul	60/100m Lauf	1/3/5/10km
E	8/9	53,0	4:15min	11,9	5:15min
E	10	48,0	3:45min	11,6	4:45min
E	11	43,0	3:25min	11,3	4:30min
E	12	40,0	7:00min	10,6	4:05min
E	13	38,0	6:40min	10,3	3:55min
D	14	35,0	6:15min	9,9	12:50min
D	15	34,0	5:50min	9,4	12:20min
D	16	33,5	5:35min	15,2	21:00min
D	17	33,0	5:25min	14,9	20:30min
D	18	32,0	5:20min	14,5	19:45min
D	19	31,5	5:15min	14,2	19:15min
U23	20	31,5	5:10min	14,0	19:00min / 39:30min
U23	21	31,5	5:05min	14,0	18:45min / 39:00min
U23	22	31,0	5:00min	14,0	18:30min / 38:30min
U23	23	31,0	4:55min	14,0	18:30min / 38:15min

Normen - männlich:

Kader	Alter	50m Kraul	200/ 400m Kraul	60/100m Lauf	1/3/5/10km
E	8/9	52,0	4:05min	11,8	4:30min
E	10	48,0	3:45min	11,3	4:15min
E	11	42,0	3:25min	10,7	4:00min
E	12	39,0	6:50min	10,2	3:50min
E	13	36,0	6:20min	9,7	3:30min
D	14	34,0	5:45min	9,2	12:00min
D	15	32,0	5:20min	8,7	11:30min
D	16	30,5	5:10min	13,5	17:45min
D	17	30,0	5:00min	13,2	17:30min
D	18	28,5	4:50min	13,0	17:00min
D	19	28,0	4:45min	12,8	16:45min
U23	20	27,5	4:40min	12,5	16:30min / 34:00min
U23	21	27,5	4:35min	12,5	16:15min / 33:45min
U23	22	27,0	4:30min	12,5	16:00min / 33:30min
U23	23	27,0	4:30min	12,5	15:45min / 32:30min

Die Normen der Mindestanforderungen über 50m KB und 50m 2.Schwimmart müssen ebenfalls erfüllt sein, um den Kaderstatus zu erlangen.

	50m KB*	50m R/ 50m D
Schüler C und B	< 70s	< 65s
Schüler A und Jugend B	< 65s	< 60s
ab Jugend A	< 55s	< 50s

* Wasserstart mit Brett

Die Berufung des Landeskaders erfolgt ausschließlich durch den Beschluss im Trainerrat.

Folgende Kriterien sind dabei zu berücksichtigen:

Schüler C und B	Erfüllen von mind. 2 der 4 Normen (je eine Lauf und eine Schwimmnorm)	
ab Schüler A	Erfüllen von mind. 3 der 4 Normen	
ab Jugend B	Erfüllen aller 4 Normen	

Ergebnisse aus der vorangegangen DM Triathlon/ DTU-Cup:		
max. Rückstand zum/zur Sieger(in) in %:		
Jugend B	älterer Jg.	6,0
	jüngerer Jg.	7,0
Jugend A	älterer Jg.	5,0
	jüngerer Jg.	5,5
Junioren	älterer Jg.	4,0
	jüngerer Jg.	4,5

Die Schwimmnormen sind in Badehose und Badeanzug (Oberschenkel frei) zu erbringen !!!

Beschluss Trainerrat:
01.09.2009

Attachment 4 – Nomination Criteria for Regional Team (TVMV)

Kadernormen für den D-Kader

Für die Aufnahme in den D-Kader muss im Verlaufe der jeweiligen Saison mindestens eine der aufgeführten Leistungsanforderungen erbracht werden:

1. Ergebnis bei Deutschen Meisterschaften:

weiblich: **Durchschnittliche Zeit der Plätze 1 bis 3 plus 5 Prozent**
männlich: **Durchschnittliche Zeit der Plätze 1 bis 3 plus 5 Prozent**

2. Ergebnis im Deutschland-Cup:

weiblich: **Gesamtwertung, junger Jahrgang Top 10, alter Jahrgang Top 8**
Einzelwettkampf, junger Jahrgang 2x 5% Rückstand Durchschnitt Top 3
Einzelwettkampf, alter Jahrgang 2x 4% Rückstand Durchschnitt Top 3

männlich: **Gesamtwertung, junger Jahrgang Top 15, alter Jahrgang Top 10**
Einzelwettkampf, junger Jahrgang 2x 5% Rückstand Durchschnitt Top 3
Einzelwettkampf, alter Jahrgang 2x 4% Rückstand Durchschnitt Top 3

3. Erreichen bestimmter Einzelleistungen:

Für Athleten, die oben genannte Ergebnisse aus unterschiedlichen Gründen nicht erreichen konnten, gelten folgende Normzeiten:

Alters-klasse	**Alter**	**Schwimmen 400 m**		**Schwimmen 800 m**		**Laufen 3 km (Bahn)**		**Laufen 5 km (Bahn)**	
		weibl.	**männl.**	**weibl.**	**männl.**	**weibl.**	**männl.**	**weibl.**	**männl.**
Schüler A	13	06:00	06:00			12:30	12:00		
Jugend B	14	05:45	05:30			12:10	11:15		
	15	05:35	05:10			11:45	10:45		
Jugend A	16	05:25	05:00	11:00	10:20	11:30	10:20	20:15	18:00
	17	05:15	04:50	10:40	10:00	11:10	10:00	19:40	17:00
Junioren	18	05:05	04:40	10:30	09:50	11:00	09:40	19:15	16:40
	19	05:00	04:35	10:15	09:40	10:40	09:20	18:50	16:10

Der Leistungsnachweis erfolgt bei den vom TVMV angesetzten Überprüfungslehrgängen.

Gültig ab 01.09.2011

Kadernormen für den D/U23-Kader

Für die Aufnahme in den D/U23-Kader ist die Erfüllung mindestens einer der unten aufgezählten Leistungen erforderlich.

Wettbewerb	**Platzierungen bzw. Abstand zur Spitze**	
	weiblich	**männlich**
Letztes Jahr bei den Junioren		
Erfüllung der D-Kadernormen	Erfüllung	Erfüllung
Deutsche Meisterschaft der Junioren	Top 8	Top 12
Deutschlandcup / Gesamtwertung	Top 6	Top 10
C- bzw. D/C- Kader	ja	ja
Erstes Jahr in der Elite bzw. U23		
Deutsche Meisterschaft - U23	Abstand 5%	Abstand 5%
1. Bundesliga	1x Abstand 5%	1x Abstand 5%
2. Bundesliga	2x Top 6	2x Top 12
EC, ITU-WK	Abstand 6%	Abstand 6%
2. und 3. Jahr in der Elite bzw. U23		
Deutsche Meisterschaft - U23	Top 6	Top 10
1. Bundesliga	Abstand 4%	Abstand 4%
2. Bundesliga	2x Top 3	2x Top 8
EM, WM, EC, ITU-WK	Abstand 4%	Abstand 4%

Gültig ab 01.09.2011