

Sports Medicine and Science
in

ARCHERY

II

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Preface



Dear Archery Family Members,

I am very pleased to introduce this second FITA publication on the medical and scientific aspects of archery.

This book deals with topics such as the scientific basis of training, psychological strategies, heat related problems, doping, bow biomechanics, muscular activation, and the travelling athlete.

I am sure both coaches and archers will benefit from this compilation of the most recent information.

Being a medical doctor myself and one of the founders of both the School of Sport Sciences and Technology and the Doping Control Center in my university, I strongly believe that archery is one of the Olympic sport disciplines that can be promoted through scientific support.

I would like to thank FITA Medical and Sport Science Committee Chairman, Dr. Karol Hibner, and members, Dr. Emin Ergen, Mrs. Nancy Littke, Dr. Jean-Claude Lapostolle, and Dr. Carlos Hermes, along with Ms. Francoise Dagouret for their enthusiasm in putting forward this second publication.

I hope our readers will be able to apply to our discipline the information presented in order to make our sport more enjoyable.

Prof. Dr. Uğur Erdener, MD
FITA President

Foreword



Karol Hibner

Dear Archery Friends,

Four years have passed since the first book “Sport Medicine and Science in Archery” has been presented. On behalf of FITA and its Sport Science and Medical Committee I have again great pleasure to introduce to you the second edition of this book, which is updated according with the constant development of archery. Some new chapters have been added which should be useful for those practising and coaching archery as well all doctors dealing with sport medicine.

Still the most important issue for all athletes, including archers is “fair play”. This means no doping in the sport. Using prohibited substances on the WADA list is not only unfair but could also be very risky for the health of those who want to enhance their performance in that way.

Archery, as well as other sports, is constantly developing due to new coaching methods and equipment. Every big event like the Olympic Games, World, and European Championships bring new records which several years ago seemed to be unrealistic. This of course causes many injuries especially among young archers. This book gives practical advice on how to avoid or minimize this risk. Warming-up exercises before shoots are essential. Also preventing archers from exposure to heat and sun is a very important issue as it is not only a risk to health but also significantly lowers shooting performance.

This book will probably not give you the answer for all your problems, therefore we would kindly ask you to tell us how this book could be improved in the future. We hope to be able to give into your hands a third edition before the Olympic Games in 2012.

Now, I would like to thank a new FITA President Dr. Ugur Erdener as well as FITA Council for their great support and help.

Special thanks should be addressed also to Dr.Emin Ergen who is a real “father” of this book as without great personal commitment this book would never have been published.

The main contributors to this edition of our book are all members of FITA Sport Science and Medical Committee, as well as other co-authors who wrote all chapters to make this book comprehensive and up to date.

Acknowledgements

This book would never have made it to publication without invaluable support of Prof.Dr. Uğur Erdener, President of FITA.

We wish to thank FITA Office, in particular Françoise Dagouret, for her support, and Nancy Littke for her carefull proof reading.

To Hacettepe University Hospitals Publishing House, especially to Uğur Korkmaz, Belgin Özkalay Koç, Hakan Balcı and Süheyla Kırıyıcı go our thanks for unfailing help and expertice.

The editors wish to acknowledge the valuable contributions to the production of this book for each of contributing authors listed below. These authors either wrote completely or contributed significantly to the chapters in the handbook (in alphabetical order).

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Scientific Foundations of Training

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Most authorities agree that improvement in performance is directly related with the quality of training (1,2) and archery is no exception to this (Fig. 1). However, there are numerous factors which play a decisive role in the determination of quality of training (1-6). Priority order of the determining factors may vary from sport to sport but it can be generalized that some of the basic elements of performance are similar in many sports (1-3,5). With regards to archery, where up

to date technologically sound equipment plays a paramount importance, it is important that there is a suitable training facilities for winter and summer to carry out the necessary and desired training with adequate equipment. Although archery does not look very physically demanding, compare to many other sports, it does however show very specific fitness demanding, which includes specific endurance, strength, flexibility, and fine eye-hand coordination and timing (7). Thus, there is a very specific demand on certain postural muscles (8), certain aerobic and anaerobic power and capacity, both for competition and training (7). Concentration, motivation, ability to cope with various forms of anxiety, will power, and determination are important prerequisites in positive mental and psychological aspects of performance (9). On the other hand, a coach with a general and specific knowledge in fitness, skill and technique for archery, ability to cope with different problems both in training and competition with a certain touch of character may have a more determining part in performance

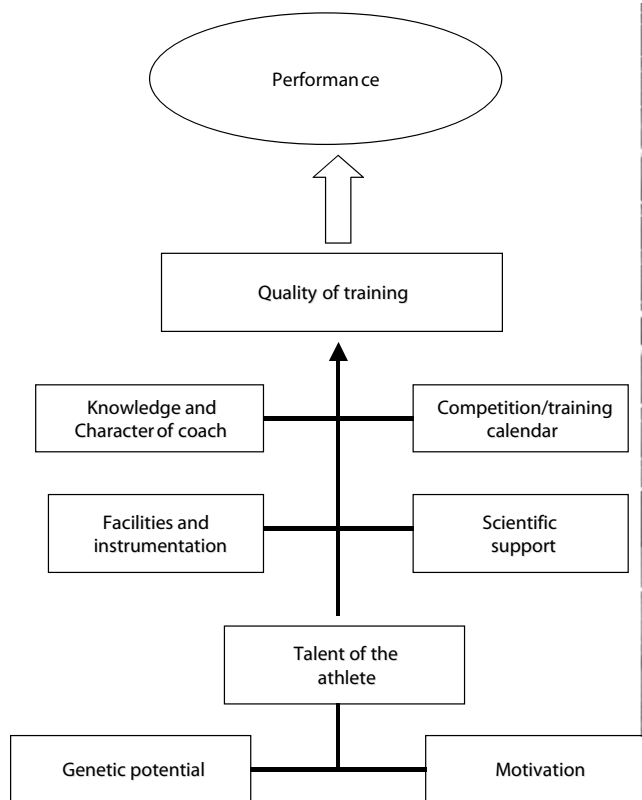


Figure 1. Performance determinants.

than any other factor. Talented athlete is also very and perhaps one of the most important aspect of the quality of training (1-3,5,6,10). Late findings in gene studies show that the ability to respond to training is genetically determined (11). Therefore, the rate of improvement in training capacity, training adaptation in endurance, strength, and ability to learn new skills are all athlete determined. Thus, it is very important to have genetically gifted or talented athletes in the training groups. It is also very important to note that short and long term planning of training and competition is important for the quality of training (2-6,12-15). Proper planning gives enough time for training and adaptation to higher fitness level, and also for peaking up and maintaining of the top form for optimal performance (2-6,12-14). Quality of training is also very much influenced by the family, school, and the community support of the athlete (3,4,12). There will be a noticeable lack of motivation without the support of the athlete by the family, school or/and the community (Fig. 2).

Principles of Training and Adaptation:

Whatever the genetic giftedness of an athlete, training is the most important prerequisite to realize the existing genetic potential of an athlete. Without training, it is impossible to change the performance capacity of an athlete. Training load, organized according to training principles, forces the athlete's organism to change and adapt to a higher performance capacity which is limited by the genetic potential (Fig. 3) (1-6,11,15-17). This explanation emphasizes the point that training load is the most important prerequisite for training adaptation and in realizing the genetic potential of an athlete. This implies that whether an athlete gifted or not, without training it is impossible to change the performance capacity. However, training without proper planning and systematic application may be far from being effective in eliciting the possible genetic potential of an athlete. Effective training, therefore, should follow specificity of training loading, overload, reversibility, alternative loading, individuality,

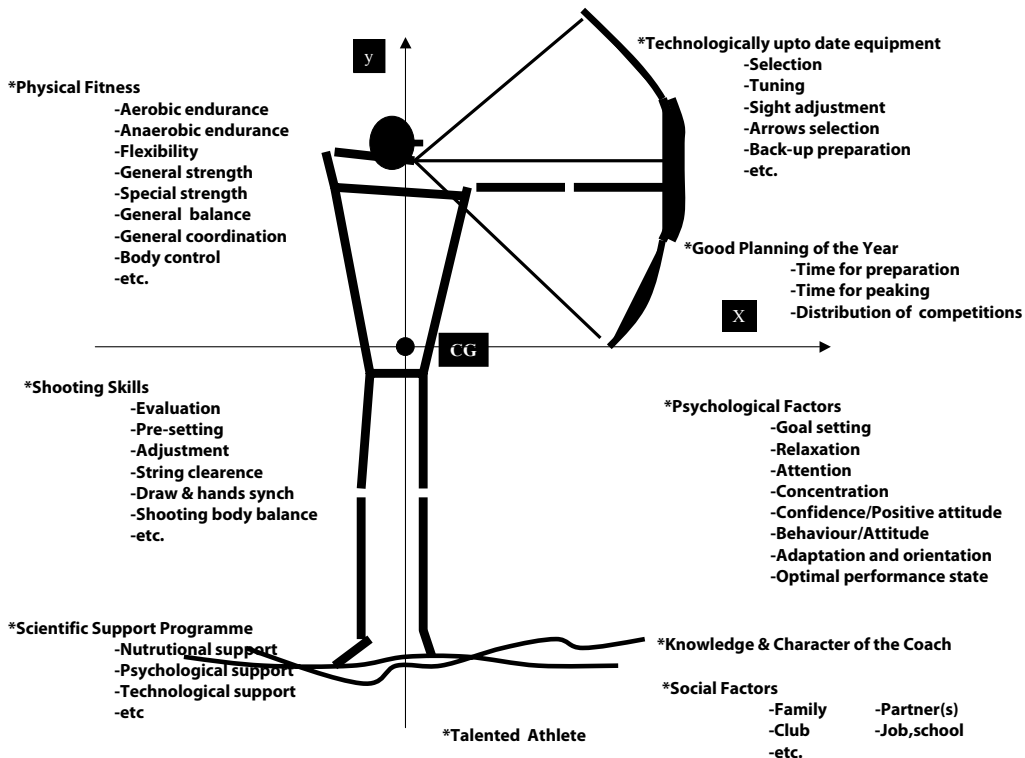


Figure 2. Determinants of Performance

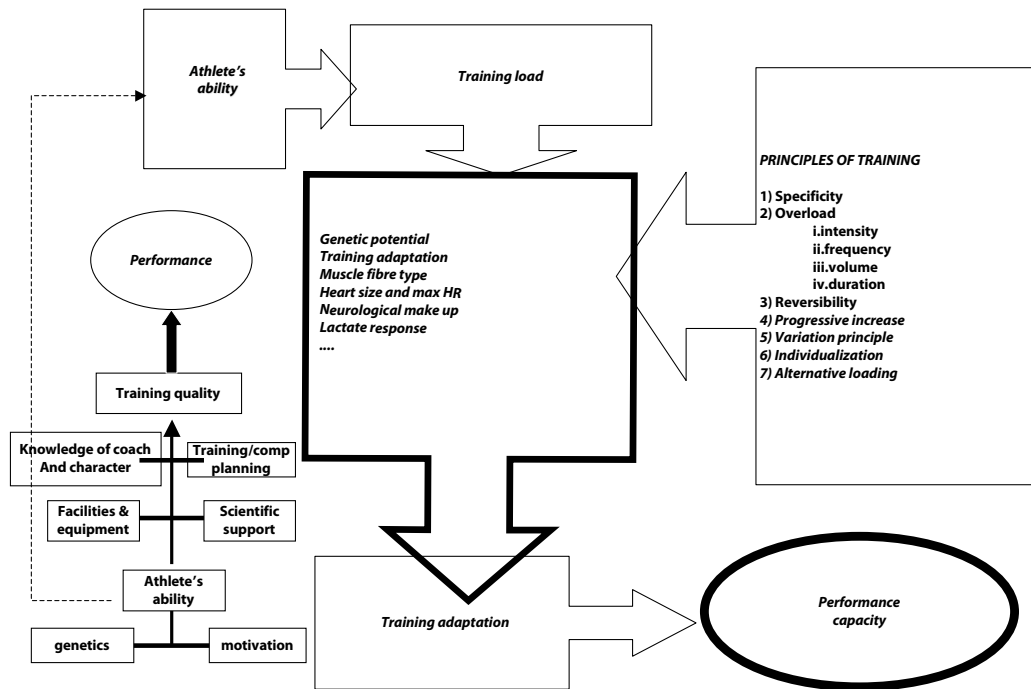


Figure 3. Various influences on training and training adaptation.

variation, and progressive increase of training principles (1-6,10,14,15,17). This chapter is going to tackle some of these principles in appropriate places in an attempt to handle the scientific foundations of training and adaptation.

Specificity and Individuality Principles:

Training principles, in this respect, are important in order to organize the training in such a way to elicit the desired training adaptation for performance (5). There are number of principles that govern the way in which the training load should be applied. One of the very first principle is the “specificity principle”. According to specificity principle, the training load should be specific to the sport or competition (2-5,10). Training elements should have similar biomechanical demands of the sport or the competition. For example, an archery competition demands approximately 150 shots in a day during the series of competition, with three shots at a time interspersed with some active rest intervals, during which the archers walk to the targets to fetch their arrows. This physical and mental behaviour in competition demands some basic aerobic

endurance to withstand the physical and mental demands of shooting with precision (7). There is a noticeable physical and physiological stress on postural musculature as well as on active muscles for drawing and aiming the bow. These physical and mental demands are very specific to archery. Each draw, depending on the stiffness of the bow, requires approximately 18-25 kg of force, and this is performed during a restricted time, under a certain state of concentration. This is performed several times, and there has to be very specific and controlled demand on muscular strength (7). Training of archery, therefore, should resemble and meet the demands of competition. In training, different basic elements of fitness, skill and technique, and mental skills should be developed according to the demands of the archery competition.

However, it should, also, be kept in mind that training adaptation is different from an individual to individual, due to different genetic inheritance. Each individual learns a skill differently and in different pace. Response and adaptation to endurance, speed and/or strength is different in every individual due to different morphological

make up (1,3-5,10). With regards to this, some athletes or archers may respond to skill and technical learning much faster and may lack in endurance or consisted shooting through out the day. Some others may be slow in improving technical skills and in learning new movements, or in precision, but very good at responding to strength work. This difference in individuals often forces the coaches to decide on training content at an individual level. In this respect, some athletes may do some extra work in skill and technical works, some may do more repetition to improve specific endurance, and some may even work on extra strength work in order to improve on body control or proper stance during shooting in archery. Even the basic endurance training has to be worked out individually. Table 1 is showing different archers heart rate at different endurance

trainings, determined by individual specific endurance tests for every archer (18). This way every archer works at different metabolic pace for the same training methodology according to their individual endurance fitness. Planning of training on the basis of individual needs in relation to training and competition performance is called “individualization principle of training”. Individualization of the training, together with other elements of training, forms adequate level of training load in desired components of performance and fitness (1,3-5,10). Some of these elements of training loading will be dealt in this chapter in appropriate places. The connection of specificity and individualization of training will be dealt and handled together with other principles at appropriate places in the text.

Table 1. Individually determined endurance training intensities for different training methods

	Regenerative training		Extensive Endurance		Intensive Endurance I		Intensive Endurance 2		Extensive Interval	
	2 mmol Velocity of run		2.5 mmol Velocity of run		3 mmol Velocity of run		3.5 mmol Velocity of run		4 mmol Velocity of run	
	m/s	HR	m/s	HR	m/s	HR	m/s	HR	m/s	HR
A.K.	1.00	140	1.12	145	1.57	147	1.92	149	2.20	168
D. G.	1.26	143	1.47	156	1.65	166	1.80	172	1.93	177
D.D.	1.31	118	1.57	146	1.80	167	2.00	182	2.18	192
E. T. K.	1.44	123	1.66	145	1.85	160	1.99	170	2.12	177
E. D.	1.63	141	1.93	156	2.19	167	2.42	175	2.61	181
G. Ç.	1.58	146	1.81	161	2.01	171	2.17	179	2.32	185
H. Ç.	1.65	120	1.94	140	2.19	155	2.39	165	2.57	172
H. O.	2.08	153	2.25	160	2.42	166	2.58	171	2.73	177
H. E. K.	1.43	122	1.67	141	1.89	155	2.07	164	2.22	170
N.N.	1.64	138	1.90	158	2.12	171	2.28	180	2.42	186
S. Ş.	2.23	131	2.58	151	2.87	163	3.10	172	3.28	178
S. K.	1.78	150	1.98	163	2.15	172	2.29	178	2.41	183
T. K.	0.00	0	2.16	161	2.17	162	2.27	167	2.44	175

Training Overload and Fatigue Principle:

In order to elicit desired adaptation in training, the training load should have some specific physiological impacts on the organism. It is, therefore, important to have some psychological and physiological stresses on the organism by a training load. In this respect, in order to organize a systematic, complex, regular, and distinct training impact on the organism, the training load should have intensity, frequency, volume, and time elements (1,3-5,10). Each of these elements should impose such a training stimulus that is above the existing fitness threshold (Fig. 4). The training load should have some psychological or /and physiological stresses which are above the existing threshold in order to form an appropriate level of stress to force the organism to change for higher capacity and power state (1,3-5,10). The training load, therefore, should have some difficulty which is called intensity, amount of training which is named as volume, and should be repeated in regular intervals or frequencies, and long enough to elicit the desired change in performance and/or fitness elements. The acute impact of training load through overload principle causes some changes in the organism. This acute

change in the state of the organism is known as fatigue (Fig. 5). Fatigue, in training sense, is stimulus through training for the organism where it is forced to change by creating fatigue (19). During training, fatigue is caused by the change of muscular depletion of glycogen, increased heart rate, increased rate of hormonal activity, increased muscular and core temperature, increased cellular and blood lactic acid and carbon dioxide levels, etc (1-4,10,13,17). There is an immediate response to changes in the organism due to fatigue. The organism is very sensitive to such changes. There is a tendency in the body functions and systems to form a balance or equilibrium, which is called homeostatic balance, and is very sensitive to such changes. Homeostatic responses of the body during and after the training load, different metabolic functions respond back immediately in order to normalize the changes and restore back the homeostatic state (3,19). If the body is able to cope with the amount of fatigue caused by the training load, there is a progress in training process to higher performance capacity (3,19). Besides an individual training load, fatigue is often caused by successive training loads which are not properly organised to give enough time

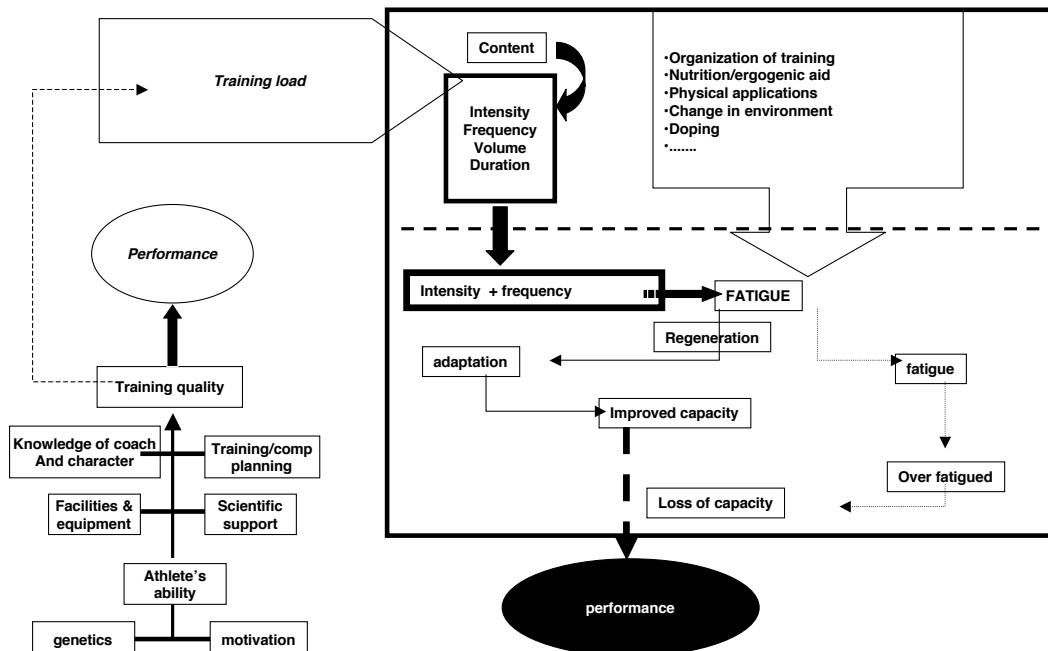


Figure 4. Training overload and fatigue response.

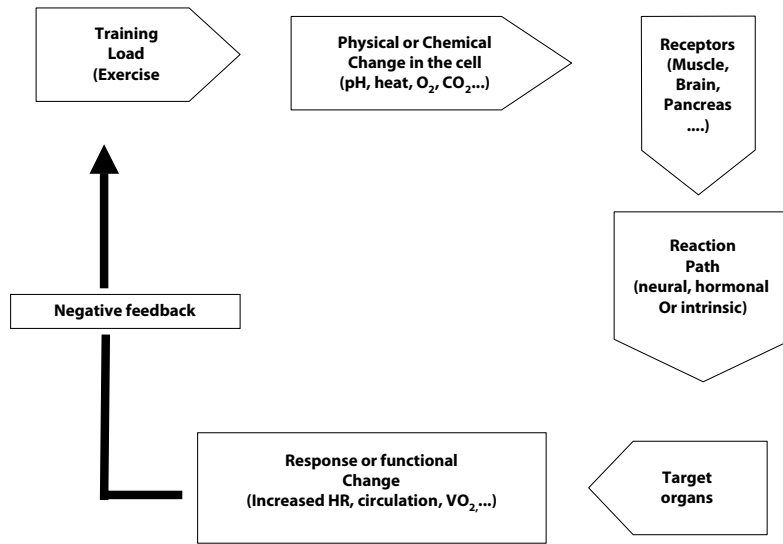


Figure 5. Acute adaptation to training load.

for rest and regeneration. If training caused fatigue is handled by proper rest, organization and planning of training, and other regenerative elements, there is an improvement in training and performance capacity. Contrary to this, if training caused fatigue and other influencing factors of daily life are not properly handled and fatigue remained and transferred to following training sessions, there will be a loss of capacity both in training and training adaptation (2,3,19). It is important that there is a controlled form of fatigue, since fatigue is the key stimulus for training adaptation of the organism. At the same time, insistent and uncontrolled fatigue leads to the loss of training capacity and loss of desired response to training (2,3,19). In terms of training and training periods, if insistent and uncontrolled fatigue state of training continues and exceeds couple of mezocycles, the state of fatigue becomes “overtraining fatigue syndrome” (2-5). This state is no longer a normal fatigue state, where training caused fatigue can be eliminated by rest or alteration of training. This state is a pathological state, where athlete needs to be treated for an appropriate period of time till there is normal and expected response to training stimulus. From physiological point of view, training stimulus is a stressor to stimulate the organism. Selye defines this state of stressor and adaptation situation as “general adaptation syndrome” (20).

For short and long term training adaptation, training is the basic stressor. Fig. 6, explains the regular training response process. If the training load is applied on a daily, weekly (microcycle), monthly (mesocycle), or yearly (macrocycle) basis, the organism is forced to make permanent changes as a response to regular training and fatigue. Lamb (21) indicates that these changes take place in the “target organs”. As a result of regular training change there is an increase in oxygen uptake, muscular buffer system, increase in muscular and hepatic glycogen contents, aerobic and anaerobic energy production, increase in vascular capillarization of the muscle, increase in protein synthesis, enzymatic activity level, cellular mitochondrial density, increase in stroke volume and cardiac output, etc (21). This change as a result of regular training is called functional change or increase in fitness level, which leads up to increased performance capacity. However, it should be noted that these changes have resulted as an outcome of training specific fatigue. In other words, if the training load was strength oriented, strength origin fatigue has developed and the changes in the organism are strength related. If the training load is endurance related, endurance origin fatigue is developed and the fitness change would take place in endurance related functions of the organism. Furthermore, whatever the changes take place, they are physiomechanical specific.

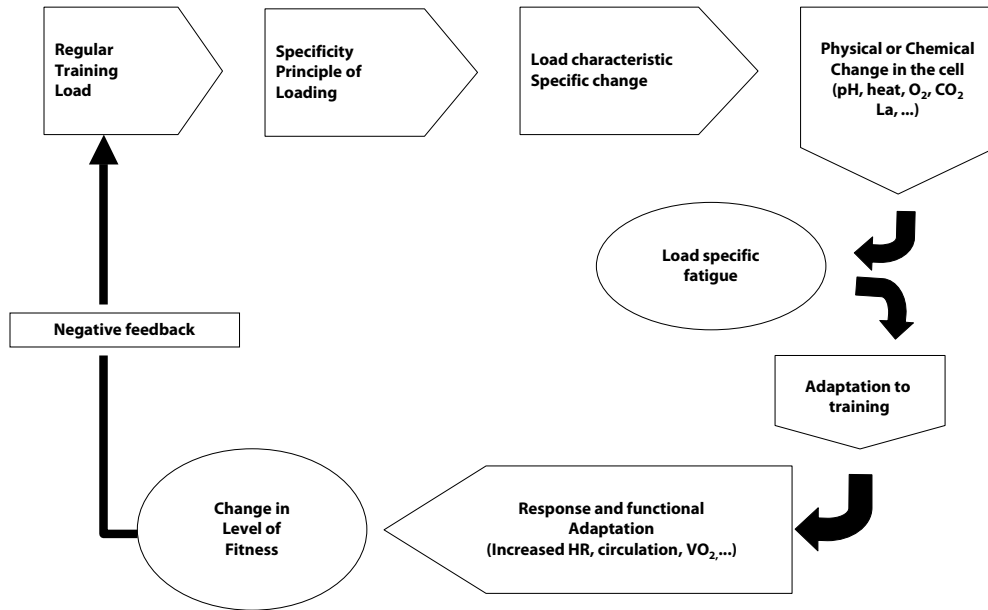


Figure 6. Chronic adaptation to training load.

In other words, the changes are muscle and skill specific.

It has to be remembered that Principle of overloading and fatigue is very much related to specificity and individualization principles at the same time (1,4,5,15). This relationship can be explained by the training load-fatigue-adaptation and the amount of training adaptation is individual specific. However, understanding of change in fitness level or increase in performance capacity is more complex than the simple explanation of training load-fatigue-adaptation relationship. This state of training load and fatigue relationship was first explained by Yakovlev (22), where he pointed out that after the training load-fatigue mechanism, the adaptation or regeneration amount is not similar to pretraining load state. There is a surplus state of regeneration which is called “supercompensation”, which means temporary increase in fitness qualities. Yakovlev (22) in his very first studies has demonstrated this in increase of muscle glycogen contents as a result of exhaustive training load. This temporary increase in glycogen content after training imposed fatigue has lead to the questioning of other training effects. This effect has also been demonstrated in different metabolisms such

as protein metabolism, enzyme responses to training load, and other metabolites. However, late studies show that the training load-fatigue-supercompensation relationship is also very complex than what has been shown by Yakovlev in the very early years of modern training development. Yakovlev’s glycogen restoration supercompensation model is named as “single factor regeneration” (14). Lately it is known that there are very complex and diverse adaptation processes taking place, where some of the changes are very immediate, and some delayed. These complex reactions of adaptation may be called as “multi-factor regeneration” or “multi-factor adaptation”. In this short review, however, it is not planned to go in to the complex reactions of training processes, and training response issue is going to be explained within the simple context of training supercompensation.

From the above explanations and concepts it is apparent that “fatigue” is a key element for training. In the one hand it is needed for training adaptation and progress; in the other hand, there has to be a caution for fatigue since it hinders the training process if the state of fatigue is beyond the managing ability of the organism or the athlete. In this case, it means that ability

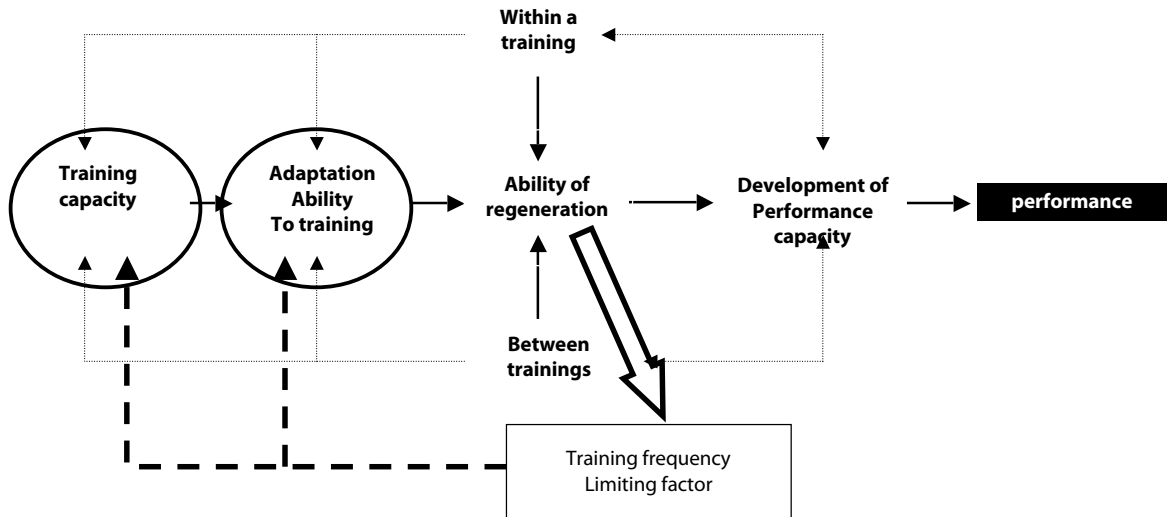


Figure 7. Influencing factors of performance.

of athlete to train as hard and as frequently as possible, which is considered as a key to improve the performance capacity, the recovery ability from fatigue state is the main restriction or limiting factor. The ability, therefore to recover faster within a training between repetitions and between trainings is an important part of the training process. Faster recovery from training load imposed fatigue, directly and/or indirectly improves performance capacity, at the same time the ability of training adaptation and training capacity (Fig. 7).

From the above description of fatigue, some form of fatigue is really needed for the training process to take place for the improvement in performance capacity (1,3,5,15,23). From the literature it is known that there are number of different stages of fatigue till it reaches to “overtraining fatigue syndrome” stage. These are fatigue, reaching, overreaching, staleness, over fatigue, and overtraining fatigue syndrome (1,24). State of fatigue, therefore, can vary and the border between one stage of fatigue to the next is not definite, and it is a continuum from one form to the next. State of fatigue, therefore, starts from a simple form and reaches to very high and complicated state. Except the state of “overtraining fatigue syndrome” rest of the fatigue states are easily eliminated by rest or

alteration of training (1,24). However, it should be noted that there is a close connection with the amount of training and the amount of tiredness or fatigue. In this respect, since there is a close connection with training amount and fatigue; there is a connection with certain forms or stages of fatigue and training (1,19,24). In some cases, the form of fatigue is achieved without knowing or unintentionally applied training. And in some cases, the form and/or stage of fatigue is achieved intentionally by organizing the training elements appropriately within training or in consecutive trainings in the form of microcycle, mesocycle, and/or macrocycle (1,3,5,15,23).

A simplest form of fatigue by training can be achieved in a form of repetitive training loads in a unit of training and in a training session with several units of training (Fig. 8).

This form of training whether it follows the training principles or not, the form and amount of training is reversible when there is a rest or proper follow up training which achieves rest and regeneration. Obviously there may be a training load over several days of a microcycle, without a proper application of training principles (Fig. 9) or with an appropriate loading with an aim of supercompensation towards the end of a week (Fig. 10). Apparently, this form of fatigue is also reversible when there is a proper rest or change

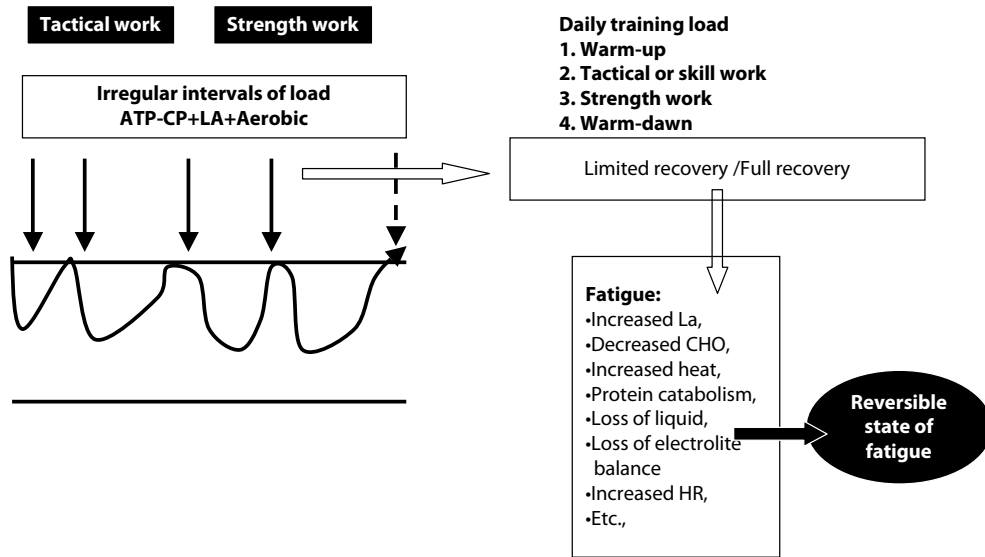


Figure 8. Acute fatigue due to a single or combined unit sessions in a training.

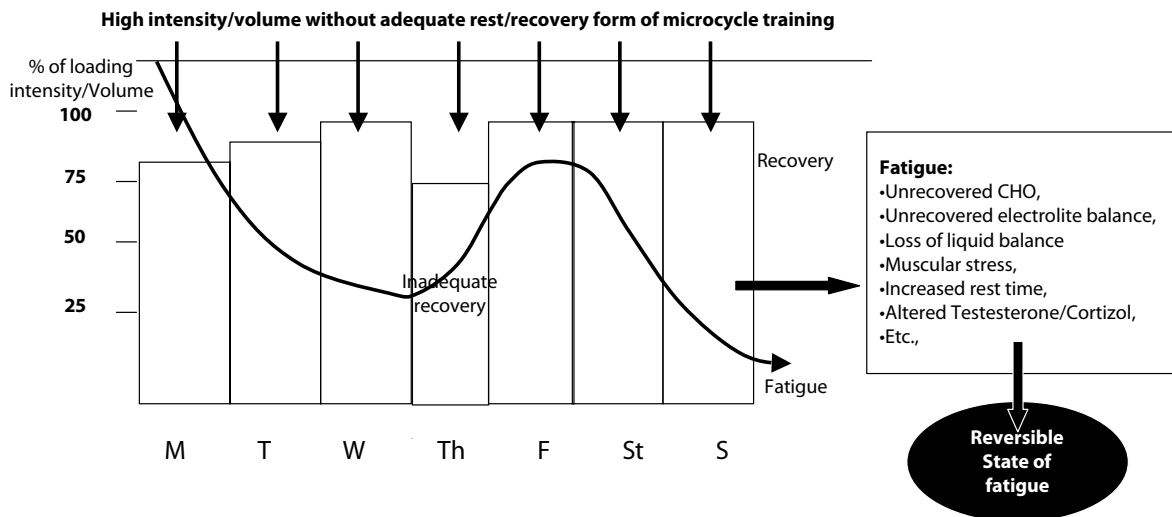


Figure 9. Improper high intensity and volume load of training where there is a lack of supercompensation effect at the end of the weekend days and loss of capacity.

of training. This form of training may be applied over several microcycles, with or without training principles. Without principles there will be some form of fatigue, without leading to a substantial improvement in fitness or no supercompensation as a result of training process (Fig. 11). If it is applied according to training principles, there will be some form of fatigue followed by supercompensation or increase in fitness or performance capacity (Fig. 12). If there is an

insistent training, lasting more than couple of mesocycles, without an adequate rest or regeneration training, may lead to a fatigue state, which is over the borders of recovery when there is a rest or regenerative training (2,3,14,24). This state is no longer reversible and is named as "overtraining fatigue syndrome" (Fig. 13). When the state of fatigue is at this stage, the organism does not respond to training stimulus in a normal way. There is a loss in the adaptation responses

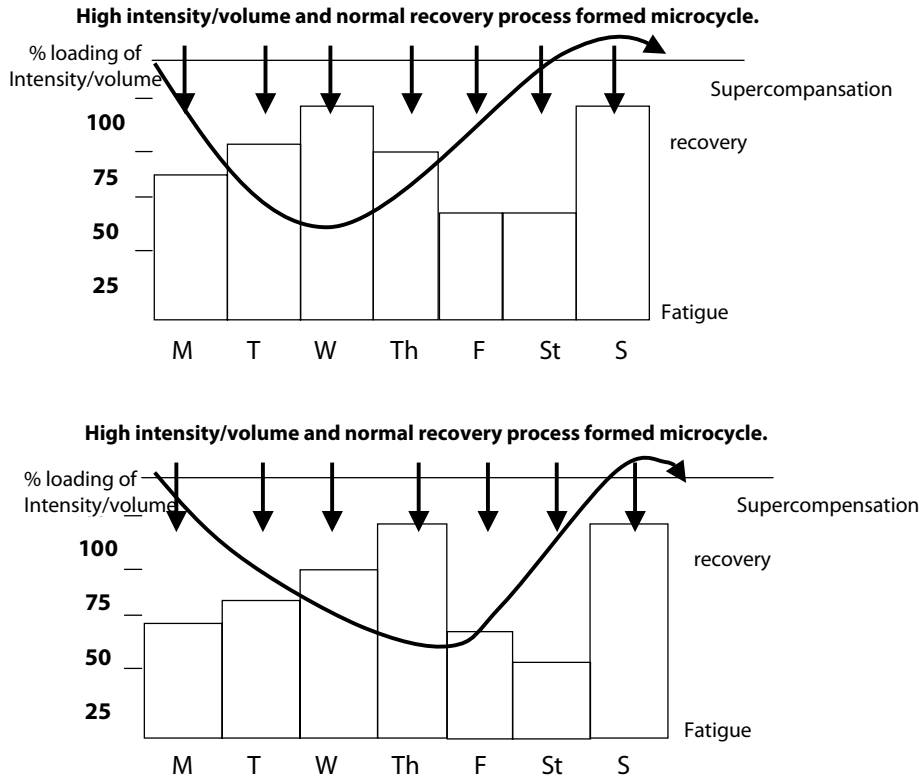


Figure 10. High intensity and volume of training with a recovery training and supercompensation aim during the weekends.

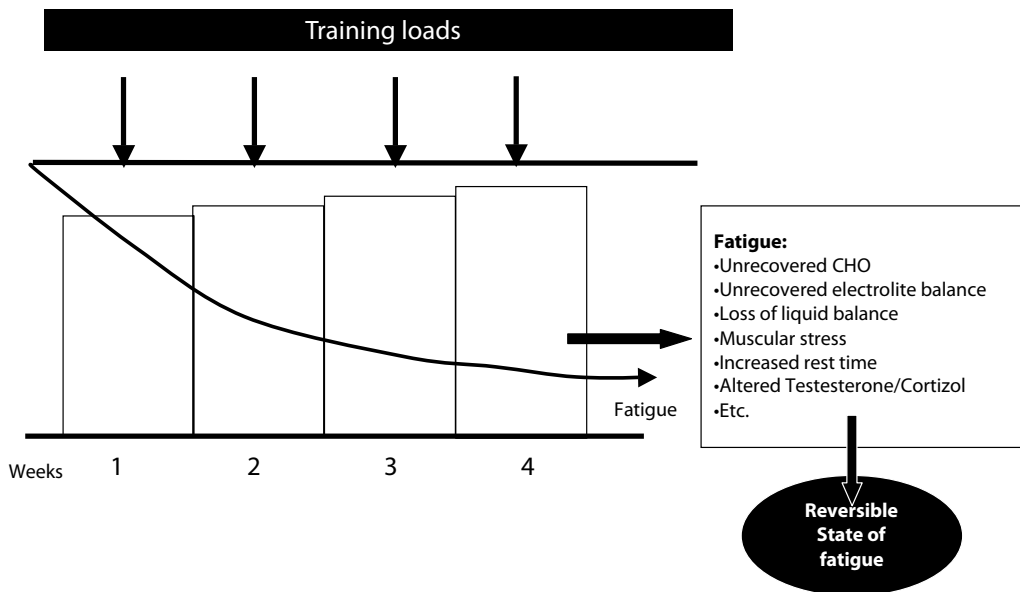


Figure 11. A mesocycles with too much training loading without any regeneration training and supercompensation effect.

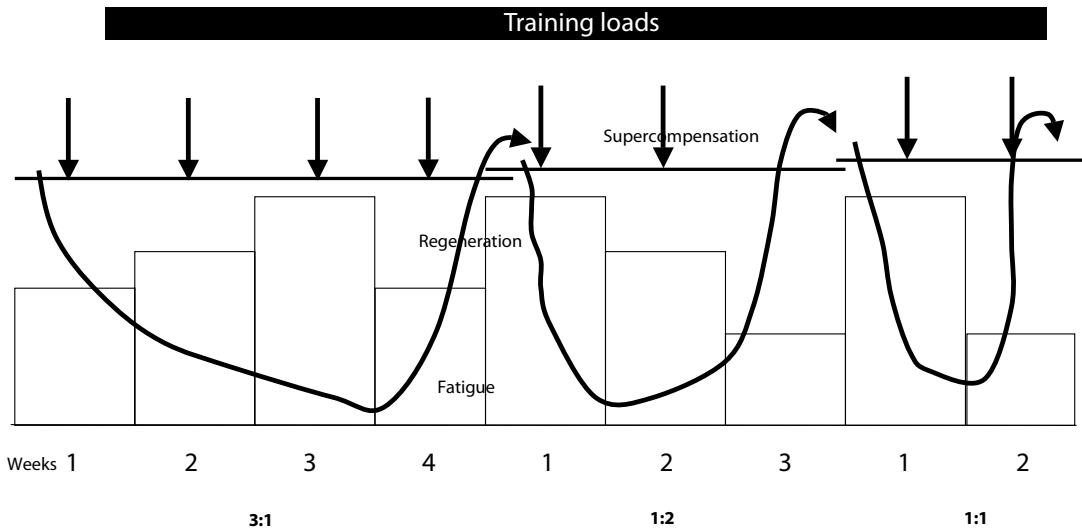


Figure 12. Different length of mesocycles with appropriate training loading and supercompensation effect.

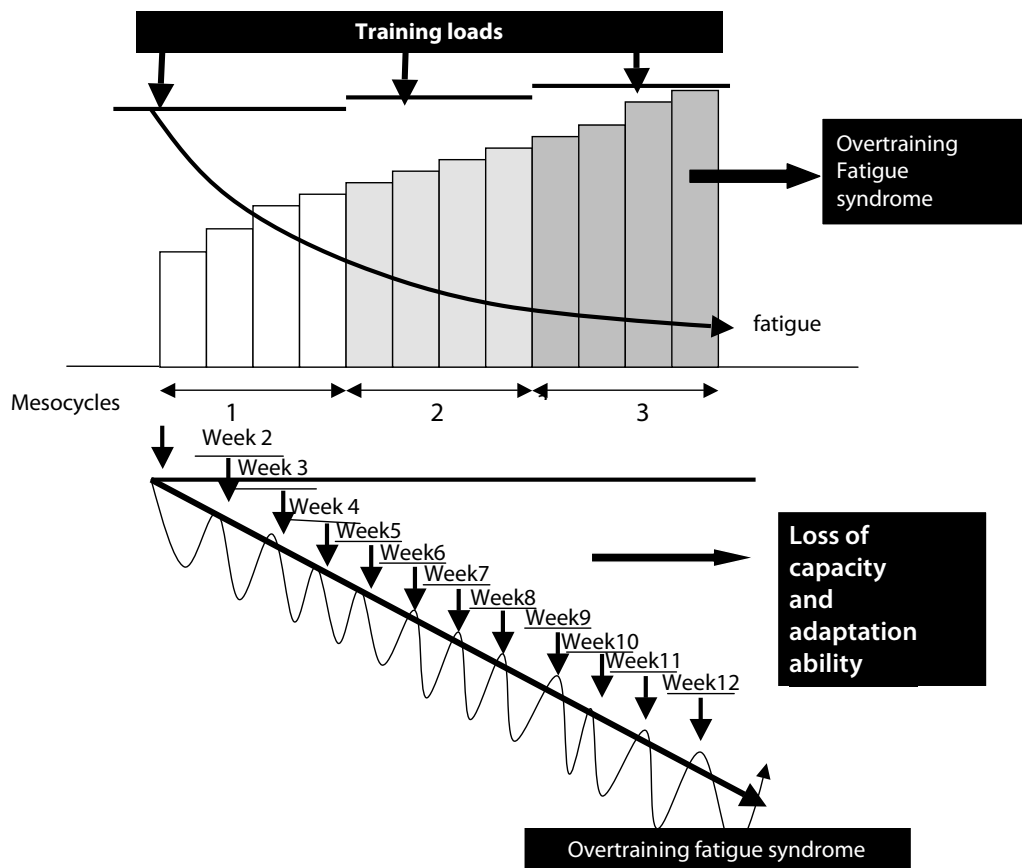


Figure 13. Overtraining fatigue syndrome state as a result of severe training without any regeneration training.

of the body, and there is an urgent necessity for the body to recover from this chronic fatigue state. In this case, there is a special treatment both for psychological and physical fatigue states to normalize the organism. This normalization process is obviously far from normal adaptation and performance training. This overtraining fatigue syndrome state, depending on the severity of the state and the individual athlete, may take from several weeks to months to recover back to normal. This chapter is not going to go in to the details of recovering from an overtraining fatigue syndrome state since this is a very special issue and needs to be handled separately. However, figure 14 explains some of different character of training loads and recovery and supercompensation processes during rest and training. It is important that the possible source and the mechanism of fatigue are well recognized and suitable precautions are taken. For example, if the training load is over an hour or totalling to or over an hour by short and several sessions a day, there is a marked reduction in energy sources,

which leads to metabolic fatigue. In this case there should be a proper rehydration before, during and after training and/or competition sessions. Proper eating of a meal one to two hours prior to training or competition, and to speed up the recovery process the energy (glycogen content of muscle and liver), nutritional (protein, carbohydrate, fat balance), water, and electrolyte balances should be restored, and by the use of contrast temperature showers or baths of hot and cold, or spa and cold plunge, or active recovery activities.

From the above argument, it should be clear that there has to be an effective way of handling of training in short and long period, as far as fatigue-recovery-adaptation-supercompensation or training effect is concerned. It is almost impossible to cheque the full recovery or supercompensation state even by means of blood and urine or by other means of analysis unless it is an extreme state, and in this case it is too late from proper training point of view, and is also impractical from daily training point of view. In this case, appropriate or proper way of dealing

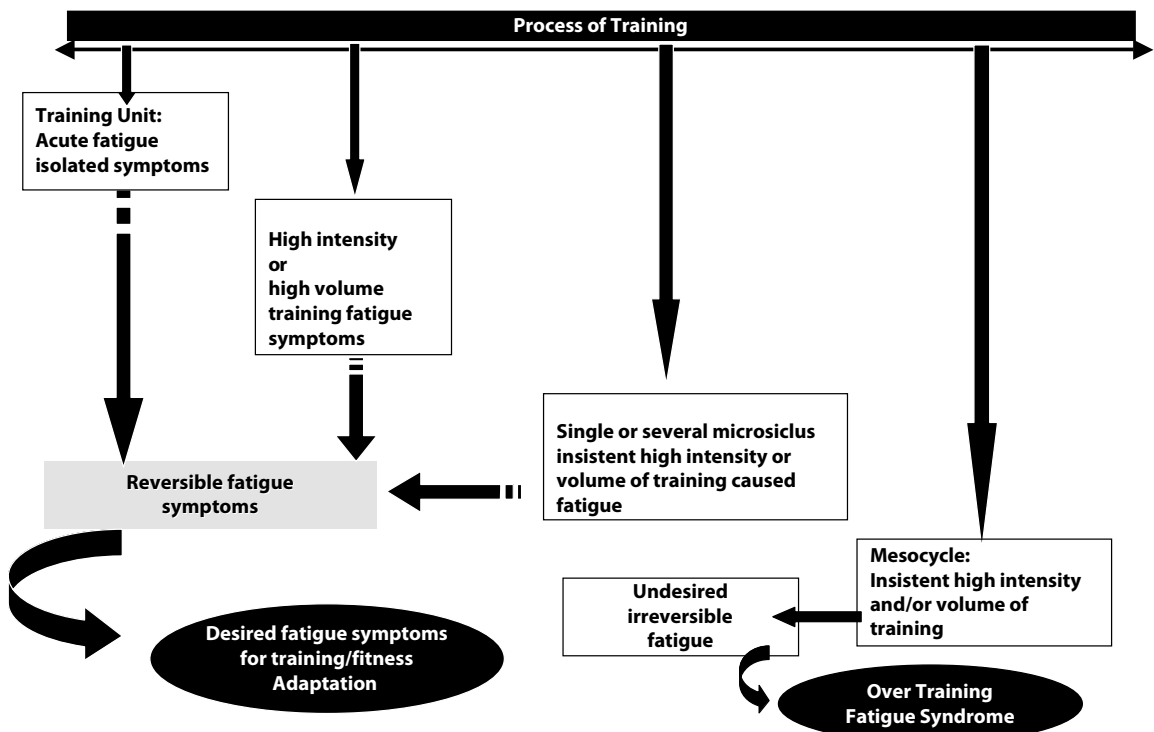


Figure 14. Different training periods, fatigue process, and training adaptation

with load-fatigue-recovery-training adaptation state is to pay serious attention to planning and periodization of training. To ensure proper progress in training load-fatigue-recovery-training adaptation state, some key points in periodization should be taken in to account (Fig. 15). An appropriate training construction accommodates proper and adequate recovery process in every training session, microcycle, mesocycle, and period according to training load and fatigue imposed on athlete's organism in order to biological adaptation processes to take place. Fig. 15, gives a brief overview of how to construct a training with microcycle, mesocycle, and macrocycle periods, where appropriate accommodation of recovery and regeneration periods are placed.

Alternative Loading Principle:

According to alternative loading principle, in each training the proceeding training units and/or the following training session should follow high/low, hard/easy or high and low intensity as well as change of loading character. In other words,

within the same training session, if there are several units of training, after the main training unit, the following unit should have different intensity and training character in order to speed up recovery and adaptation processes. This very same principle is also valid for the following training session taking place either on the same day as second or third training session, or the following day. It is therefore, very important that in each sport and in archery different training zones are properly recognized and training methods are classified for the appropriate zones since this identifies the intensity and the character of the training methods (Fig. 16) (16). In this case, a strength session, using some weights for general and specific strength work is from ATP-CP training zone (3,16). On the other hand doing an intensive session of shooting in preparation period, from a short distance with many shots as possible with limited or no rest between the shooting sessions, method of work can be regarded as anaerobic threshold, VO_2 max or lactate tolerance training zone according to length and intensity of work employed (16).

Periodization: Recovery process in constructing micro, meso, and macro cycles

- 1) **Alternative Loading Principle:**
Alternate and construct microcycles with easy/light sessions/days following hard sessions/days or vice versa
- 2) **Microcycle and Recovery Process:**
At least one full day per week should be assigned to passive recovery.
- 3) **Mesocycle and Recovery Process:**
-Allow for full recovery every 2 weeks (Minimum period of mesocycle).
-Every 4 – 6 weeks allow for a 1 – 3 regeneration days.
- 4) **Period and Recovery Process:**
Every 16 – 22 weeks there should be a more extended period of planned regeneration. Typically, 5 – 10 days ... some of which will be passive in nature.
- 5) **Intensity and Recovery Process:**
Intense training should be limited to 2 – 3 sessions per week or 7 – 10 day cycle.

Figure 15. Key points in constructing training program (periodization).

Intensity Zone	Training Methods	Repetition Period	Work and Recovery ratio	Lactate concentration (mM)	HR	Intensity (%Max)
5	Fosfagen System Training Methods	4-15 s	1:4 1:25	-----	Submax Max	95-100
4	Lactic Acid Tolerance Training methods	1. 30-60 s 2. 2-2.5 min	1:2 1:3	12-18 (20)	Submax Max	95-100
3	Max VO ₂ Training methods	3-5 min	2:1	6-12	180	85-90
2	Anaerobic Threshold Training Methods	1. 1.5-7 min 2. 8-60 dk	1:1 1:2	4-6	150-170	85-90
1	Aerobic Threshold Training Methods	10-120 min	1:1 1:0.2	2-3	130-150	60+

Figure 16. Different zones of training according to character, intensity and recovery.

Or, a competition intensity work out during competition period, with competition specific timing and number of shots can be regarded either VO₂ max or ATP-CP training zones depending on the length of the workouts and rest intervals between the sessions. Fig. 17 is showing a microcycle where each and proceeding training sessions are organized according to alternative principle of training loading. In this case, each and following training session is organized according to different intensity and training load character. It is argued that alternative way of training load allows the athlete to recover and supercompensate faster, and, therefore, enables to train more frequently at higher training intensities, and be able to train more in volume.

Progressive Loading Principle:

From the above explanations it should be noted that supercompensation increases the functional and performance capacity of the organism of the athlete. According to gathered information on different training lengths and supercompensation, there are different periods of training which can

influence the supercompensation occurrence. Microcycles and mesocycles are the basic components of periodization process where supercompensation effects are controlled more effectively (3). Mesocycle is, therefore, forms the basis for the main objectives of the training and this is coordinated in macrocycle periods. Microcycles, in the other hand, forms smaller units or periods within mesocycles, where desired training adaptations are coordinated. Therefore, although microcycle is the smallest periodic unit of training, macrocycle should be planned with mesocyclic units according to desired objectives (3). A mesocycle may last from minimum 2 to maximum 5-6 weeks, according to training and competition calendar.

When there is a training adaptation and rise in fitness level of an athlete, the following training week or mesocycle should provide relatively higher training load, for the elevated fitness level in order to provide new adaptation. Otherwise, similar training load for the new fitness level is not going to provide enough training stimulus for new adaptation (1,3). In this respect, mesocycles are formed from such microcycle units which

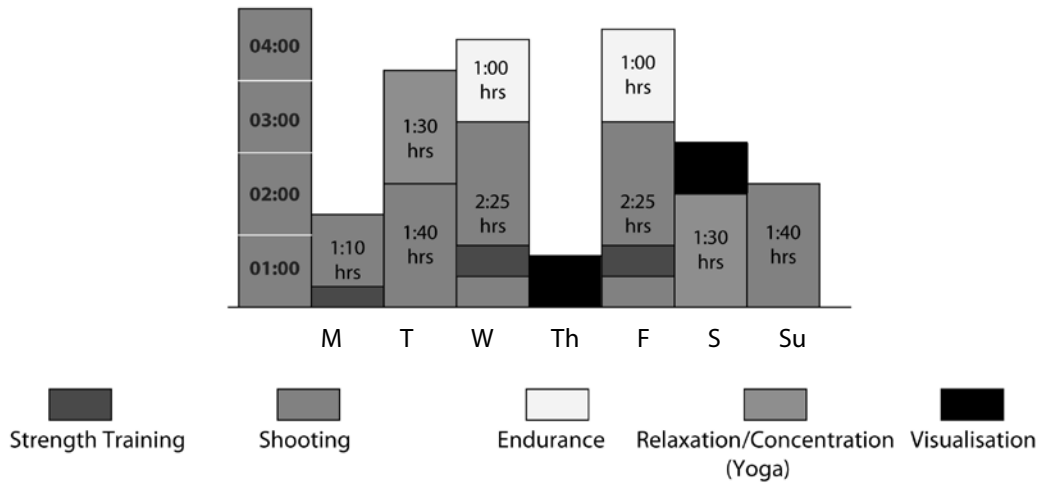


Figure 17. Formation of microcycle according to alternative loading principle

contain the desired trainings planned for that particular period. In return, these periods are formed in such length where they are dictated by competition frequencies and/or desired training periods. The length of mesocycle, therefore, can vary from 2 to 5-6 weeks in length (3). The coach, therefore, has to fit in appropriate length of mesocycle according to time of length available in the yearly or seasonal program (Fig. 18). According to progressive loading principle, in each and every following mesocycle, there should be an increase of load in proceeding weeks, followed by decrease of loading where supercompensation effect is expected at the end of each mesocycle. Progression of higher training load is desired to have adequate load on the working organism in order to have higher training adaptation. However, progression of loading at top level of training does not progress in a linear fashion, since there are some biological limitations on the amount of training can be performed at a given period, time, and an individual athlete (2,3,5,14,23). In the case of archery for example, the amount of shooting can not increase linearly in an unlimited fashion. There is an optimal limitation for a given training period, state of form, and for a given archer. Periodization of top level athletes, therefore, requires more individualization in training to alleviate this problem and elicit best progress,

both in physical fitness and shooting skills, as possible. It should be noted that beginner or novice athletes or archers progress in greater steps in performance capacity at the beginning of their training years. As the trainings improve, they have to train harder and greater as their fitness and performance capacities are higher. However, the improvement is smaller as they get better. As an outcome of this development, athletes train harder as they get better, but the improvement rate is smaller, and injury or overtraining risks are higher (Fig. 19). This state of improvement in top sport, therefore, necessitates the recovery and regeneration periods as explained above.

Periodization in Archery

Although archery yearly preparation and competition calendar fits in to Matveyev's (15) single or double periodization planning to start (Fig. 20), as the archer progresses and competition calendar becomes more demanding, there are considerable variation and deviation from the classic periodization. In top level archery, there are more number of top level competitions which demand high level of competition performance compare to past. High competition performance, therefore, demands more extensive preparation in top level archery. However, due to international

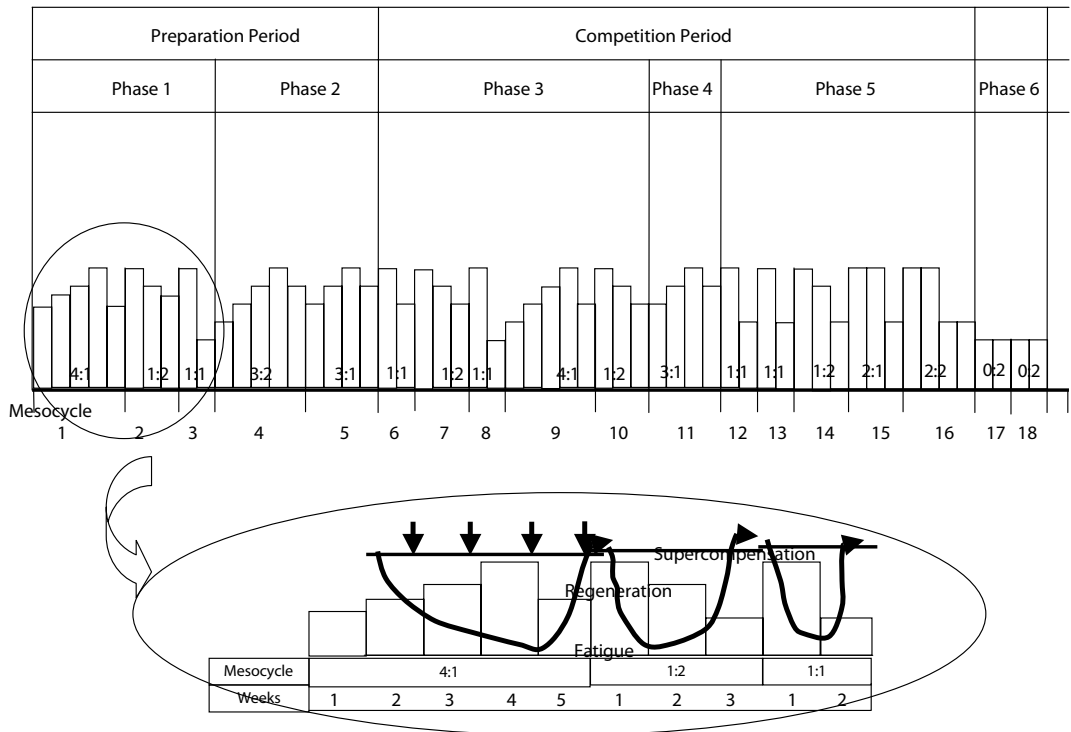


Figure 18. Formation of mesocycles in the seasonal program

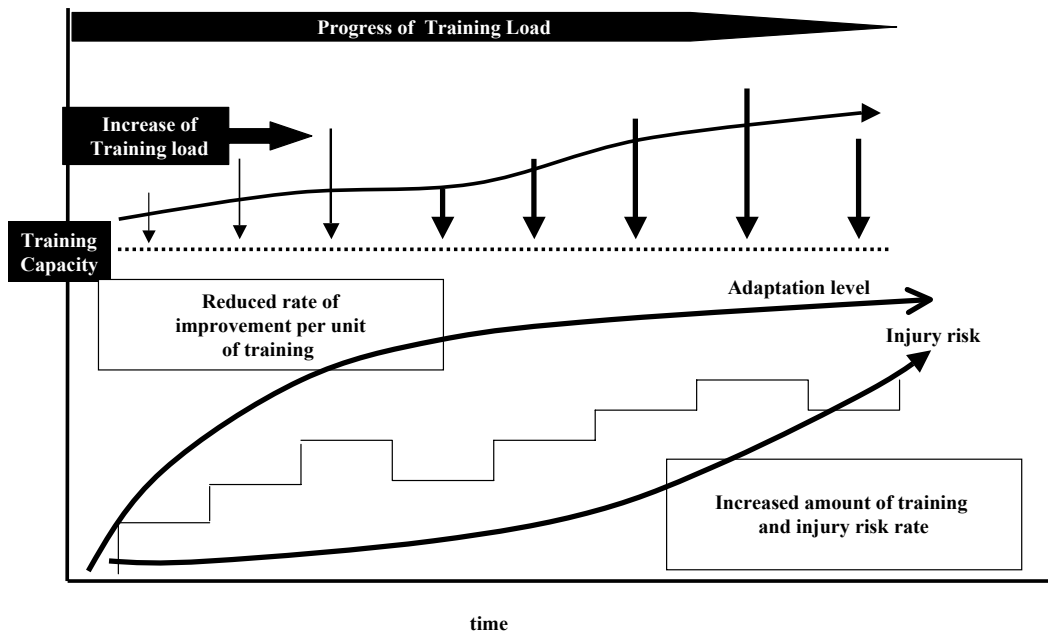


Figure 19. Training load and adaptation process

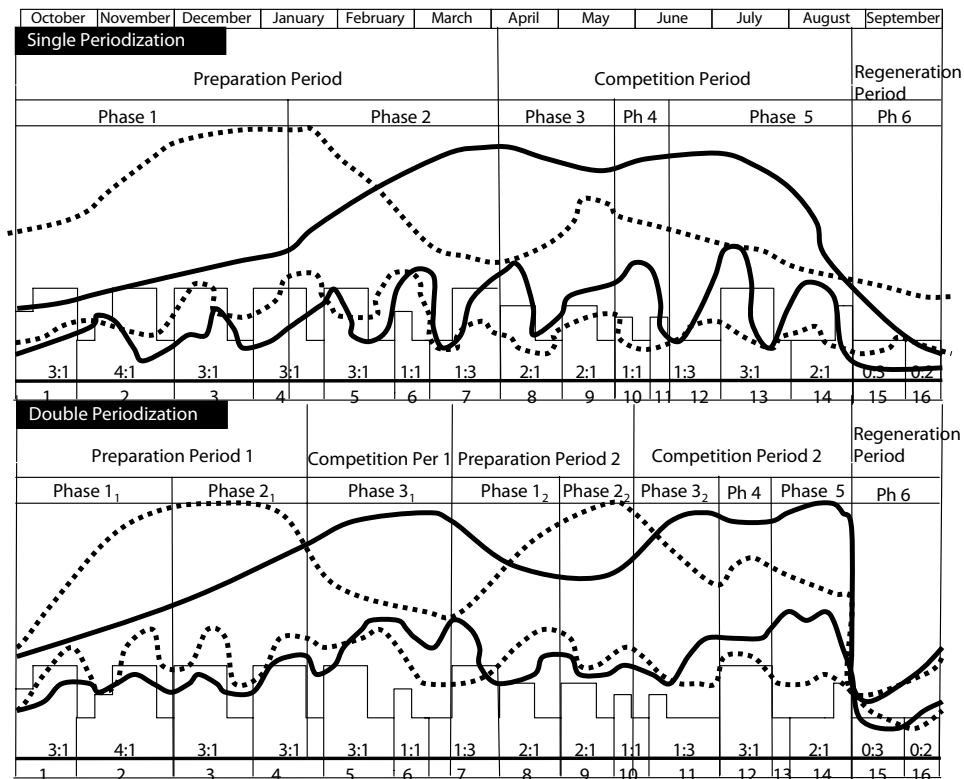


Figure 20. Organization and construction of training according to Matveyev's single and double periodization concept.

calendar, archers are forced to start compete earlier than Matveyev's (15) periodization concept, especially in indoor championships. Furthermore, outdoor competitions start immediately following indoor season, which does not leave much time for preparation between winter and summer seasons. As an outcome of this, the top archers are forced to compete starting from January till the end of season in August, and train for preparation only around 3 or 4 months (Fig. 21). This limitation in preparation creates some problems in some of the general preparation contents, which lead to some problems in competition period in terms of achieved level of competition form and duration. In classic periodization, the length of preparation period is usually longer than the competition period. It is suggested that the shortest possible length should be at least as long as the competition period (25) (Fig. 22). Shorter duration of preparation period compare to competition creates some problems in competition period. One of the problems of short preparation period

is lower level of competition form and difficulty in keeping the achieved level of form for long duration. It is, therefore, very apparent that there is a problem with a short preparation period, which is forced with the existing national and international competition calendar throughout the training year. To overcome the problem of under preparation some special blocks of trainings have to be inserted to the appropriate places in competition period in order to improve training capacity, adaptation ability to high level of training by improving on volume of training. Since the first application of classic periodization concept of Matveyev, in 1960's and 1970's, there have been several variation and different application of volume, intensity and technique of work amount, especially during the competition period, in order to overcome of the problems of limited development of basic fitness components and low level of training and competition ability in top level sports. Depending on the individual athlete the volume, intensity and amount of

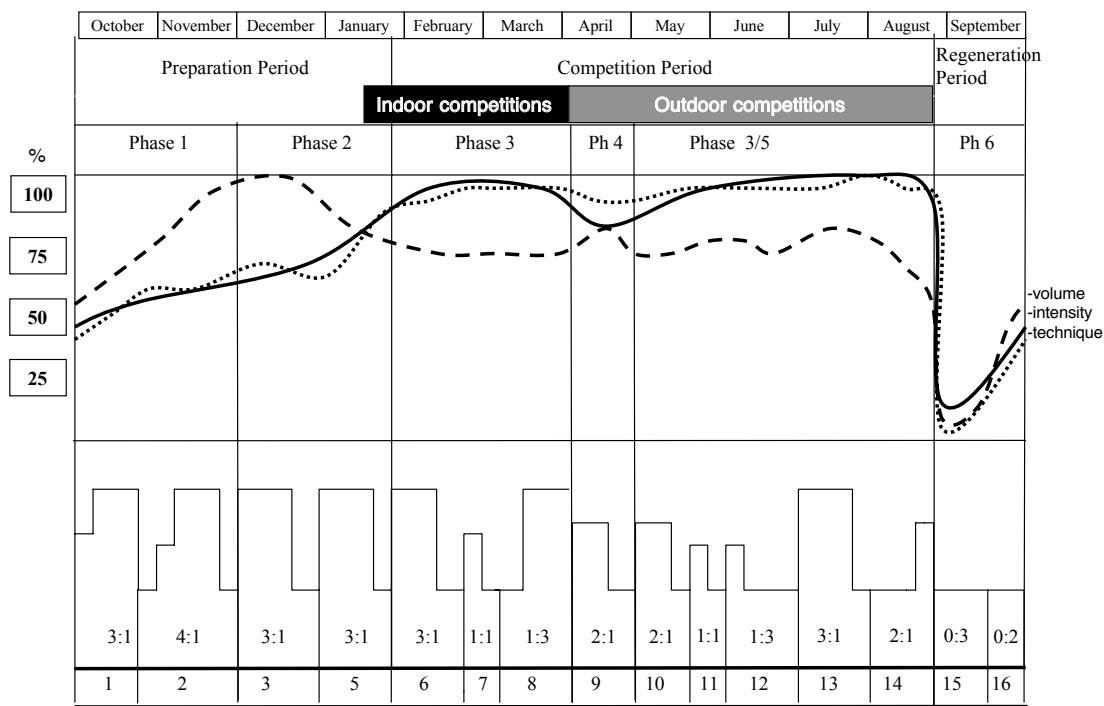


Figure 21. Classic Matveyev's macrocycle periodization concept where volume and intensity are inversely related and macrocycle adapted to archery preparation and competition periods.

Macrocycle		Period					
		Preparation	Competition		Recovery		
Months	Weeks		Comp 1	Comp 2	Weeks	% Preparation / Competition	
12	52	32	9	6	5	70	30
8	35	20	5	6	4	65	35
6	26	13	5	5	3	55	45
4	18	8	3	5	2	50	50

Figure 22. Ratio of preparation and competition periods with available duration for a training year or macrocycle.

technique work have been increased or decreased all together forming an oscillation by which the athlete is able to train in high amounts of loading, in order to overcome over under preparation, followed by a recovery and supercompensation periods with an assumed high level of competition form (Fig. 23). In some periodization variation in order to form some basic training capacity,

the volume of training is kept at certain level in order to achieve continuous training capacity and adaptation ability for training throughout the competition period (Fig. 24). In this case intensity and amount of technique work in training load are increased or decreased according to competition and training calendar in order to have peaking

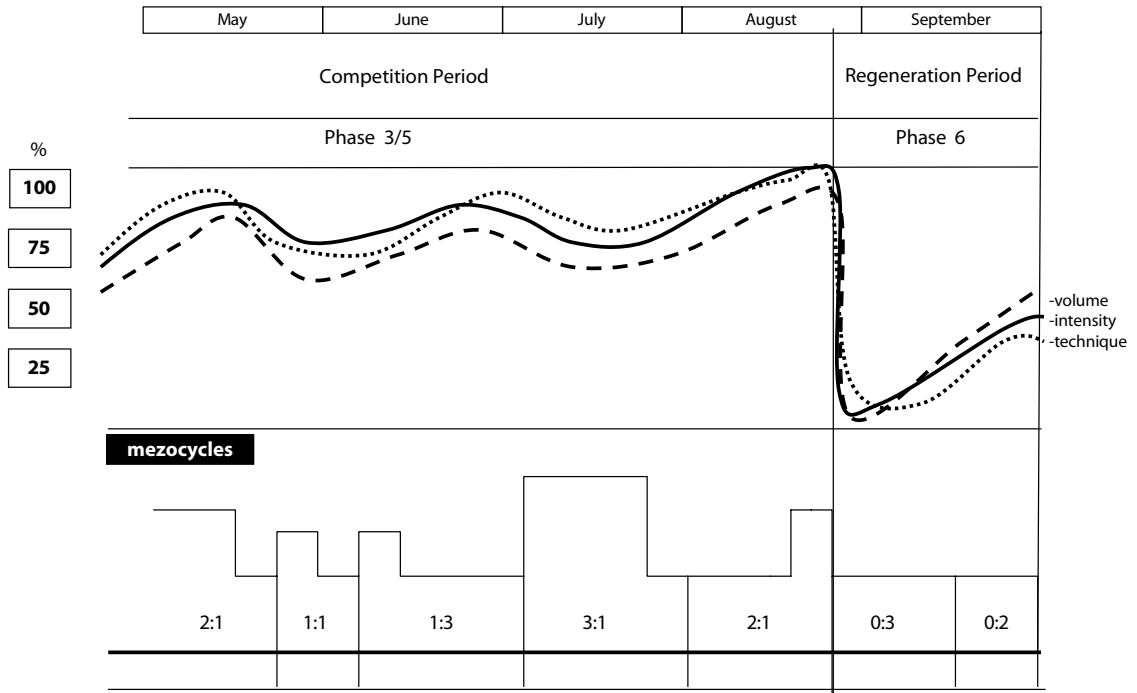


Figure 23. Periodization model with an oscillating volume, intensity and technique work allowing for a high level of training load with recovery periods.

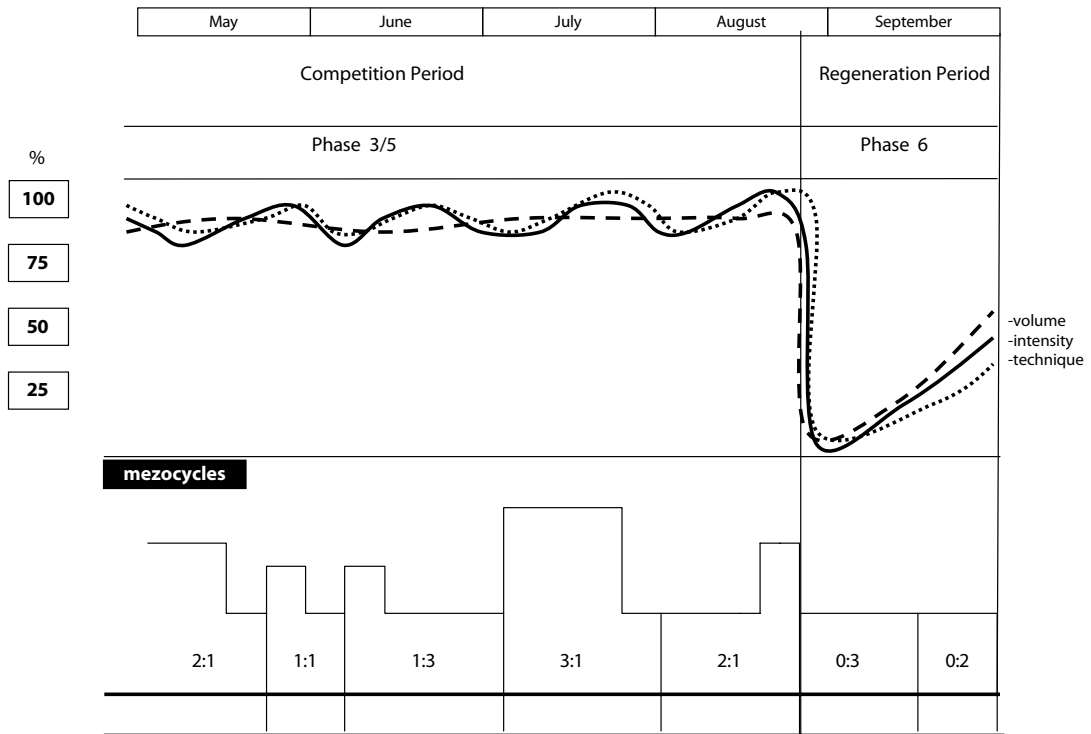


Figure 24. Periodization model with a constant volume with a changing intensity and amount of technique work.

for a competition or to extent the competition form if necessary. In some cases, contrary to constant volume, intensity and technique work of the training loading are kept constant and oscillation formed in volume of training according to competition and training calendar (Fig. 25). However, there are many variations in the application of model of periodization. At this point it should be noted that the variation is very much influenced by individual interpretation and the needs of the athlete or the archer. Observations show that there are even some athletes who do not follow a strict planning of training, and the training is changed or organized according to daily feelings, especially with very experienced top athletes.

The above statement and explanations show that, at very top athletic training the improvement in performance capacity becomes very much individualized. The training planning, therefore, has to accommodate the basic elements of performance capacity in order to maintain what has achieved, and, also, has to cater the individual needs of the athlete or the archer. This chapter, has attempted to show some of the determining factors of training planning and periodization, at least, if not provide thorough answers for the issue and problems of periodization, try to give some broad answers to the logic of training, training adaptation, and periodization.

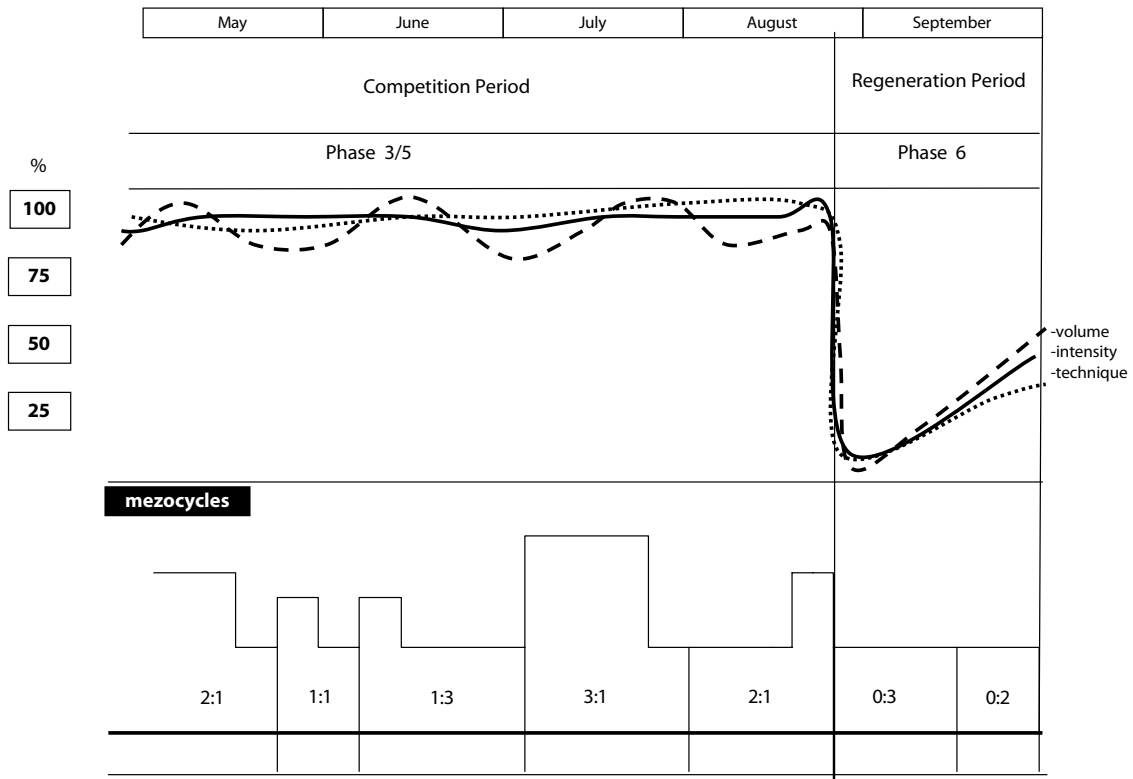


Figure 25. Periodization model with a constant volume with a changing intensity and amount of technique work.

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Muscular Activation Strategies in Archery

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1. Introduction

Archery is described as a static sport requiring the strength and endurance of upper body. Shooting an arrow includes some specific movement patterns. These patterns occur in the same sequence all the time. Archer inserts the arrow into the bow, holds the bowstring and the grip, starts drawing, reaches a full draw position, aims to the target, releases the bowstring, and performs a follow-through phase. The important thing is that movements of the bow arm and the drawing arm should be performed simultaneously and the strength of the both arms should be equal to each other [1].

The bowstring is released when an audible stimulus is received from a device called “clicker” that is used as a draw length check [2]. Each arrow can be drawn to an exact distance and a standard release can be obtained using this device (Figure 1). The clicker is reputed to improve the archer’s score and is used by all target archers. The archer should react to the clicker as quickly as possible, and synchronise the muscle activity of the whole body to attain eventual optimal accuracy. In particular, there should be a repeated contraction and relaxation in the back, shoulder, arm, forearm, and pull finger muscles during archery training and competitions according to the high number of arrows. That is why the movements in archery are suitable for studying the motor control and skill acquiring processes. So, the purpose of this review is to make summary of the findings of the previous studies related with the muscular activation patterns in different muscular groups having specific participation in the whole shooting movement.

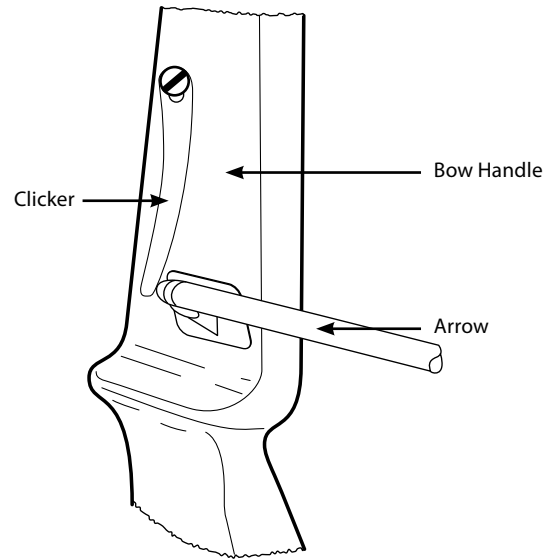


Figure 1. Clicker; a spring-loaded lever that produces an audible impetus to the archer that the arrow has been drawn to a fixed distance

2. Classification of Muscular Activation Analysis

The archer should coordinate the whole muscles involved in archery shooting movement in a short time span. As it is mentioned before, the clicker is used in target archery. The archer should release the bowstring as soon as possible after receiving the stimulus from the fall of the clicker to reach an optimal accuracy. There are some studies analysing the archery shooting movement by evaluating the activation patterns of muscles involved in the shooting movement before and after the fall of the clicker. All of the articles were made use of Electromyography (EMG) in conducting these researches. The division of the muscles is made according to their placement in upper body and involvement of the muscles in the whole archery action. The muscle groups and their activation strategies are classified as follow: (1) the back muscles, (2) the shoulder girdle muscles, (3) the arm muscles, and (4) forearm and pull finger muscles.

2.1. The back muscles

Nishizono et al. (1984) conducted a study for making the analysis of the activation levels of

muscle groups involved in archery shooting. They involved five archers in their study. Two of them were beginners, one of them was middle-class, and two of them were world-class archers. The results of the analysis of back muscles showed that the world-class archers showed strong activities of *M. deltoideus*. The muscular contraction level was higher in back muscles than that of the arm muscles in world-class archers compared with middle class and beginner archers. Besides, the world-class archers displayed almost same activity levels in back muscles in both sides. However, the beginner and middle-class archers showed an unbalanced activity in the same muscle groups [3].

The comparison was also made between the world-class archers and middle and/or beginner archers in the release and follow through phases. The disappearance of action potential (silent period) in the *M. deltoideus* was observed in world class archers compared with the other subject groups. In the follow through stage, almost the same level of activities in the back muscles was maintained during 1.5 – 1.7 sec after release in world-class archers [3].

An archer pushes the bow with an extended arm, which is statically held in the direction of the target, while the other arm exerts a dynamic pulling of the bowstring from the beginning of the arming phase, until the release is dynamically executed [2]. The release phase must be well balanced and highly reproducible to achieve commendable results in an archery competition [3]. So, the balance between the contraction levels of the back muscles in both sides can be used as an indicator of performance level. If one wants to achieve commendable results in archery, he/she needs to draw the bowstring with a drawing arm force that is equal to the force of the bow arm back muscles. So, the release of the bowstring by the drawing arm would not disturb the statical position of the extended bow arm.

2.2. The Shoulder Girdle Muscles

The agonist (*M. deltoideus*) and antagonist (*M. pectoralis major*) muscles were analysed in world-class archers. The results of this analysis showed that *M. deltoideus* actively involved in the

movement of drawing the bowstring. However, it displayed an unexpected silencing just before the release movement. After the silent period, the tension about 18 kg dispersed at the moment of release, after which the tonic discharge reappeared. At this silent period in the activation of *M. deltoideus*, the *M. pectoralis major* showed only a little deflection from the baseline (Figure 2). The *M. extensor digitorum*, which seemed to be one of the main muscles engaged in the release movement, began to contract while the *M. deltoideus* was silent (n). This finding was considered to be not a reciprocal inhibition of the agonist and antagonist muscles. It seemed that the silent period in the *M. deltoideus* played a major role in allowing the *M. extensor digitorum* to react effectively to the clicker signal. This coordination between *M. deltoideus* and *M. extensor digitorum* was considered to be closely related with performance level [3].

Prior to the release the posterior fibres of the *M. deltoideus* of the drawing arm act to hold the shoulder in position against the force of the bowstring. This force is removed when the string is released coinciding with a reduction in activity level at release. This change help protect the joint structures of the shoulder, including the capsule of the glenohumeral joint, from repetitive sudden horizontal extension of the shoulder. This is different than that of the activation of muscles in the shoulder girdle in throwing and pitching where the joint is protected at follow through by increased activity of the posterior muscles of the shoulder [4].

2.3. The Arm Muscles

The analysis was also made in elbow flexor and extensor muscles by involving world-class archers. The activation strategies of *M. biceps brachii* and *M. triceps brachii* in the bow arm were evaluated by placing surface electrodes on both muscles. The findings of the studies showed that activity of *M. biceps brachii* increased from beginning to the end of the shooting movement. On the other hand, the activity level of *M. triceps brachii* decreased 60 ms before the click signal (Figure 3). By the sound of the clicker, the activation level of *M. triceps brachii* returned to almost same level with the preceding the 60 ms before the clicker signal [4].

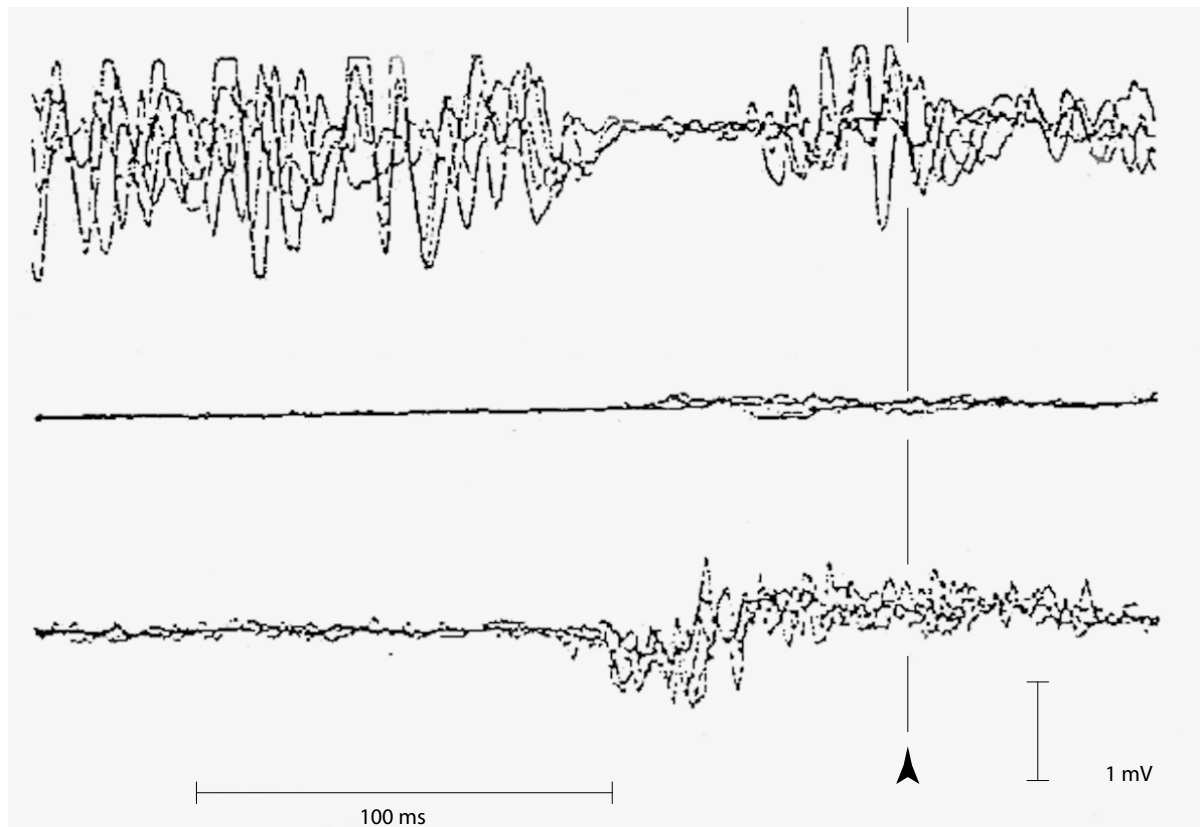


Figure 2. The five traces of EMGs in *M. deltoideus* (upper trace), *M. pectoralis major* (middle trace) and extensor digitorum (lower trace) are superimposed, triggered by the appearance of the releasing signal (The figure is adapted from Nishizono et al., 1984).

The reduction of the activation level of *M. triceps brachii* (like in *M. deltoideus*) in the midst of sustained contraction is considered as EMG silent period. This period is considered to be a transitory decrease of EMG activity in the sustained contraction elicited from passive muscle stretch, unloading of a muscle or provoked from peripheral nerve stimulation. It has also been described as an EMG phenomenon that may precede a phasic burst of activity in a muscle undergoing isometric contraction [4].

2.4. The Forearm and Pull Finger Muscles

The contraction and relaxation strategy in forearm muscles during the release of the bowstring is critical for accurate and reproducible scoring in archery. Ertan et al. (2003) [5] made a study evaluating the activation patterns in forearm muscles during archery shooting. They involved

elite ($n = 10$), beginner ($n = 10$) archers, and non-archers ($n = 10$). EMG of *M. flexor digitorum superficialis* (MFDS) and *M. extensor digitorum* (MED) were quantified. The results are shown in figure 4, 5, and 6 for elite and beginner archers and non-archer respectively.

Before the fall of the clicker, normalised MED activity in non-archers was higher than in the elite and beginner archers, but this difference was not significant. The normalised activity MED and MFDS of the elite and beginner archers were almost constant and showed similar patterns. Non-archers' MED activity was significantly higher than MEDS during all time intervals before the fall of the clicker.

All subjects showed a gradual relaxation of the MFDS after the fall of the clicker. This relaxation was more rapid in elite archers than in beginner

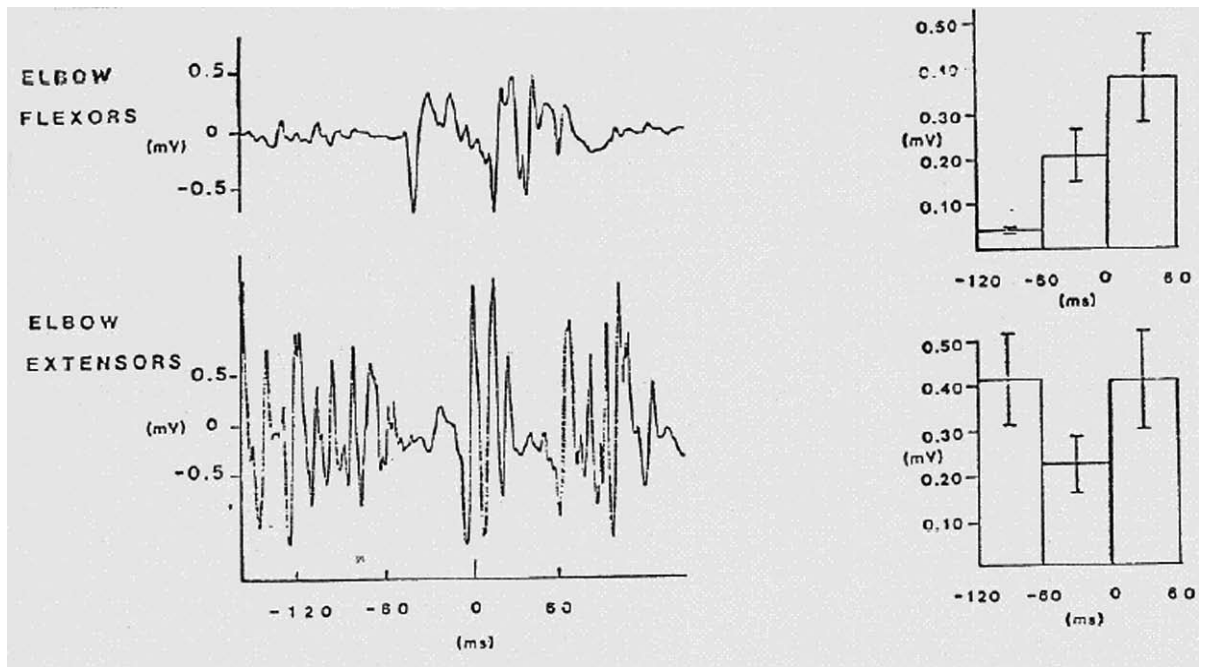


Figure 3. The direct and integrated EMGs from the M. biceps brachii and the M. triceps brachii of the drawing arm (The figure is adapted from Hennesy and Parker, 1990).

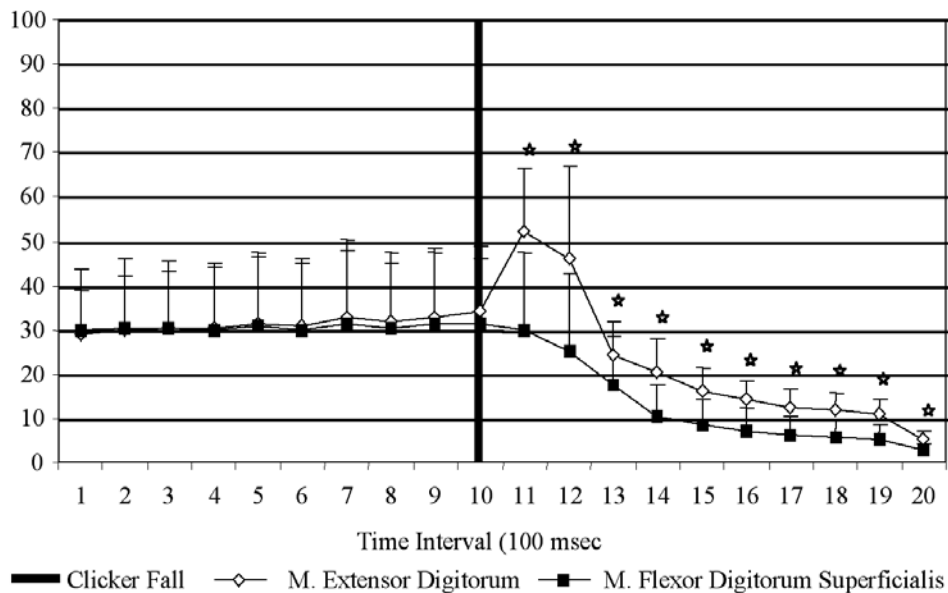


Figure 4. IEMG results of 5 female and 5 male totally 10 elite archers (*the difference is significant at 0.05 significance level between MED and MFDS) (The figure is adapted from Ertan et al., 2003).

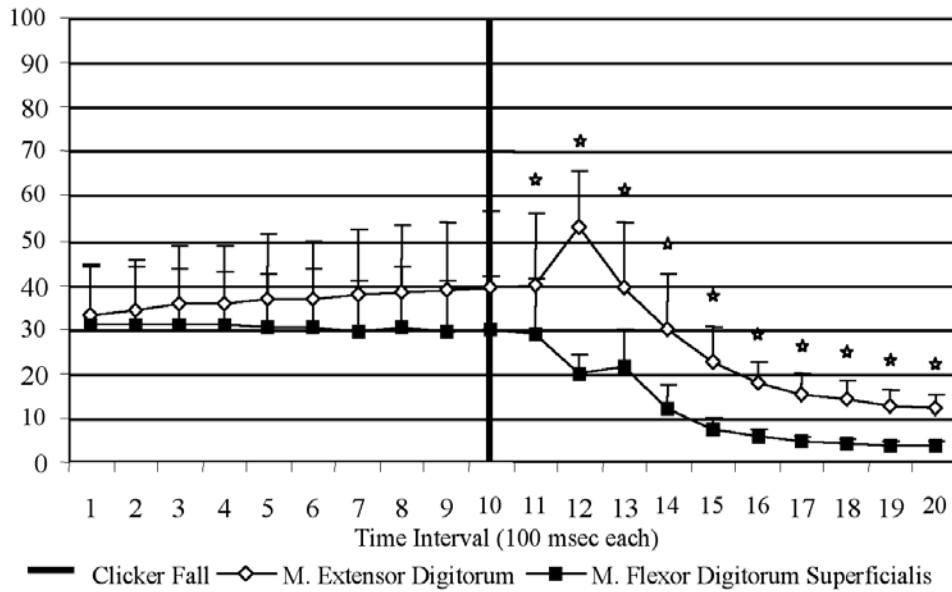


Figure 5. IEMG results of beginner archers (*the difference is significant at 0.05 significance level between MED and MFDS) (The figure is adapted from Ertan et al., 2003).

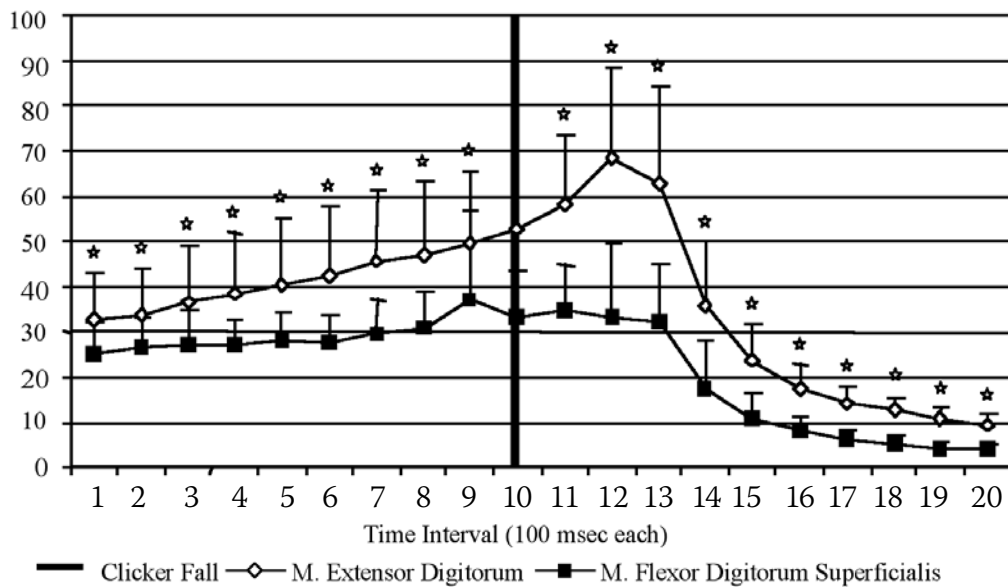


Figure 6. IEMG results of non-archers (*the difference is significant at 0.05 significance level between MED and MFDS) (The figure is adapted from Ertan et al., 2003).

and non-archers. Normalised activity of the MFDS between elite and beginners ($p = 0.017$), between beginners and non-archers ($p = 0.025$) differed significantly 200 ms after the fall of the clicker. MED and MFDS activity of all subjects were significantly different during all time intervals after the fall of the clicker.

It was established that archers develop a specific forearm flexor and extensor muscular strategy to accurately shoot an arrow to a given target after the fall of the clicker. Active contraction of the MED and gradual relaxation of the MFDS is an integral part of this strategy. Elite archers presented a faster reaction time to the fall of the clicker than that of beginners and non-archers [6].

3. Conclusion

Ertan et al. (2005) created some skill indexes for forearm muscles to analyze the correlation between FITA scores and the mentioned skill indexes. They have found negative significant correlation between FITA scores and log of skill indexes showing that increase in archery experience causes a decrease in area under the processed EMG data. The amplitudes have been found to be lower in highly experienced archers [6]. Besides, Nishizono et al. (1987) have proved that world-class archers stronger activities of M. deltoideus than that of national level or middle-class archers. Moreover, the muscular contraction level was higher in back muscles than that of the arm muscles in world-class archers compared with middle class and beginner archers. The current literature review reaches a common conclusion that high level archers use their back and shoulder girdle muscles more than arm and forearm muscles in drawing the string. That strategy may have two advantages; (1) reaching to exhaustion may be delayed because of using stronger muscle groups [7] and (2) having lower contraction levels of forearm muscles may not cause lateral deflection of the bowstring [8]. The both advantages of the mentioned strategy help increasing the scores on the target.

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Mathematical Models in Archery

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1. Introduction

A bow is braced by fastening a string between both ends of elastic limbs. After an arrow is set on the string the archer pulls the bow from braced situation into full draw while the bow is held in place. In this way potential energy is stored in the elastic parts (limbs and string) of the bow. After aiming, the arrow is released. Then the acceleration force in the string propels the arrow. In this way part of the potential energy is transferred as kinetic energy to the arrow. When the acceleration force becomes zero the arrow leaves the string. Finally the bow returns to the braced position because of damping.

A number of disciplines are involved in modeling and the design of the bow: Physics-Mechanics (modeling), Mathematics (solving the resulting mathematical equations including optimization algorithms) and Material Sciences (interdisciplinary field involving the properties of matter and its applications). A model should predict the arrow velocity, with which it leaves the bow, sufficiently accurate. In a later stage the model can be used for sensitive analyses during an optimization process to improve the design or tune the bow-arrow combination.

Experimental research is an essential part of the design process to improve the performance of archery equipment. Often the classical 'trial and error' approach (1) is followed where good ideas are evaluated step by step, regularly iteratively, by production and experiments. An alternative is to use mathematical models in the design and optimization process. The models are based

on physical laws and constitutive relationships. An example of the former category is Newton's second law and of the latter the force in the string and the resulting elongation of the string. The final model consists of state variables which described the state of the system for instance the position of the tip of the limb, arrow and so on, and parameters, such as material properties of the bow limbs and arrow. The deflection of a limb of the bow caused by loading by the drawing force depends on the stiffness of the material from which the limbs are made. Experiments with standard sample pieces provide the parameter that describes the relationship between loading and deflection: the so called Young elasticity modulus. The bending property of the arrow is measured using the standard three-point bending test. To measure the spine of an arrow a bob is hung in the center of the arrow supported at two points separated a distance (the span) of one inch less than the arrow length. The deflection measured is a measure for the spine of the arrow. Another simple example of a parameter is the specific mass of the used material for limbs, string and arrow, obtained by weighting and measuring the volume.

In Section 2 experimental results obtained by filming the bow and arrow motions during release are given. These observations are the source for motivations of certain simplifying assumption made during the modeling process. Various models for the prediction of the performance of bow and arrow combinations are reviewed in Sections 3 and 4. We distinguish models for bows where the arrow is a lumped mass, for arrows treated as a slender beams and their interaction. This allows for the study of the archer's paradox.

2. Experimental results

Mullaney (2) describes the principles of bow testing including the equipment he used to measure force-draw curves and the velocity of the arrow. The various factors that affect the performance of the equipment reported in the Bow Reports for *Bowhunting World magazine*, are mentioned and the terminology is explained. Important factors reported are: brace height, draw length, bow weight (holding force), draw-force

curve, stored energy, ratio of the stored energy to peak force, virtual mass, arrow velocity, bow mass and bow efficiency. Mullaney uses a shooting machine with a pawl-release that simulates finger shooting and the arrow velocity was measured with two chronographs set in tandem (the second one is used as a checking instrument). Similar equipment for measuring the Force-Draw curve was used by Tuijn and Kooi (3) and Olsson (4). However, in (3,4) the arrow velocity is measured accurately by means of the induction voltages, evoked by shooting arrows with a magnetized point through two coils at a fixed distance. Nowadays equipment is available from (5), namely the *bow force mapper* which measures the force-draw curve and the *arrow chronograph* to measure the velocity of the arrow.

In this section some experimental results are presented dealing with the motion during the launch of parts of the equipment. Firstly, the motion of the limbs and string of a modern working-recurve bow are shown. The bow is clamped horizontally so that the arrow glides on the arrow rest by its weight. Thereafter the vibratory motion of the arrow during the launch of the arrow measured by Pękalski (6,7) is given.

Bow limbs and rigid arrow

Fig. 1A,B,C show the static deformation of the working-recurve bow a Greenhorn Comet TD 350, 68" 30# the unbraced bow, braced bow and fully drawn bow. The dynamics after arrow release is shown in Fig. 1D.

In the dark room the shutter of the camera was open. A small stiff flag fixed to the string 5 cm above the nocking point was in the fully drawn position within a light beam. The arrow was released using a mechanical release device fixed to the table. When the button of this device is pressed the string starts to move forward propelling the arrow. As a result the flag on the string leaves the light beam and triggers the stroboscope that produces flashes each 1.85 ms after a small set delay. Spots on the side of the limbs are marked by attached reflecting material. In this way the positions of the limbs and arrow becomes visible. Since we depict the

negative image these spots become the small black dots. The limbs and arrow move forward with increasing speed until arrow exit. The position of the middle of the string for the last two positions at 13.95 and 15.8 ms after release are almost equal but the shapes of the limbs differ because the limbs are still moving forwards. During this last interval the arrow leaves the string. The position of the vanes of the arrow at the last instant is partly behind the riser. Due to damping the limbs and string return towards the braced situation and the bow is ready for the next shot.

From these pictures a number of observations are made which are important for mathematical modeling. Firstly, there is almost symmetry with respect to the horizontal line, the line of aim of the arrow. Secondly, in the braced situation the string has contact with the limbs over intervals adjacent to the tips. The intervals diminish when the string is drawn and for the final part of the draw there is only contact between the string and the limbs at the tips. After release this happens in the reversed order. Similar conclusions can be drawn from high-speed video and films Videodiscovery (8) and Beiter (9).

Flexible arrow

In Fig. 2 we show experimentally measured transverse displacements of the arrow during the release of the arrow till its nock passes the grip. These deflection curves are measured by Pękalski (6,7) and taken from the film made with the camera viewing the archer from above. The bow used by Pękalski (6,7) was a Hoyt Pro Medalist T/D, 66 inch, 34 lbs bow and an Easton 1714X7 arrow. Observe that the arrow has only contact with the arrow rest for a limited period and that the deflection of the arrow is initiated by a side way movement of the middle of the string, and therefore the rear-end of the arrow. A left-hand shooter is assumed.

These results measured by Pękalski show that the arrow and the bow have to match in order to avoid that the rear-end of the arrow strikes the grip by snaking around the grip. This phenomenon referred to as the archer's paradox was already known for a long time (see (10)). Initially it was

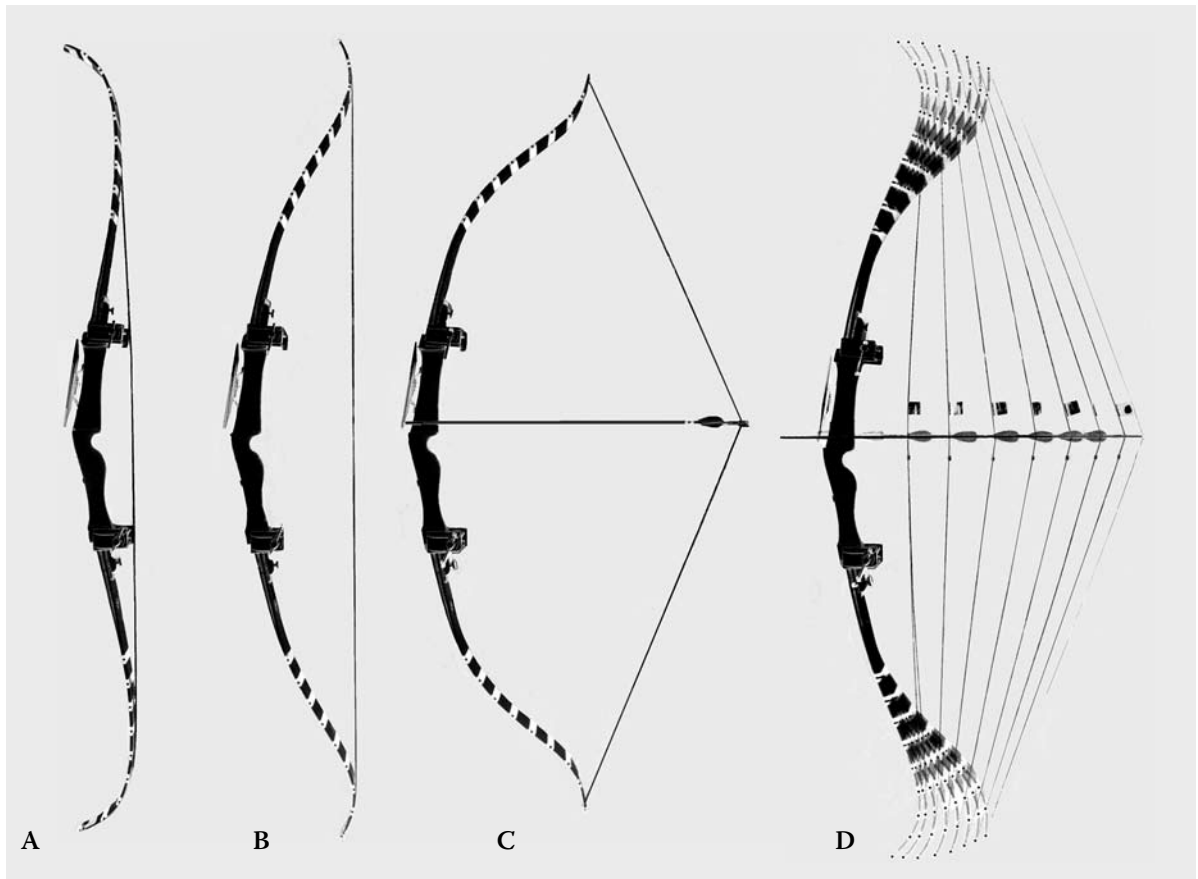


Figure 1. Shape of the static unbraced (A), braced (B) and fully drawn (C) bow and dynamic motion of the bow at various instants after arrow release (D). The bow is fixed horizontally in a mechanical shooting device. Stroboscopic picture of the shape of the working-recurve Greenhorn Comet TD 350, 68" 30# bow is shown at 8 instants at 2.85, 4.7, 6.55, 8.4, 10.25, 12.1, 13.95 and 15.8 ms after release. The vague initial position is the fully drawn position shown in (C).

related to the thickness of the grip where the arrow passes the bow sliding over the arrow rest. Nowadays all bows possess a window allowing for a center shot. It appears that the archer's paradox is still relevant because an initial bending of the arrow occurs due to the release of the string over the finger tips which cause a side-way movement of the nock of the arrow while the arrow has contact near the head with the arrow rest (see also Axford (11)). Due to the flexibility of the arrow this causes a bending, and then oscillatory motion of the propelled arrow.

These experimental results show clearly that when the dynamics of the arrow is concerned, the motion of the nock during release and the support of the arrow at the arrow rest on the grip

are important. From high-speed video and films Rabska and van Otteren (12) and Beiter (9) the same conclusions can be drawn.

3. Mathematical description of the bow and arrow

In the 1930's bows and arrows became objects of study by scientists and engineers, for example by Hickman, Klopsteg and Nagler (13) and Klopsteg (14) and later Liston (15). In previous papers, Kooi and Sparenberg (16), Kooi, (1,17,18) we dealt with the mechanics of the different types of bow. For a detailed discussion of the mathematical model and the used numerical techniques, the reader is referred to these papers. In (19) the design of the

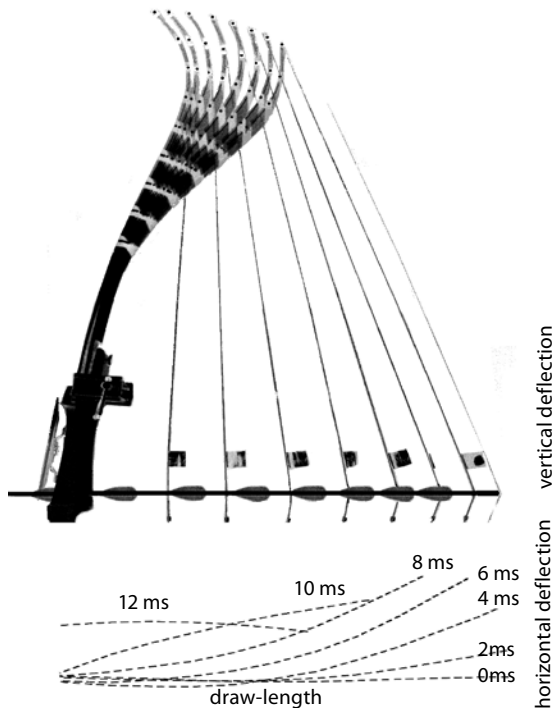


Figure 2. Deformation of arrow for every 2 ms after release. High-speed film experimental data after Pękalski (6,7) till 12 ms. Pękalski used the Hoyt Pro Medalist T/D, 66 inch, 34 lbs bow and the Easton 1714X7 (Aluminum 7178) arrow. Arrow is shot by a left-handed shooter. The depicted bow is the Greenhorn Comet TD 350, 68" 30# also shown in Fig. 1D.

bow was dealt with from a historical point of view where we followed the change of the shape and materials used in history.

The bow

From the shapes shown in Fig. 1 we learn that the upper and lower limbs of the bow act almost symmetrically. During the reported experiments the bow was held horizontally while the bow is always used vertically. We can assume that the effects of gravitational forces are negligible, see Zanevskyy (20), for the arrow acceleration after release is more than one hundred times greater than gravitational acceleration. Therefore in all models only the upper part is considered, taking into account that there is a symmetric lower part. Furthermore the string is moving forward almost

in a straight line. Therefore with the modeling of the motion of the limbs and string, the mass of the string is lumped into one point placed at the middle of the string and two points at the tip of the upper and lower limb.

The model contains many parameters that describe the dimensions of the bow. For instance: length of the limbs, shape of the unbraced limbs, brace height, draw length, mass of the string, elastic properties of the string, and mass of the arrow. Furthermore the physical properties are important such as specific mass and mechanical properties such as the elasticity coefficient and strength. In this paper we focus on the performance of a working-recurve bow that can be seen at target archery events such as the Olympic Games.

In order to assess the performance of a bow and arrow combination the following quantities are important: the amount of energy stored in the fully drawn bow, the efficiency, that is the kinetic energy transferred to the arrow divided by the recoverable energy stored in the drawn bow and the arrow velocity.

In (16) we discussed the importance of the string for a good shooting efficiency. We showed that a shooting efficiency of 100% could be obtained if the model of the bow is unrealistic simple. Consider a bow of which the elastic limbs and the string are without mass. Then it is clear that all the deformation energy is transformed into the kinetic energy of the arrow at arrow exit. The assumption of zero-mass string and limbs is not in correspondence with reality. Therefore we now discuss a more realistic model.

The bow consists of a rigid grip and two rigid limbs (Fig. 3.a) that are connected each to the grip by means of a hinge (**S** for the upper limb) with a torsion spring. The string is still assumed to be inextensible and without mass. The assertion is that this bow (Fig. 3.a) converts all the deformation energy of the torsion spring into kinetic energy of the arrow. In (16) it is shown that during the stretching of the bow (Fig. 3.a) the arrow keeps its contact with the string that, along straight lines, connects the arrow end to the tips of the limbs.

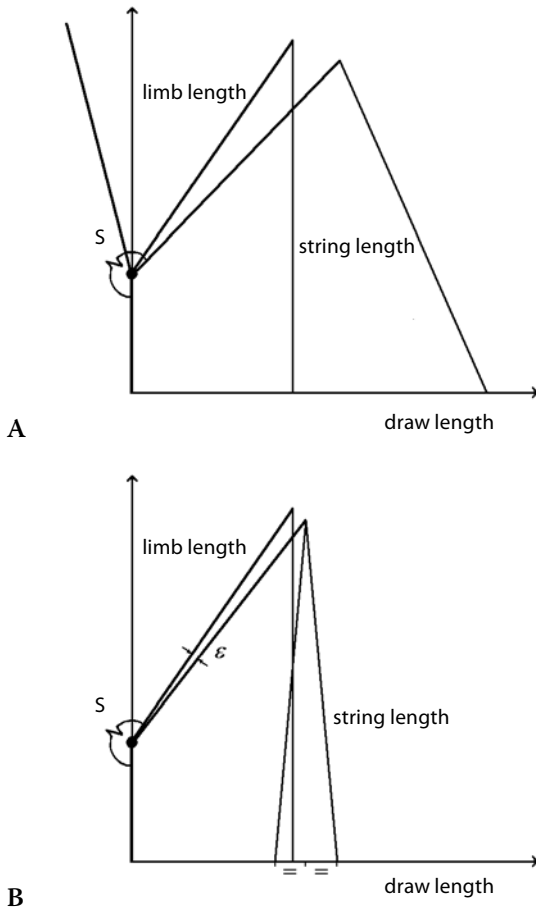


Figure 3. Bows with two elastic hinges, rigid limbs and massless and inextensible strings. A: the mechanism in the three situations, unbraced, braced and fully drawn. B: the situation just before and after arrow exit where the string is in the vertical position.

In Fig. 3b the position of the string is shown just before and after the vertical position. In both situations the angle of rotation of the hinge is the same. When we assume that the velocity of the arrow is constant, then the angular velocity in both situations is opposite and this holds for arbitrarily small angle ϵ . We conclude that the angular velocity is zero when the string is in the vertical position, and therefore also the kinetic energy of the limbs in that position is zero. In addition the angle of the hinge is the same as in the braced situation and consequently also the potential energy stored in the hinge in the braced situation and where the string is in the vertical

position are the same. The conservation of energy (no damping is assumed) gives that the potential energy stored in the hinge by drawing the bow from braced into the fully drawn position equals the kinetic energy of the arrow when the string is in the vertical position. In reality the arrow leaves the string in this position because the acceleration force is zero. Theoretically this means that by the action of the inextensible string without mass, all kinetic energy of the rigid limbs is transferred into the arrow, how large the stiffness of the limbs and how small the mass of the arrow may be. This shows clearly why the bow-arrow system can be efficient equipment.

In order to be able to store the available energy to propel an arrow, limbs have to be relatively heavy due to strength constraints on the used material. The limbs that store the energy are connected to the arrow by a string. Since the part of the string connected to the arrow possesses the same speed as the arrow at exit, the string has to be light. At that moment the heavy limbs have to move slowly. These two requirements are met perfectly for the simple construction described above.

We recall that this model is too simple to yield realistic predictions. This is mainly due to three effects. Firstly, limbs are working over a large part of their length, secondly the string possesses mass and thirdly it is extensible. As a result, at arrow exit the limbs and string still move and possess kinetic energy which is not delivered to the arrow and therefore reduces the efficiency.

The mass of the string can be taken into account by the following reduction factor proposed by Hickman (13)

$$\frac{\text{mass of arrow}}{\text{mass of arrow} + \frac{1}{3}\text{mass of string}}$$

The extra term in the denominator stands for the kinetic energy of the string of which one-third of its mass is attached to the moving arrow (the remaining two-third part is attached to the tip of the limbs which move much slower than the arrow at arrow exit).

Klopsteg (13,14) proposed a formula to take loss due to the kinetic energy of the limbs into

account by introducing a so called virtual mass. In this case the factor becomes

$$\frac{\text{mass of arrow}}{\text{mass of arrow} + \text{virtual mass of bow}}$$

Unfortunately this entity is not directly related to for instance the mass of the limbs or parts thereof. Therefore it has to be measured for a reference case and can then be used for sensitivity analysis, for instance to predict the effects of the mass of the arrow on the efficiency.

Despite the fact that these models do not give reliable predictions we learn a lot from these considerations. The excellent property of the bow is that it allows propelling a projectile toward the target with high efficiencies and that the light and relatively stiff string is indispensable and the limbs meeting strength conditions as light as possible.

The arrow

From the pictures in Fig. 2 we conclude that the arrow acts as a slender beam in the horizontal plane. Consequently, when the action of the arrow itself is concerned, we have to replace the point mass by a much more detailed model where three parts are distinguished: the shaft, nock and arrow head. Also the interactions between the bow at the arrow rest and middle of the string and arrow have to be taken into account. The use of a plunger combined with the arrow rest allows the archer to adjust the initial lateral position of the arrow.

Observe that Klopsteg (13,14) associated the archer's paradox phenomenon with the width of the grip. The arrow has to pass the grip at a distance half the width to the center plane of the bow and therefore it would slap against the grip if the arrow would be stiff. However, the arrow is flexible and snakes around the grip. Later a window in the grip was introduced making a center-shot bow possible and theoretically no vibrating arrow would be the result. However, during the release the rear-end of the arrow is pushed sideways and this still initiates the vibratory motion: hence the archer's paradox is still real.

Various models of different levels of detail have been proposed to describe the interaction of the bow and arrow. Pratt (21) proposed to consider the arrow as a vibrating beam. Pratt and Hardy (22) used the well-known equation for an approximation of the natural frequency of a vibrating beam. The acceleration force acting upon the arrow is assumed to be constant and is equals to the mean draw force during drawing the bow. Pratt states that the time for the nock of the arrow to travel a distance equal to the draw, has to equal the time comprising one and a quarter vibrations of the arrow, that is, 1.25 times the natural period of the arrow. In this way he derives a requirement for matching of the arrow to the bow which is a relationship between parameters describing both bow and the arrow.

In the next section we discuss more detailed models for the bow and arrow and their interaction, and the predictions obtained by simulations on the computer.

4. Model predictions

The bow

In simple models the string has contact with the limbs only at their tips. Modern bows are working-recurve bows where the string lies along an adjacent part to the tips of the limbs. When this mechanism is taken into account in the model, solving the resulting mathematical model is much more complicated. For models more detailed than described in the previous section the mathematical equations can not be solved with pencil and paper. Computer packages are available to approximate the solutions of these equations. The calculations yield a lot of information about the motion of the limbs, string and arrow but also about forces in the string, bending moments in the limbs and the acceleration and speed of the arrow.

In Fig. 4 the calculated shape of the different parts of the bow and the arrow in Kooi (18) is depicted. Fig. 4.a shows the shape at different static positions, the unbraced, braced and the fully drawn position and a number of intermediate positions (dashed). During the first part of the draw the outer parts of the string lie against the

limbs. At a certain draw length the string leaves the limbs from the tip just as in for a simple straight-end bow. This occurs in the reversed order after release, see Fig. 4.b. Just before arrow exit the effective string length is shorter and as a result the limbs are more slowed down. After the arrow left the middle of the string the limbs and string vibrate heavily as shown in Fig. 4.c. This shows that not all energy is imparted to the arrow. Since we assume no damping, the model predicts that this oscillatory behavior does not stop. In reality the limbs slows down towards the braced position due to damping.

In Fig. 5 the predicted Static Force Draw (SFD) curve F and the Dynamic Force Draw (DFD) curve E for the working-recurve bow are compared. Both quantities are depicted as function of the draw length, which is the distance between the middle of the string and the grip, the draw length. F is the draw force, which is exerted by the archer with the middle of the string (Mediterranean release). The area below this curve equals the potential energy available to propel the arrow. This curve illustrates the importance of using a clicker to have a consistent release point so that the draw length is the same for each shot. The shape of the SFD is important when the amount of energy stored in the fully drawn bow is concerned. When the shape is more convex more energy is available to propel the arrow. E is the acceleration force which propels the arrow. The area below this curve equals the energy imparted to the arrow. The jump at arrow release in the DFD curve represents the force involved with the acceleration of the part of the string attached to the tip of the limbs and the middle of the string. The acceleration force drops after release sharply and increases in the last phase. It is even higher than the static force just before arrow exit. The arrow leaves the string when the acceleration force is zero. Due to the elasticity of the string arrow exit happens after the arrow passed the braced position.

We recall that the efficiency of a bow equals the kinetic energy of the arrow divided by the available potential energy stored in the fully drawn bow. Therefore the area below the DFD curve divided by that area below the SFD curve is

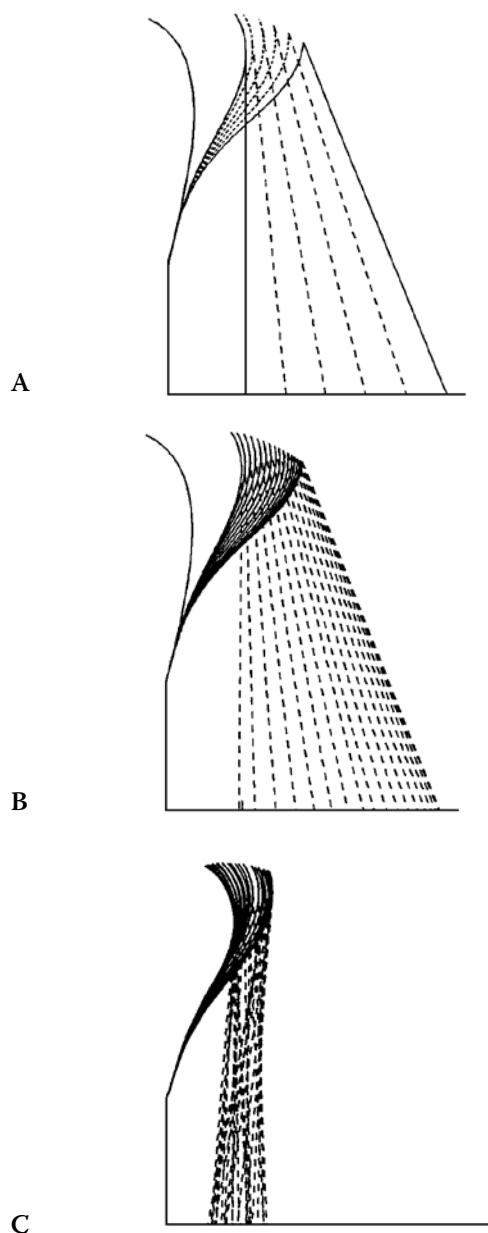


Figure 4. Static and dynamic shape of a working-recurve Greenhorn Comet TD 350, 68" 30# bow (18). Because the bow is assumed to be symmetric only the upper part is shown. A: the unbraced, braced and fully drawn as well as for a number of intermediate positions the shapes are shown. B: the movement of the limbs, string and arrow, attached to the string at the middle, are depicted. Arrow exit occurs after the arrow passed the braced position. C: the motions of the limb and string are shown after the arrow left the string. This motion is caused by the energy stored in the limbs and string which has not been used to propel the arrow.

the efficiency. The remaining energy lets the limbs and string vibrate after arrow exit.

Observe that the numbers of merit or quality coefficients used here differ from those used in (2). Here three quantities, the amount of energy per weight per draw length, the efficiency and the arrow velocity per square root of weight times draw length per mass of one limb. These three coefficients are dimensionless and this means that it allows for comparison of the performance of different bows for the same weight, draw length and mass of the limb. In order to elucidate the importance of this we note that taking the mass of the limbs lower the efficiency increases. Because our coefficients correct for the effects of the mass of the bow limb and also the weight and draw length, we obtain an honest comparison.

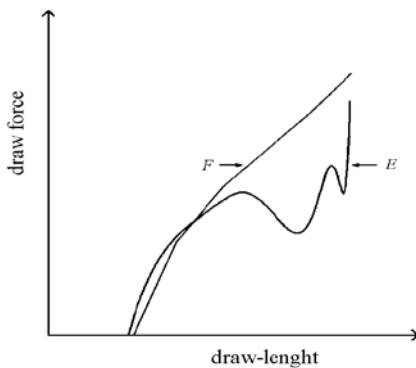


Figure 5. Static Force Draw curve, F , and Dynamic Force Draw curve, E , for the working-recurve bow, after (18).

The arrow

Pękaliski (7), Kooi (23), Zanevskyy (20) proposed different physical and mathematical models dealing with the interaction between the bow and the arrow. In all models the arrow is modeled as a slender beam (the shaft) with two particles: the nock (tail) and the arrowhead (head). There is a difference in how the local interactions between the bow and arrow, at both the middle of the string and via the pressure button attached to the grip of the bow. A detailed comparison of the three models is beyond the scope of this chapter.

Important is the acceleration force acting on the nock of the arrow in longitudinal direction of the

arrow. This force is exerted by the string and is calculated with models discussed above, for the bow system where the arrow is assumed to be represented by a point mass attached to the string in the middle. The arrow has a cylindrical shape of length slightly longer than the draw length. Since the length of the arrow is much larger than the cross-section diameter the arrow has to be modeled as a slender beam. The arrow head and nock at both ends are modeled as point masses. With all mathematical models the motion of the arrow is calculated using computer simulations.

In Fig. 6 the calculated shape of the arrow predicted by a model developed in (23,24) at different times are shown. Various positions of the arrow from the moment of release till arrow exit are shown. The side way movement of the arrow nock during release is prescribed to model that the string slides over the finger tips. Observe that the arrow has only contact with the button during restricted time intervals. This suggests application of the right boundary conditions that describe the interaction of the arrow and the bow is vital. At arrow exit the nock at the rear-end of the arrow does not touch the grip of the bow when the arrow matches the bow. For matching important are the mass and bending properties, the spine, of the arrow but also the weight and draw length of the bow. By changing various parameters of the arrow, for instance the spine, we were able to show that if the arrow does not match the bow, the nock of the arrow slaps against the grip.

5. Summary

Models for the static and dynamics action of the bow and arrow have been proposed in the literature at two levels of detail. Simple versions give a qualitative descriptions and reveal already the first principles on which archery is based and direction for improvement of the performance of archery equipment. More detailed models give rise to mathematical equations containing more parameters and the obtained predictions are quantitative. However these equations are much more difficult to solve. Programs running on computers with adequate computer power have to be used to make simulations and can be used to optimize the performance of archery equipment.

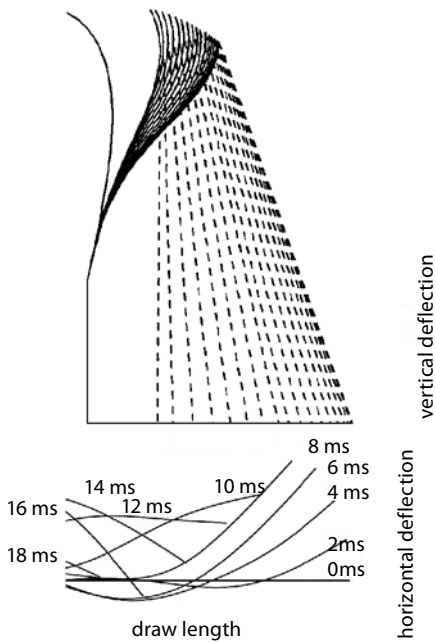


Figure 6. The dynamic shapes for the bow are those from Fig. 4B. The deformation shapes of the arrow for every 2 ms after release until the arrow nock passes the grip. These shapes are predicted by the mathematical model described in (24). In the last two instants, 16 and 18ms after release, the arrow left already contact with the string. Arrow is shot by a left-handed shooter. Compare these results with the experimental results presented in Fig. 2.

Taking parameter values for a specific bow and arrow combination shot by an individual archer allows to analyze and to improve the archer's technique.

Nowadays measurement apparatuses like the *bow force mapper* are available to measure the SFD curve and an *arrow chronograph* to measure the velocity of the arrow. Via an interface with a computer the measured data can be stored on a computer and post-processed with supplied software *shaft selector*, see (5). The video camera is already used as a tool for analyzing errors and teaching proper techniques (see (25) and (26)).

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Sun and Heat Exposure

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Introduction

Outdoor archery, in whatever form it is practiced, is more likely to take place under conditions of elevated temperatures than under conditions of extreme cold. This statement does not mean that tournaments do not take place and arrows do not get shot under cold conditions. Not at all. However, the problems and hazards faced by archers under low temperatures differ significantly from those experienced by archers under conditions of high temperatures. How hot the conditions are will depend on when and where in the world the archery is practiced. Linked to the considerations of temperature are important factors such as the influence of humidity and wind which are also variable factors.

In the discussion that follows, the fundamental assumption will be that the archer is healthy, physically and physiologically fit with no observable nutritional deficiencies or underlying latent or chronic infections or debility. Also, for the purposes of this chapter, the problems and complications of pediatric dehydration will not be dealt with in detail.

It is also important to note that the sport of archery shows rather large differences when compared with other sports. Archers are not continuously moving from one point to another as is common with many team sports, when they do move they move at a slower pace than players in field sports, there is no physical contact between competitors other than transient and accidental forms of contact and they do not have to react to the actions of opponents or team

members. And yet archers expend significant amounts of muscular energy during the course of a tournament or event. Whereas competitors in track, field and most team sports expend large amounts of energy moving themselves (for example athletics, football or gymnastics) or other objects (for example weight lifting, tennis) from one point to another, the effort in archery is directed more towards the suppression of body displacement and the attainment of stability. Perhaps it is understandable that McArdle *et al.* (1994)(1) refer to archery as “light aerobic exercise.

The energy expended by an archer in a full tournament is not insignificant, nor is the amount of fluid lost by perspiration during tournaments in some parts of the world, and yet very little investigative research has been done on the effect of heat exposure and dehydration on an archer's performance. Of necessity, therefore, the archer and the coach who wish to formulate guidelines for dealing with heat exposure have to rely on body responses and performance indicators derived from investigations in completely different sporting codes, such as basketball (Dougherty *et al.*, 2006)(2), cycling (Ebert *et al.*, 2007)(3), marathon running (Ayus *et al.*, 2000)(4), tennis (Bergeron, 2003)(5), soccer (Kirkendall, 1998)(6) and wrestling (Bartok *et al.*, 2004)(7), to mention a few. However, the reaction of the human body to conditions of elevated temperature will be the same, regardless of which sporting discipline is considered. The only major difference between them will be that of work intensity.

What Happens Under Normal Conditions?

The human body contains living cells of a wide variety of types. What they all have in common, however, is that they show metabolism, i.e. they need to receive continuous and adequate supplies of oxygen and nutrients, as well as requiring removal of waste products and end products of metabolism. One such waste product is CO₂ while another important end product is heat (McArdle *et al.*, 1994)(1). Cells can only function within a relatively narrow range of temperatures and the control mechanisms of the body will attempt to maintain the core temperature of the body within that range which is normally taken

as 37°C (Lugo-Amador *et al.*, 2004)(8); McArdle *et al.*, 1994)(1)

This body temperature is maintained by the release of heat from cellular metabolism and is retained, or dissipated, according to the needs of the body at any given moment. The thermoregulation is an involuntary process which will adjust the body's response and actions on a continuous basis (McArdle *et al.*, 1994)(1).

In a state of rest comparatively little heat is generated by a body. It is also a basic fact of physics that a body which is at a higher temperature than its surroundings will lose heat to the surroundings. The converse is equally true that if a body is at a lower temperature than its surroundings, it will take up heat from the environment. When the environment is such that any excess body heat is dissipated easily without reducing the amount of heat required for normal bodily functioning and survival, the amount of physiological stress is minimal (Plowman & Smith, 2004)(9).

However, bodies are not perpetually in a state of rest and exposure of a body to temperatures markedly above the "comfortable" range is not uncommon either. Depending on the activity level or metabolic rate, environment and clothing, exercise can induce a marked raise in body temperatures (Sawka *et al.*, 2007)(10). The situation could, and does, then occur that the body generates more heat than it requires and needs to get rid of the excess.

What Happens During Exposure to Sun and Heat

At times a body will be exposed to temperatures well below or above the normal range. The body's responses to cold and hot conditions will also differ quite markedly. In this chapter the effects of cold temperatures will not be discussed and the emphasis will be on the reactions of the body to raised temperatures and ways of dealing with them.

Transfer of heat occurs in the following ways (Grubenhoff *et al.*, 2007)(11):

1. Conduction – the transfer of heat from one solid object to another of lower temperature by direct contact;
2. Convection – when a gas or liquid absorbs heat and moves away from the heat source, in this case, the body;
3. Radiation – direct absorption of infrared rays from the sun (known as insolation) but also from other sources of radiant heat (for example furnaces, open fires, etc);
4. Evaporation – the change of a liquid to a gaseous phase following the uptake of heat by the liquid from a heat source.

Where can the Extra Heat Come From?

- 1 **From increased muscular action.** This can be either deliberate exercise or strenuous physical activity. The additional muscle action increases the metabolic rate which releases more energy than in the sedentary state and which has to be removed and dissipated (Armstrong *et al.*, 2007)(12).
- 2 **By direct absorption of radiant energy** from the sun (insolation) or another heat radiant source (Lugo-Amador *et al.*, 2004)(8).
- 3 **Convection.** Just as a body can lose heat by convection it can also gain heat in the same way from hot winds or high temperature ambient conditions (Lugo-Amador *et al.*, 2004)(8).

It is important to note that the radiant heat absorbed from the sun is not what causes sunburn. The radiant heat is in the form of infrared radiation while sunburn is caused by ultraviolet rays. The use of sunscreen barrier products which block off the ultraviolet will have no effect on the absorption of infrared radiation. The use of sunscreens is, however, recommended as sun-burnt skin is painful or uncomfortable and interferes with the body's ability to cool itself (CDC, 2006)(13)

What are the Effects on the Body of Raised Temperatures?

Just as heat is taken up by radiation the first reaction of the body to raised temperature is to increase the amount of heat radiated to the environment. This is done by the channeling of

an increased volume of blood to the vessels under the skin, thereby bringing heat from the deeper organs and structures of the body to the surface (Lugo-Amador *et al.*, 2004)(8); Armstrong *et al.*, 2007)(12).

According to Armstrong *et al.*, (2007)(12) hyperthermia occurs when heat generated by muscular activity cannot be dissipated fast enough by increased sweating. During heavy exercise metabolic heat production in active muscles can increase up to 15 - 20 times that of inactive muscles. If this heat is not dissipated the internal temperature will rise 1°C every 5 minutes and can result in heat stroke, a condition with a high mortality rate if not treated promptly. Therefore, failure to dissipate this excess heat holds definite life-threatening consequences.

Dissipation of excess heat is most commonly and easily done by evaporation of perspiration from the surface of the skin (Lugo-Amador *et al.*, 2004)(8). Under normal conditions there is a regular movement of water from the deeper tissues of the body to the skin where it evaporates. Consider that evaporation requires the uptake of heat by the water, in the form of sweat in this case. That heat is drawn from the body, thus cooling the blood which is re-circulated to the deeper tissues (Plowman & Smith, 2004)(9). This loss is called “insensible perspiration” as it is not obtrusive or obvious. However, an average adult can lose approximately 350ml daily in this manner (McArdle *et al.*, 1994) (1).

When the increased radiation from the body proves inadequate for heat stabilization, the production of perspiration is increased markedly to cool the skin surface by evaporation (Sawka *et al.*, 2007)(10). However, sweating does not occur without a price, which is the loss of fluid from the body or dehydration (Haggerty, 2006(14); Maughan *et al.*, 1996)(15).

Radiation and convection are normally adequate to dissipate the increased body heat derived from moderate exercise if environmental conditions are cool with low relative humidity. As soon as environmental temperatures rise the effectiveness of radiation and convection decrease as the differential between body heat and air

temperature decreases. The air temperature may even be higher than skin temperature, in which case there can be an uptake of heat by the skin which can only be compensated by copious evaporation. However, the rate of evaporation depends on the relative humidity of the environment and movement of the ambient air, the composition of the sweat and the concentration of the sweat (Barrow & Clark, 1998(16); Plowman & Smith, 2004(9); Seto *et al.*, 2005)(17).

Cooling effect of evaporation: The process of evaporation is the primary and main mechanism of heat loss from the body and provides the major physiologic defense against overheating. The evaporative loss of 1 liter of sweat from the body's surface releases about 600 kcal of heat energy from the body to the environment (McArdle *et al.*, 1994(1); Seto *et al.*, 2005(17); Sawka *et al.*, 2007)(10).

Note that copious perspiration in visible drops has very little effect in cooling the skin as the droplets run off and do not evaporate (Cheuvront *et al.*, 2004)(18). It may be very impressive to an onlooker but holds little benefit to the athlete. It is only when sweat evaporates on the skin that the cooling is effective.

As described above, perspiration is an essential process in the regulation by the body of its internal temperature and is highly dependent on a number of factors. Important among these will be body mass, heat acclimatization, genetics and metabolic efficiency (Sawka *et al.*, 2007)(10). There will, therefore, be large differences in the amount of perspiration produced by different individuals on the same day under the same conditions. During prolonged exercise in a hot environment 8 to 12 liters of sweat can be produced (McArdle *et al.*, 1994)(1) leading to the comment by Sawka *et al.*, (2007)(10) that “The difference in sweat rates between individuals, different sports and climatic season demonstrate the difficulties in providing a single one-size-fits-all recommendation”

Sweat can only come from fluid within the body and the most accessible fluid is blood plasma. Perspiration must therefore inevitably lead to a loss of liquid from the body. This liquid is water

and it is perhaps appropriate to consider the role of water in the body

Water and its Role in Cellular and Body Activity

Body cells require adequate perfusion to function optimally, which is dependent on a sufficient circulating blood volume. To survive cells need to receive adequate supplies of oxygen and nutrients, as well as requiring removal of waste products and end products of metabolism, such as Carbon Dioxide (CO₂). An important end product of metabolism is heat (Seto *et al.*, 2005)(17). Cells can only function within a relatively narrow range of temperatures, otherwise they will die (Lugo-Amador *et al.*, 2004)(8) and the control mechanisms of the body will attempt to maintain the core temperature of the body within that range. To do that also requires an adequate circulating volume.

From the above it is clear that any condition that leads to a loss of water from the body can hold serious consequences for the person concerned. The most common non-traumatic reason for water loss, and the one that is of concern in this chapter, is perspiration, especially excessive perspiration. For our continued well-being it is essential that an adequate water balance be maintained in the body and that can only be done by replacement of the amount of water lost by ingestion of an appropriate volume of water (Caroline, 1991(19); Plowman & Smith, 2004(9); Sawka *et al.*, 2007)(10).

Water Management

Water loss at rest (McArdle *et al.*, 1994)(1)

A sedentary adult under normal conditions requires an intake of approximately 2550ml water daily (McArdle *et al.*, 1994)(1). This volume of water is required to compensate for the water lost daily via skin and lungs (± 1200 ml) and via the kidneys and bowel (± 1250 ml).

As pointed out earlier, water is lost continually through movement from the deeper tissues of the body to the skin where it evaporates (McArdle

et al., 1994)(1). Under conditions considered normal this loss is not even noticed as it is not obtrusive or obvious and an average adult can lose approximately 350ml daily in this manner. In addition, besides the approximately 350ml water lost daily through “insensible perspiration”, water is also lost through the kidneys (± 1000 -1500ml), intestine (± 100 -200ml) and through exhaled air (± 250 -350ml).

Water loss during exercise : Muscle activity produces heat and a working muscle requires that this heat be removed. This is done by increasing blood flow to the skin where radiation of thermal energy, aided by the cooling effect of evaporation of perspiration gets rid of excess heat (McArdle *et al.*, 1994(1); Plowman & Smith, 2007)(9). While exercising under hot conditions the volume of water lost can increase significantly (McArdle *et al.*, 1994)(1). While 500 – 700ml of sweat are produced each day under normal conditions this can rise to 8 – 12 liters at a rate of ± 1 liter/hour during prolonged exercise. Furthermore water is lost in the form of water vapour through the respiratory passages at a rate of approximately 3.5ml per minute during exercise. The amount lost varies with the climate, being less in hot conditions and greatest under cold dry conditions.

The volume lost can, therefore, rise to ± 6300 ml, through the skin (± 5000 ml), lungs (± 700 ml) and kidneys (± 500 ml). The situation may, however, occur where a body is no longer able to cope with raised temperatures which could have important and even life threatening consequences.

Effects of Dehydration on the Body

“Water deficit without proportionate sodium chloride loss is the most commonly seen form of dehydration during exercise in the heat. Regardless of the dehydration method, for any water deficit there is similarity in altered physiologic function and performance consequences” (Sawka & Coyle, 1999(20); Sawka *et al.*, 2007)(10). The greater the body water deficit, the greater the increase in physiologic strain for a given exercise task (Montain & Coyle, 1992(21); Montain *et al.*, 1995)(22), with an unreplenished loss of fluid equivalent to 2% of body weight resulting in reduced physical performance (Latzka

& Montain, 1999)(23). When the fluid deficit exceeds 3-5% of body weight sweat production and flow of blood to the skin reduces, with the effect that the cooling effect is reduced (Barrow & Clark; 1998(16); Armstrong *et al.*, 2007)(12). As circulating volume decreases the effectiveness of muscle perfusion is reduced further. The flow of nutrients and oxygen to structures and organs is impaired and the removal of waste materials and excess heat from active muscles is equally affected. As a result of the reduced circulation a smaller amount of sweat is produced leading to a reduction in evaporative cooling of the skin. As evaporative cooling is reduced the ability of the body to control a rise in temperature is reduced, giving a rise in skin and core body temperature, known as hyperthermia. This gives rise to a range of conditions known collectively as "heat illness" which will be dealt with in more detail below.

The Effects of the Environment on Water Relations

What happens when the body builds up heat?

Even a moderate loss of fluid through sweating is not without consequences. Blood volume, as opposed to total body fluid volume, becomes reduced when sweating causes a fluid loss equivalent to about 2% of body mass. For a 100Kg athlete this represents 2Kg or a volume of approximately 2 liters of fluid. This places a strain on circulatory function that ultimately impairs the capacity for further exercise and thermoregulation (Barrow & Clark, 1998(16); Armstrong *et al.*, 2007)(12).

Furthermore, even when fully hydrated adequate muscle perfusion can only occur when a muscle is not under tension. A tense muscle forces the blood out (largely responsible for the return flow of venous blood) (McArdle *et al.*, 1994(1); Plowman & Smith, 2004(9); Powers & Howley, 2004)(24) and while tense the muscle can receive no supply of oxygen and/or nutrients, nor can unwanted products, including heat, be removed. The accumulated heat in the muscle can only be removed when the muscle relaxes prior to the next contraction. Under conditions of reduced circulating volume due to dehydration there is

less blood available to give adequate perfusion so that the heat removal, and its dissipation, is less effective.

This has important implications for archers. The action of drawing a bow and holding it at full extension requires an isometric pushing action in the bow arm while the string is drawn to the face at the same time. The initial action of drawing the string to the face is an action involving a large spatial displacement of the drawing arm but as the string reaches the face the movement slows down to being almost imperceptible. The action of the drawing arm will, therefore, not be truly isometric since there is movement, albeit very little, but the drawing muscles will be fully under tension. Only upon release of the arrow is there a major movement of the drawing arm again, followed by relaxation of the muscles of the pectoral girdle.

There are many archers who hold their fully drawn bows for much longer than just a few seconds before releasing the arrow. If the body is already under stress in a hot environment with incipient dehydration due to raised ambient temperatures, putting this additional extended effort, with the resulting increased heat loading, on to a set of working muscles cannot fail to have a negative effect on the archer's performance.

Furthermore, cognitive or mental performance, which is important where concentration, skilled tasks and tactical issues are involved, is also degraded by dehydration and hyperthermia (Hancock & Vasmatazidis, 2003(25); Rodahl, 2003)(26). Dougherty *et al.*, (2007)(2) found that the intake of carbohydrate-electrolyte sports drinks gave a significant improvement in the skills of basketball players. This is an observation which is no less important for archers.

Signs and Symptoms.

As the body temperature rises the initial reaction of the body is to increase the output of perspiration (Armstrong *et al.*, 2007)(12). The skin is, therefore, flushed and moist. As long as the perspiration can evaporate and give the desired cooling there may not be pronounced moisture on the skin which can lead to an underestimation by the athlete of the volume of circulating volume actually lost.

Factors that can influence the rate of evaporation of sweat from the skin

An increase in body heat may have its origin in the exertion of exercise or physical activity or could be due to external conditions. There are also several factors that may influence the ability of the body to lose unwanted heat, irrespective of where the heat may have come from.

Wind

Wind is movement of air and its effect on the rate of dehydration can be extremely insidious. Even a slight wind will cool the body by increasing the rate of evaporation of sweat from the skin, increasing the convective loss of heat and giving the sensation of “the cooling breeze.” Strong winds will increase the rate of evaporation and persons in such winds, be they athletes, archers or officials, need to be very aware of this effect, especially if their exposure is of lengthy duration. Archers are inevitably acutely aware of the influence of wind on their shooting performance but can easily forget that wind can have severe other effects. Wind can of course interact with humidity to give moist or dry winds of varying velocities.

It is obvious that a hot dry wind will cause rapid evaporation of sweat from the skin by displacement of moisture-containing air from the surface of the skin, causing potentially serious dehydration in the process whereas wind under conditions of high temperature linked with high humidity may have very little evaporative effect. Even a dry wind that is not perceived as warm can have serious dehydration, leading to all the complications associated with dehydration even in the absence of raised temperatures. For archers this is an important consideration as wind is an almost constant feature of most outdoor archery events.

Humidity

Conditions of raised humidity reduce the rate of evaporation of perspiration from the skin (Bailes & Reeve, 2007)(27). The cooling effect is reduced while at the same time, the efforts of the body to cool itself result in the production of more sweat

which then pools into droplets that fall from the skin. As mentioned above, such droplets contribute virtually nothing to the cooling of the body. When the Relative Humidity (RH) reaches 75% and higher, heat loss by evaporation begins to fail and the ability of the body to cool itself by perspiration is lost (Bailes & Reeve, 2007)(27). Continued sweating gives no cooling but results in increased dehydration with little benefit to the athlete. The volume of water lost under such conditions can be 2 liters or more per hour, with an associated loss of sodium. If not replaced this loss impairs thermoregulation, so that an increase in body temperature, either due to heat uptake by the body because of its exposure or heat generated by exertion, can no longer be controlled. This can lead to a serious increase in body core temperature which can be life threatening (Bailes & Reeve, 2007)(27).

Clothing

Inappropriate clothing would be of material that traps air, that does not allow heat dissipation, that traps sweat without allowing it to evaporate (McArdle *et al.*, 1994)(1). Suitable materials would be loose enough to allow free circulation of air, allow radiated body heat to be dissipated, would increase the evaporative area and thus enhance the cooling effect. Cotton materials absorb moisture from the skin and spread it over a greater area (McArdle *et al.*, 1994)(1); Powers & Howley, 2004(24); Plowman & Smith, 2004)(9).

Dehydration

Prolonged exposure to raised temperature with no fluid replacement leads to reduction in circulating volume (dehydration), reduction in perspiration and hence to reduced cooling. The skin becomes hot and dry to the touch, the ability of the body to channel blood to the skin for radiation and sweating to occur is reduced, the body core temperature rises, followed in extreme cases by an increase in blood viscosity, a rise of body temperature beyond the ability of body structures to cope, leading eventually to coma and death. Nervous tissue is especially vulnerable and in extreme cases the brain can suffer thermal injury (Rodahl, 2003) (26). The scenario outlined above

is obviously an extreme one and no athlete should ever run the risk of its occurrence. Endurance sports, like marathon runners and similar athletes, have to be especially aware of the dangers of under-hydration and take appropriate measures to ensure an adequate fluid intake.

Water requirements in exercise

During a vigorous workout sweating frequently causes a person to lose between 1 – 2Kg of body fluid. The amount of water lost depends on the severity and duration of physical activity as well as environmental conditions. An adequate intake of fluid to compensate for the volume lost is, therefore, essential. Care must be taken, however, that appropriate fluids are taken in. Replacement fluids that have a diuretic effect (for example those that contain caffeine or alcohol) will increase the state of dehydration (Barrow & Clark, 1998)(16).

The Relative Humidity of the ambient air is also important as this greatly affects the cooling efficiency of sweating. Relative Humidity (RH) refers to the water content of the air. During conditions of 100% RH the air is completely saturated with water vapour and evaporation of fluid from the skin is impossible so that this important avenue for body cooling is closed. Under such conditions sweat beads on the skin and runs off with no cooling effect (Cheuvront *et al.*, 2004)(18). On a dry day air can hold considerable amounts of moisture and fluid evaporates rapidly from the skin. This enables the sweating mechanism to function at optimal efficiency and body temperature is more easily controlled.

Signs and Symptoms of Increasing Levels of Dehydration

Dehydration increases the risk of heat exhaustion (Sawka *et al.*, 1992)(28); Barrow & Clark, 1998)(16) and is also a risk factor for heat stroke (Epstein *et al.*, 1999)(29). Heat stroke is also associated with other factors such as lack of acclimatisation, medication, genetic predisposition and illness (Eichner, 2004(30); Sawka *et al.*, 2007)(10).

The conditions under which heat stroke can occur are not normally found in the more

climatically temperate regions of the world. This circumstance makes awareness of the possibility of heat stroke an important consideration for any athlete from a temperate climate who is intending to participate in events in geographic areas, or under conditions, of high temperature and humidity.

While the expectation is that cases of heat stroke will not occur under conditions of formally organised sporting activities of high quality, this section is included here for the sake of completeness. Recognition and awareness of the conditions under which increased perspiration or dehydration may occur, both before an event and also during the event, is the first step to prevention of heat exhaustion. The next step is taking the necessary steps to ensure adequate rehydration.

If the normal signs of heat stress – thirst, tiredness, grogginess, and visual disturbances – are not heeded, cardiovascular compensation begins to fail and a series of disabling complications of heat illness can result.

Heat Illnesses

What is heat illness? It can be described as a spectrum of disorders that range in intensity and severity from mild cardiovascular and central nervous system disruptions to severe cell damage, including the brain, kidney and liver (Plowman & Smith, 2004)(9). There is even evidence that individuals who have experienced prior hospitalization for heat illness show an increased risk of an early death (Wallace *et al.*, 2007)(31).

The magnitude of cardiovascular stress placed on the body by exercise in the heat has been described in Plowman & Smith (2004)(9) as: “Probably the greatest stress ever imposed on the human cardiovascular system is the combination of exercise and hyperthermia. Together these stresses can present life-threatening challenges, especially in highly motivated athletes who drive themselves to extremes in hot environments”

When the cardiovascular system is unable to meet the thermoregulatory and metabolic demands of the body, heat illness ensues. **Heat illness** represents a spectrum of disorders that range in intensity and severity from mildly annoying

(for instance, prickly heat and fainting) to life threatening (heatstroke) (Seto *et al.*, 2005)(17). Heat illness may manifest itself in a number of ways. In order of increasing seriousness heat illness can be categorized as heat cramps, oedema, heat syncope, heat exhaustion and heatstroke (Bailes & Reeve, 2007)(27).

Armstrong *et al.*, (2007)(12) point out that immediate recognition of cases of heat exhaustion is extremely important to the survival of the affected person. They quote the signs and symptoms as including disorientation, confusion, dizziness, irrational or unusual behaviour, inappropriate comments, irritability, headache, inability to walk, loss of balance and muscle function. These symptoms are variable depending on the individual, the degree of dehydration and the duration of hyperthermia. Some of the above signs and symptoms are subtle so that fellow athletes, coaches and managers have to be aware of the need to look out for them.

Heat exhaustion in athletes can be affected by a number of different risk factors (Seto *et al.*, 2005(17); Armstrong *et al.*, 2007)(12). These risk factors have been identified by Seto *et al.* (2005)(17) as either intrinsic or extrinsic. Intrinsic factors have their origin in the physical and physiological condition of the athlete while extrinsic factors would be conditions in the environment and the activity performed.

Among the intrinsic risk factors identified by Seto *et al.* (2005)(17) are a history of previous heat illness, recent illnesses, poor fitness level, lack of acclimatization, inappropriate clothing, obesity, sleep deprivation, dehydration, alcohol, fever and upper respiratory tract infections, gastrointestinal illness, skin conditions such as sunburn or heat rash and other medical conditions such as uncontrolled diabetes.

Extrinsic risk factors include environmental conditions of temperature, humidity, wind and sun, intensity and duration of the exertion, lack of, or poor access to, water and shade, a lack of awareness about heat illness among athletes and coaches, delay in recognizing the onset of heat illness and the absence of a plan to deal with heat illness should it occur. Armstrong *et al.*, (2007)(12) state that the combined effects of heat stress and dehydration reduce exercise capacity

and performance to a greater degree than either alone.

It is realistic today to expect coaches to be aware of any of the above conditions in their athletes and to make informed decisions on whether to permit any affected athletes to participate or not.

The reference to sleep as an influencing factor in performance and susceptibility to heat illness draws attention to the need to consider the effects of jet-lag on the sleep-patterns of international athletes. This aspect will have to be considered in the acclimatization programme of any competitor who has to cross international time zones.

Heat Cramps

Heat cramps are an acute disorder consisting of brief, recurrent and excruciating pain in the voluntary muscles of the legs, arms or abdomen. Typically, the muscles have recently been engaged in intense physical activity (Plowman & Smith, 2004)(9). Heat cramps may result from a fluid-electrolyte imbalance.

Skeletal muscle cramps are believed associated with dehydration, electrolyte deficits and muscle fatigue. Persons susceptible to muscle cramps are believed to be often profuse sweaters with large sweat sodium losses (Bergeron, 2003)(5). Persons showing heat cramps usually respond well to salt supplementation of liquids. It is important to note that individuals who have shown heat cramps and have recovered should not continue with the activity that brought on the cramps, despite their desire to do so (Caroline, 1991)(19).

Oedema

Bailes and Reeve (2007)(27) describe heat oedema as occurring in persons who are not acclimatized to extreme temperatures. It occurs as transient peripheral dilation and oedema of the lower limbs in the affected individual and, while uncommon in athletes, is common in older adults.

Heat syncope

Heat syncope is a temporary disorder characterised by circulatory failure due to pooling of blood in the peripheral veins (Seto *et*

al., 2005)(17). Thus, the individual feels light-headed and may faint. Heat syncope occurs most often when individuals have stood for extended periods or get up suddenly from a seated position. Moving the individuals to a cooler location and having them rest in a recumbent position is the appropriate treatment for heat syncope.

Heat exhaustion

Heat exhaustion is caused by prolonged exposure to high temperatures, physical activity, excessive perspiration coupled with inadequate volume of appropriate replacement liquid. It is characterised by irritability, thirst, dryness of the mouth, rapid and weak pulse, nausea and/or vomiting, fatigue or lassitude, weakness, muscle cramps, profuse sweating, mental confusion, light-headedness or psychological disorientation and fainting (Caroline, 1991(19); Grubenhoff *et al.*, 2007(11); MUSC, 2007)(32). The skin is often pale and clammy and body temperature is near normal or moderately elevated (usually below 39.5°C). Heat exhaustion is caused by an acute fluid loss which leads to an insufficient circulating volume to meet the demands of internal organs for adequate perfusion and at the same time channel enough blood to the peripheral vascular system under the skin to enable sufficient evaporative cooling to take place.

In the light of current knowledge today, one would hope that the extreme effects of dehydration will never be evidenced on a formal archery range or any other competitive sporting event. However, because of the severity of the reaction to dehydration it must always be considered as a potential danger. Furthermore, besides being person-dependent, children and persons of small stature may be more susceptible to heat exhaustion because they have a smaller plasma pool from which fluids can be lost. The proportional loss of body fluid is, therefore, so much greater and the resulting effects so much more severe (Bailes & Reeve, 2007)(27)

Individuals suffering from heat exhaustion should be moved to a cool place, given cool, not icy, fluids and encouraged to lie down (Caroline, 1991)(19). Alcohol must not be given as it is a dehydrating agent and will exacerbate the dehydration. In

severe cases of heat exhaustion a person may require intravenous administration of fluids and electrolytes but this is clearly only to be done under appropriate medical supervision (CDC, 2006)(13). By the time the archer presents as clinically affected the condition is too far advanced for the archer to continue in either practice or competition.

Heatstroke

Heatstroke is a serious medical emergency (Armstrong *et al.*, 2007(12); MUSC, 2007)(32). It is characterized by elevated skin and core temperatures (core temp may exceed 40°C), tachycardia (rapid heart rate), headache, syncope (fainting), vomiting, diarrhea, seizures, delirium and hallucinations and hyperventilation and, in extreme cases, coma (Grubenhoff *et al.*, 2007)(11). Sweating may have stopped or be present but the skin is hot. Heatstroke represents a failure of the thermoregulatory mechanisms; thus, core temperature increases rapidly to dangerous levels. If heatstroke is suspected, the individual should be cooled as quickly as possible (using water, ice or a fan) and medical personnel notified immediately. Heatstroke is a life-threatening medical emergency and must be treated as such (Caroline, 1991(19); Grubenhoff *et al.*, 2007)(11).

Cases of heatstroke should never be allowed to happen in a formal archery event, or any other, where adequate medical facilities are, or can be, provided. Any case of incipient hyperthermia should have been noticed and attended to long before. It is also important to note that, in contrast to heat exhaustion, complete recovery from heat stroke may take up to a year (Bailes & Reeve, 2007)(27)

Prevention of Heat Illness

The best treatment for heat illness is prevention (Bailes & Reeve, 2007)(27). Maintaining hydration and staying cool will prevent heat-related disorders from developing but this escape mechanism is not always feasible. Recognition of the factors that can contribute to the development of heat illness is important and in this regard a "Heat Index" (Bailes & Reeve, 2007)(27) becomes

extremely valuable. The Heat Index Chart is provided as Table 1.

Bailes & Reeve (2007)(27) describe the Heat Index as a measure of how hot it feels when temperature and humidity of an environment are combined. They state that when the heat index is between 90°F (32.2°C) and 104°F (40.0°C) heat cramps or heat exhaustion are possible. Heat stroke is possible when the heat index is between 105°F (40.6°C) and 129°F (53.9°C). Heat stroke will occur quickly with index values of 130°F (54.4°C) or higher. They also point out that exposure to full sunshine can increase the heat index values by up to 15°F (8.4°C). Ambient temperatures above 105°F (40.6°C) do occur and sports events are held under such conditions. It is, therefore, abundantly clear that any outdoor sporting activity, of any kind, at these temperatures will impose extremely stressful conditions on any athlete and participant.

Table 2 shows that the increase in perceived temperature with rising ambient temperature and humidity is progressive and non-linear. Therefore, the higher the temperature and humidity the increasingly greater risk of heat illness developing. Note how the perceived temperature changes with a one degree Celsius rise in ambient temperature from, for example 39°C to 40°C, under conditions of 30% percent humidity (=2.2°C) compared with 90% humidity (=7.2°C). As the ambient temperature rises above 40.6°C the gradients can be expected to become even steeper.

Although exercise professionals should be able to recognise and respond to heat illness, they should preferably prevent heat injuries by using sound judgement and observing some basic recommendations (Barrow & Clark, 1998(16); Seto *et al.*, 2005(17); CDC, 2006)(13):

Table 1. Heat Index Chart (Temperature and Relative Humidity (RH))*

Ambient temperature								
RH %	32.8°C	33.9°C	35.0°C	36.1°C	37.2°C	38.3°C	39.4°C	40.6°C
90	50.6	55.6	60.6	66.7	72.8	78.9	85.6	92.8
85	48.3	52.8	57.8	62.8	68.3	74.4	81.1	87.8
80	46.1	50.6	55.0	60.0	65.0	70.6	76.1	82.2
75	44.4	48.3	52.2	56.7	61.7	66.7	71.7	77.2
70	42.8	46.1	50.0	53.9	58.3	62.8	67.8	72.8
65	41.1	43.9	47.2	51.1	55.0	59.4	63.9	68.3
60	39.4	42.2	45.6	48.9	52.2	56.1	60.0	64.4
55	37.8	40.6	43.3	46.1	49.4	52.8	56.7	60.6
50	36.7	38.9	41.7	44.4	47.2	50.0	53.3	57.2
45	35.6	37.8	40.0	42.2	45.0	47.8	50.6	53.9
40	34.4	36.1	38.3	40.6	42.8	45.0	47.8	50.6
35	33.3	35.0	36.7	38.9	41.1	42.8	45.6	47.8
30	32.2	33.9	35.6	37.2	38.9	41.1	43.3	45.6

*This table is condensed from Bailes & Reeve (2007)(27). The original table was given in degrees Fahrenheit and has been converted to degrees Celsius.

Table 2.** The increase in perceived temperature with rising temperature and humidity.

RH %	33.9°C	35.0°C	36.1°C	37.2°C	38.3°C	39.4°C	40.6°C
90	5.0	5.0	6.1	6.1	6.1	6.7	7.2
85	4.4	5.0	5.0	5.6	6.1	6.7	6.7
80	4.4	4.4	5.0	5.0	5.6	5.6	6.1
75	3.9	3.9	4.4	5.0	5.0	5.0	5.6
70	3.3	3.9	3.9	4.4	4.4	5.0	5.0
65	2.8	3.3	3.9	3.9	4.4	4.4	4.4
60	2.8	3.3	3.3	3.3	3.9	3.9	4.4
55	2.8	2.8	2.8	3.3	3.3	3.9	3.9
50	2.2	2.8	2.8	2.8	2.8	3.3	3.9
45	2.2	2.2	2.2	2.8	2.8	2.8	3.3
40	1.7	2.2	2.2	2.2	2.2	2.8	2.8
35	1.7	1.7	2.2	2.2	1.7	2.8	2.2
30	1.7	1.7	1.7	1.7	2.2	2.2	2.2

** This table is derived from Table 1 (Bailes & Reeve, 2007)(27). The original table was given in degrees Fahrenheit and has been converted to degrees Celsius. Each value given is the difference between the Heat Index of the temperature given at the top of each column with that of the column to its left in Table 1. Therefore, the value of 5.0 given at the intersection of RH 90 and 33.9°C is the difference between its Heat Index value (55.6°C) and the Heat Index value given for RH 90 and 32.8°C (50.6°C) in Table 1.

Acclimatization

What is acclimatization? It can be described as the changes by which an individual adapts to repeated exposure to a stressful warmer environment. These changes reduce the physiological strain produced by such an environment allowing an individual to undergo heat stress that could otherwise have led to his/her death (Lugo-Amador *et al.*, 2004)(8). Acclimatization to heat is accomplished by exposure to heat while doing light to moderate exercise 1-2 hr per day. When done appropriately, acclimatization results in changes in physiology that will increase plasma volume and rate of sweating, as well as the onset of sweating at an earlier stage. The process of acclimatization will take about 10 – 14 days. The acclimatization

can, however, be lost fairly quickly as well. An acclimatized athlete is, therefore, able to exercise for longer and at a higher level of exertion, than a non-acclimatized athlete.

Seto *et al.*(2005)(17) list the changes in body physiology associated with acclimatization to heat as : Increased plasma volume, increased rate of sweating, increased blood vessel dilation under the skin, sweating commences earlier, decrease in electrolyte content of the sweat and decrease in the heart rate at a given work load.

Heat Stress

Recognition

In this context 'Recognition' implies different aspects. Recognition implies firstly the

understanding and acceptance by organizers and participants alike whether thermal stress conditions will be encountered and, secondly recognition of cases of clinical heat- and dehydration related conditions wherever they occur, should they occur. It would be irresponsible for any organization to run a formal event or tournament under conditions where heat stroke becomes a distinct possibility without taking all the necessary measures to counteract the possible effects. If a venue or event cannot be changed because of organizational considerations, then the possibilities of re-scheduling activities to avoid the times of greatest risk will have to be seriously considered. It would also be the duty of the organizing committee / body to advise intending athletes and other participants well in advance of the fact that anticipated conditions could hold possible risks.

Every effort should be made for archers to acclimatize to the expected conditions if these are markedly different from their home environment. According to Seto *et al.* (2005)(17) and Armstrong *et al.* (2007)(12) 10 to 14 days of exercise training in the heat will improve heat acclimatization and reduce the risks of exertional hyperthermia. However, the financial constraints of travel, accommodation and participation in major events will often make it difficult, if not impossible, for athletes (including archers) who need to acclimatize to expected ambient conditions, to do so. They will simply not have the time available. Archers and coaches must, therefore, be aware of the potential dangers of high temperatures and be prepared for them.

(Armstrong *et al.*, 2007(12); Seto *et al.*, 2005)(17) point out that coaches must be aware of the physical condition of their athletes. Conditions such as sunburn, skin heat rash, alcohol use and drug abuse, low fitness levels, antidepressant medications, obesity, over 40 years of age, poor heat acclimatization, sleep deprivation, viral illnesses and a history of heat illness have all been linked to an increased risk of hyperthermia. Athletes should also not exercise under hot conditions if they have a fever, respiratory infection, diarrhea or nausea.

It is also easy to forget that athletes are usually accompanied by coaches, managers and other

team officials. These persons are often no longer young, may well be overweight and physically unfit, and may also have a history of medical conditions. They may, therefore, be more susceptible than their team members. Team officials may not be as physically active as their athletes but it can be expected that they, especially coaches, will be exposed to the same environmental conditions of elevated temperatures as their athletes. It is, therefore, essential that coaches are aware of the dangers posed by high temperatures, not only to their athletes, but to themselves and take all appropriate precautions to safeguard themselves. Few things are likely to unsettle an athlete more than having his or her coach suffer an attack of heat illness during a competition and be incapacitated as a result.

Facilities will have to be made available, created if necessary, where athletes can take refuge from extreme heat and/or humidity and cool themselves down. This is one aspect where the health and well-being of athletes will have to take absolute precedence over the demands and expectations of TV and the media. Water and shade have to be provided in quantities appropriate to the conditions.

It is also important for National Sport Associations and National Olympic Committees to give more than a passing thought to the design and material of the uniforms their athletes are going to have to wear and compete in. Uniforms of materials and design that are inappropriate for the conditions that will be encountered could have a serious negative impact on performance.

How to avoid dehydration.

While poor physical fitness and inadequate acclimatization are major contributors to heat exhaustion when strenuous exercise is done in high temperatures (Armstrong *et al.*, 2007)(12) even fit and acclimatized athletes can become susceptible if environmental conditions are such that the effectiveness of heat dissipation becomes reduced.

The primary aim of fluid replacement is to maintain plasma volume so that circulation and

sweating progress at optimal levels. However, the rate at which fluid is lost by sweating may be twice the rate at which fluid can be absorbed by the body (Murray, 1987)(34). Sawka *et al.* (2007)(10) caution against over-drinking and emphasize that individuals should avoid drinking more fluid than the amount needed to replace their sweat losses.

The rate at which an ingested fluid actually enters the body's water supply depends on the rate at which it leaves the stomach (gastric emptying) and the rate at which it is absorbed across the intestinal membrane (intestinal absorption). Both gastric emptying and intestinal absorption are influenced by the composition of the ingested fluid (Murray, 1987)(34).

Three factors need to be considered for gastric emptying.

1. The gastric emptying rate decreases as the caloric content of the ingested fluid increases. Difference between water uptake and a solution containing 2.5 – 10% carbohydrate is negligible (Maughan, 1991)(35)
2. The rate of gastric emptying is related to the volume of fluid in the stomach (Maughan, 1991(35); Murray, 1987)(34) i.e. the amount of fluid emptied from the stomach is relatively large in the first minutes and then the rate slows down. Therefore, frequent ingestion of small amounts of fluid is preferable to the reverse. Thus 200-400ml of fluid should be ingested every 15-20 min because approximately 400 ml can be cleared in 15 minutes.
3. The temperature of the fluid may be important. The suggestion has been made that any sports drink that is ingested should be cold (15-21°C has been recommended) to enhance gastric emptying but recent evidence suggests that the gastric emptying rates of hot and cold beverages are the same (Maughan, 1991)(35). The real advantage of a cold drink may simply be that it tastes better, thereby encouraging a larger intake (Sawka 2007)(10). Of course a cold fluid also does not add heat to the body which a hot drink would.

In those situations where fluid replacement is more important than energy substrate

supplementation (i.e. short endurance events of 1-2 hr or an activity in high heat and humidity) the carbohydrate concentration should be low (2.5-8%) and the sodium content moderately high (30-110mg) (Maughan, 1991(35); Murray, 1987)(34)

Mineral replacement is important for cellular function as well as neurological competence (Rodahl, 2003)(26). This is important as archery is a highly mental sport so that any impairment of mental acuity can have serious consequences on the quality of the performance

Recommendations for Fluid Replacement

(Plowman & Smith, 2004(9);

Sawka *et al.*, 2007)(10)

Prior to exercise or exertion

1. The goal of prehydrating is to start the physical activity fully hydrated with normal plasma and electrolyte levels. If sufficient fluids are consumed with meals and a sufficiently long recovery period of about 8 – 12 hours has elapsed since the last exercise session, the person should be very close to full hydration.
2. Seto *et al.* (2005)(17) recommend the intake of 500 – 600 ml of fluid (preferably a carbohydrate/electrolyte sports drink) about 2 – 3 hours before exercise or exertion. A further 200 – 300 ml of fluid are then taken in 10 – 20 minutes before the exercise. Consuming beverages with sodium (20-50 mEq per Liter) and/or small amounts of salted snacks or sodium-containing foods at meals will help to stimulate thirst and retain the consumed fluids (Maughan *et al.*, 1996(15); Ray *et al.*, 1998)(36).
3. McArdle *et al.* (1994)(1) recommend taking in extra water before exercising in the heat as it provides some thermoregulatory protection. It delays the development of dehydration, increases sweating during exercise and brings about a smaller rise in body temperature compared to exercising without prior fluids. In this regard it is wise to consume 400 – 600ml of cold water 10 – 20 minutes before exercising. Doing this, however, does not eliminate the need for continual fluid replacement during exercise.

4. Drink early and often. Fluids are normally emptied from the stomach at a rate of about 800 – 1200ml per hour (McArdle *et al.*, 1994)(1). However, when a person is already dehydrated, gastric emptying is significantly delayed and symptoms of gastro-intestinal disturbance increase. The important lesson is to drink sufficiently early on during exercise before a state of dehydration is reached.
5. To avoid dehydration, adequate fluid intake is necessary (Seto *et al.*, 2005)(17). However, one of the problems is that thirst is an unreliable guide to the amount of water needed. By the time the athlete experiences a thirst during training or participation, the level of dehydration is already well established (Rodahl, 2003)(26).
6. Whether to supplement with plain water or carbohydrate/electrolyte beverage (Sports drink) is still matter for debate. For the vast majority of sports or fitness workouts plain water is the beverage of choice. Sodium is the only electrolyte that is physiologically beneficial under normal conditions when consumed during exercise (Maughan, 1991)(35); Murray, 1987)(34). Sodium is, however, also important in the post-exercise period. Drinks containing insufficient quantities of sodium dilute the plasma leading to increased kidney activity and also slow down the onset of thirst. Rehydration is thereby decreased. However, taking salt tablets is not recommended. Do not remove soaked clothing as it increases the evaporative area and aids cooling that way (McArdle *et al.*, 1994)(1).

According to Sawka *et al.*, 2007)(10) the composition of the fluid intake could be important. The recommendation for general “sports beverages” for persons performing prolonged physical activity is that it should contain sodium, potassium and carbohydrate. The need for these components will depend on the specific exercise task (for example, intensity and duration) and weather conditions. The sodium and potassium help to replace electrolytes lost in sweat, sodium also helps to stimulate thirst while the carbohydrate provides energy. These components could be ingested by non-liquid means, such as energy bars and other foods.

Important in this case would be the simultaneous intake of adequate volumes of liquid.

During exercise or exertion

1. Guard against dehydration, bearing in mind the volume of fluid lost to the body. This loss is by perspiration as well as the amount of water lost in exhaled air during exercise (3.5 ml of water per minute) referred to above (McArdle *et al.*, 1994)(1).
2. During exercise 200 – 300 ml of fluid, which could be either water or a sports drink, should be consumed approximately every 10 – 20 minutes of exercise or exertion (Seto *et al.*, 2005)(17)
3. The amount and rate of fluid replacement depends on the individual sweating rate, (Sawka *et al.*, 2007)(10). The goal of drinking during exercise or competition is to prevent excessive dehydration (which is more than 2% body weight lost by water loss) and excessive changes in electrolyte balance to avert compromised exercise or competitive performance.
4. If possible wear loose-fitting clothes while exercising in elevated temperatures. Loose clothes that absorb sweat and allow air circulation over the skin lead to enhanced evaporation, hence better cooling of the body. Do concentrated and can lead to gastric discomfort, dehydration and electrolyte loss (Caroline, 1991)(19); Steen, 1994)(37).
5. The above recommendation has its inevitable restrictions and limitations. Many sporting codes prescribe the attire worn by their sportsmen and women, which is frequently of a cut, material and colour designed with distinctiveness, visibility or national identity in mind, rather than functionality and comfort. Furthermore, some sports demand certain restrictions because of the nature of their activity. It would, for example, be completely inappropriate for a gymnast or sprinter to compete in a large loose floppy garment. The same comment applies to an archer. In such cases it becomes imperative that the athletes and their coaches remain alert for any sign of excessive dehydration or the onset of hyperthermia.

6. In most instances water replacement is more important than electrolyte replacement. Bigard *et al.* (2001)(38) found that rapid rehydration failed to restore muscle endurance after dehydration. It is, therefore, advisable to consume small volumes at regular intervals before the onset of dehydration and the detectable sensation of thirst.
7. Avoid the intake of alcohol (Haggerty, 2006)(14). Alcohol is a drying agent and will increase the level of dehydration rather than alleviating it. In certain societies the intake of alcohol after an event is a common occurrence but this is inadvisable in a dehydrated individual. Caffeine (tea and coffee) will also increase the volume of fluid that is excreted, which will aggravate the dehydrated condition.

For archers, FITA rules prohibit the intake of alcohol during competition in any case. Testing for alcohol ingestion can be done at any stage during a competition and persons found to be over the specified limit will be subject to disciplinary action (FITA, 2006)(39)

After exercise or exertion (Sawka *et al.*, 2007)(10)

1. Hydration after exercise or exertion has as its aim the replacement of any fluid and electrolytes lost. Approximately 500 ml of fluid (preferably a sports drink) should be ingested for every 2kg of body weight lost during exercise (Seto *et al.*, 2005)(17).
2. How aggressively the rehydration is to be done will depend on how rapidly the lost components have to be replaced and how much was lost during the preceding exercise or exertion.
3. If time permits consumption of normal meals with sufficient volume of plain water will restore full hydration, provided the food contains enough sodium to replace that which has been lost. Consuming sodium during the recovery period will help retain ingested fluid and help stimulate thirst (Ray *et al.*, 1998)(36).
4. Individuals needing rapid rehydration should drink about 1.5 liters of fluid for each kilogram of body weight lost during exercise (Sawka *et al.*, 2007)(10). This intake should, however, be

over a period with smaller volumes taken at intervals rather than the whole volume at the same time.

Hyponatremia

A word of warning would not be inappropriate at this stage. The intake of fluid (water) is essential for the physiological well-being of the body. However, as in so many other things, even water intake can become excessive and lead to a condition known as “water intoxication” or “Hyponatremia” described by (McArdle *et al.*, 1994)(1) as:

“Under **normal** conditions a maximum of about 9.5 liters of water can be consumed daily without straining the kidneys or diluting important chemicals. Consuming more than this volume can produce hyponatremia, or water intoxication, a condition related to significant dilution of the body’s normal sodium concentration. Early symptoms include headache, blurred vision, excessive sweating and vomiting. In extreme cases the person can develop cerebral oedema and can even become delirious, convulsive, comatose and eventually die. It is an extreme condition, is uncommon but has been reported even in experienced athletes”.

Exercise-associated hyponatremia has been reported in endurance runners (Ayus *et al.*, 2000)(4) and a number of participants from a variety of recreational activities (Backer *et al.*, 1999)(40). Contributing factors to exercise-associated hyponatremia include overdrinking of hypotonic fluids and excessive loss of total body sodium by excessive sweating (Sawka *et al.*, 2007)(10)

Recovery From Heat Illness

While every effort has to be towards preventing the onset of heat-induced illnesses due to dehydration, it may well happen that such cases are encountered. The very important consideration is: once the athlete has recovered from the hyperthermic episode, how soon can he / she return to training or competition?

Armstrong *et al.* (2007)(12) make the following recommendations:

1. Refrain from exercise for at least 7 days after release from medical care;
2. Follow up in about 1 week for a physical examination and repeat the laboratory testing or diagnostic imaging of affected organs that may be indicated, based on the physician's evaluation;
3. If cleared by the examination, begin exercise in a cool environment and gradually increase the duration, intensity and heat exposure for 2 weeks to acclimatize and demonstrate heat tolerance;
4. If return to activity is difficult then consider a laboratory exercise-heat tolerance test about one month after the hyperthermic incident;
5. Clear the athlete for full competition if heat tolerance is shown after 2-4 weeks of training.

The above recommendations show that competitive athletes and their coaches have to be very aware of the consequences of hyperthermia and take all the precautions to prevent its onset. The time required (shown above) before full recovery from an episode of hyperthermia can be assumed will exclude the athlete from participation in the remainder of the specific competition and, in certain sporting disciplines, could even mean the end of a career.

Comments and Recommendations Specifically For Archers

The dangers inherent in dehydration discussed above and the recommendations for the prevention of dehydration have been described and formulated from results obtained from sporting disciplines other than archery. However, they are equally and fully applicable to archers as well and it behooves the serious archer to take careful note of these.

The competition format currently used (at time of writing in 2007) in FITA outdoor tournaments involves several hours spent on the tournament

field shooting a full tournament round or a derived round. This exposure could be split by a shorter exposure on two consecutive days. Whatever format is used, the competitors are fully exposed to ambient environmental conditions for several hours. The environmental conditions that have been experienced in several world level archery tournaments in recent times have made it abundantly clear that archers have to be aware, and take careful notice, of the effects of high temperatures. One need only refer to the conditions at the Olympic Games of 1996 (Atlanta), 2000 (Sydney) and 2004 (Athens).

Ambient conditions at indoor tournaments could, of course, be equally strenuous, depending on the venue and the time of the year. The competitors are as exposed to these conditions as they would have been outdoors, with the same consequent risks of heat exposure.

It is incumbent on archers and coaches to take full cognisance of the effects of dehydration and respond appropriately. Especially the post-exertion rehydration requires consideration and frequently seems to be either forgotten or ignored.

During the match-play phase of the competition it is equally important for archers to remain hydrated. Archery is a technique-dependent sport requiring full mental acuity and any depression of that acuity by dehydration can lead to an unnecessary and disappointing reduction in performance. Brain function is particularly vulnerable to heat so any situation or condition, such as dehydration, that could lead to an increase in body temperature is to be avoided (Rodahl, 2003)(26)

One has to bear in mind that a muscle under tension is not perfused and can, therefore, not have its heat removed. In an archer who is possibly already partially dehydrated under elevated ambient temperatures and has a shooting style involving an extended holding period on full draw, the increase in body heat due to the inadequate perfusion of the tensed shooting muscles can only have negative effects on the physical and psychological wellbeing and performance of the person so affected. This should be avoided at all costs.

According to Rodahl (2003)(26) there are a number of indications that the head, and particularly the face, play a key role in the body's reaction to heat stress. It has been shown that cooling the face in physically active subjects caused a drop in heart rate without any change in blood pressure or rectal temperature. This could have important implications for archers. Stability of the bow arm is affected by the heart beat and a fast heart rate will show. Any action or mechanism that slows the heart rate without affecting perfusion rate will be of great benefit to a competitor in this sport.

There are restrictions on fluid intake which are found in other sporting codes (Ebert *et al.*, 2007)(3). These could be interruptions of a racing pace while running to take and swallow fluid, or it could be a change in posture to allow drinking, as in cycling (Coyle, 2004)(41). Coyle (2004)(41) also refers to a perceived benefit of under-hydration which is that it lowers the energy cost of movement or increases the available power-to-mass ratio. These considerations may be valid in sports where the athlete has to move his/her own body from one point to another but none of these restrictions apply to archers, who have ample time and freedom of movement, in which to maintain their hydration level.

A workable regimen of liquid intake for archers in an outdoor setting could well be the drinking of approximately 150-200ml of water or a palatable sport drink, taken on the competition line, after every 12 arrows during the Qualification Round. The intention is not to limit the volume taken in and if the archer feels the need for more than the volume mentioned there should be no limitation imposed. The important consideration is that the fluid intake is regular and in small quantities at a time.

As it normally takes about 20 minutes for 12 arrows to be shot, the fluid intake adds up to a minimum of about 450-500ml per hour. Depending on ambient conditions more can be taken but 450-500ml per hour is probably the minimum required. During breaks between distances additional fluid can be taken according to perceived demand. Following this regimen

will give a fluid intake of at least 2000ml over the four distances of the Qualification Round. For a shorter round the intake becomes correspondingly less. If ambient temperatures are really extreme a larger volume of fluid is likely to be required.

The intake regimen described above is what the author has recommended to the archers for whom he has been responsible. Experience has shown that the archers following this regimen did not feel dehydrated at the end of a full outdoor tournament lasting several hours.

A word of caution

With the consequences of substance abuse (even if inadvertent) as severe as they are, it behooves competitors to be very aware of what they drink. Leaving water bottles where they are easily accessible to someone else could contain an element of risk. On the other hand the level of wastage of bottled water seen at most competitions, probably because it is often supplied free to competitors, is hardly acceptable and represents a significant financial loss to the Organising Committee. Therefore, consider that clean and safe water is a scarce and expensive resource in many parts of the world. Don't take a mouthful or two from a bottle and discard it. If need be, carry your water with you. The bottles are not that big.

Conclusion

As pointed out in the introduction, outdoor archery is a sport where the stability and stamina of the archer are more important requirements than the ability to perform rapid movements of either an object or the archer's own body. A certain level of physical fitness is, therefore, a prerequisite for success in archery. Also, a significant amount of energy is expended during the course of a tournament. That is beyond doubt. Expenditure of energy leads to fatigue which has to be counteracted. The successful archer thus has not only to be physically fit but also physiologically fit, a condition which is susceptible to influences external to the archer. Outdoor archery is commonly associated with wind and elevated temperatures which can lead to

dehydration and which can result in poor muscle perfusion, resulting in fatigue.

The above discussion has also shown that mental acuity can be affected by dehydration. In archery a decrease in mental performance translates all too easily into a decrease in scoring performance, leading to intense disappointment. It is, therefore, advisable for a competitor, in any outdoor sport, to take careful note of the conditions under which the competition is to take place, and take all due precautions to counter any inhibitory external conditions.

One can only quote with acclaim the statement by Kirkendall (1998)(6) referring to soccer: “Hopefully, some respect for heat will be gained as well as confidence in the methods to minimize heat’s role as an additional opponent for the soccer player.” This is no less applicable to archery.

This review has shown that the dangers and possible consequences of exposure to high temperatures are not to be taken lightly. Athletes, and their accompanying team officials, must take serious note of the topics covered here, as experience has shown that no-one is immune. The recommendations by eminent specialists on how to avoid being affected by raised temperatures deserve to be taken seriously and it is in the interests of all, athletes and officials, that the health and performance of competitors is safeguarded at all times. If this review of the subject of sun and heat exposure leads to an increased awareness of the topic and saves one person from suffering a heat-related illness, it will have achieved its purpose.

Summary

Information on the response to heat exposure derived from athletes in other sporting codes are put into an archery perspective. The normal response to heat and the stressed responses to raised temperatures are described. The factors that lead to the onset of dehydration and heat illness are discussed as well as principles of water intake management. Hyperthermia and dehydration are shown to be fundamentally important to athletes and team members and

actions aimed at prevention of these condition are provided. Prevention is best achieved by the regular intake of small quantities of fluid before the onset of detectable thirst. Recommendations on water intake management, clothing, and acclimatization are discussed. Recommendations specific to archery are also presented.

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Sun Protection in Archery

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Introduction

Archery may necessitate prolonged exposure to the sun in summer and archers must avoid painful sunburn which may adversely affect their performance (1). Furthermore, epidemiologic evidence suggests that ultraviolet radiation (UVR), from **sun exposure** and sunburns during early life, is associated with increased risk of melanoma and other skin cancers in adulthood (9 and 10). Extensive print, radio, and television coverage about the dangers of sun exposure and benefits of **sun protection** occurred over the past decades (4).

Effects of Sun Exposure

The harmful effects of sunlight in children and adolescents are several. Apart from the most pronounced **skin cancer, photosensitivity disorders** can be listed as one of these effects and include genetic and metabolic diseases. Another harmful effect of sunlight is **photoimmunosuppression**, which refers to the suppression of the immune system by UVR. Both UVA and UVB participate in the suppression of immunity. **Photodamage (photoaging)** is another problem related to sun exposure which is a direct result of UVR-induced changes in the skin. The damage is cumulative and results in the characteristic signs: dry coarse skin, coarse and fine wrinkles, telangiectasia, mottled hyperpigmentation, roughness, and easy bruisability (8).

Even though UVR to the skin is essential for the synthesis of vitamin D₃, this beneficial UV effect is attained with minimal exposure. Thus, the harmful effects of exposing the skin to UVR far

outweigh any benefits. The need for protection from this radiation is urgent and must start in childhood (10). Adequate protection can be attained by changes in lifestyle, using protective clothing, and applying sunscreen (8).

The International Radiation Protection

Agency has issued guidelines for professional UV exposure (3 and 7). There is a need to study and identify the sun exposure characteristics in archery.

Sun Protection

Protective clothing

In Europe a standard of solar UV-protective properties of textiles is being discussed (European Committee for Standardisation CEN/TC248 WG14) (5). **Ultraviolet protection factor (UPF)** is the measure of UV transmission through fabric. The UPF of a fabric, which is measured spectrophotometrically, is affected by several factors, such as the type of fabric material, color, weight, thickness, porosity, stretch, hydration, and fabric-finishing processes. Summer lightweight fabrics such as bleached cotton, viscose, rayon, and linen provide limited UV protection, while polyester is more protective. Shrinking, by decreasing the “pores” between yarns, increases the UPF of the fabric. Treatment of the fabric with detergent having a UV absorbant significantly increases the UPF, while dyeing the fabric a dark color markedly increases the UPF. Hydration of the fabric by sweat or water decreases the sun protection properties of some fabrics. Stockings seem to offer limited protection to the legs. Once stretched (on human legs), the stockings’ UPF decreases substantially. Polyester fabrics offer increased protection against UVB but have significantly higher transmission for UVA compared to cotton, viscose, and linen. When finishing the polyester fiber with titanium dioxide, UVA transmission decreases. Fabric coatings may lose efficacy over time, however (5 and 8).

Hats with wide brims (>7.5 cm) impart acceptable protection to the nose and cheeks, while those with narrow brims provide negligible protection to the face; baseball-type hats can give some protection to the nose only (5 and 8).

Sunscreens

The sun protection factor (SPF) denotes the degree of protection afforded by a sunscreen in the spectrum between 290 and 340 nm. SPF is defined as the ratio of the time of UVR exposure required to produce minimal erythema in sunscreen-protected skin to the time for unprotected skin. The US Food and Drug Administration (FDA) has issued a monograph in an effort to standardize SPF ratings and labeling issues, instituted by December 31, 2001. Some of the current labeling will be implemented and others will be removed. As examples of changes in labeling, a “sun alert” statement may be included to warn consumers as to the harmful effects of sun exposure, to use “water-resistant” and “very water-resistant” instead of “waterproof,” and to drop the term “sunblock.”(8).

There are **physical and chemical sunscreens**. Physical sunscreens absorb and scatter all UVRs, as well as infrared and visible light. The usual ingredients in such sunscreens are titanium dioxide, zinc oxide, and red petrolatum, and these can be combined with a chemical sunscreen. As microfine particles of these physical compounds have become available, their use has made physical sunscreens more cosmetically acceptable. Chemical sunscreens are grouped into UVA blockers, UVB blockers, or blockers in both ranges. Most of the sunscreens available today are termed broad-spectrum sunscreens. The main classes of UV chemical sunscreens are as follows;

Cinnamates – UVB; Para-aminobenzoic acid – UVB; Salicylates – UVB; Benzophenone – UVA; Camphor – UVA; Dibenzoyl methane – UVA; Anthralin – UVA.

These chemicals differ in their relative protective value for a specific UV wavelength, as well as in their solubility, stability, and antigenicity. Combinations of chemicals are used to impart stable, safe, and effective sunscreens (8).

Not only is the active ingredient of a sunscreen important, but also the vehicle, amount of sunscreen applied, and frequency of application are important. The vehicles (ointments, lotions, creams, sprays) affect water resistance, durability, and cosmetic acceptability. The amount of sunscreen applied is important, as the SPF value is related to it. The FDA's recommendation is 2

mg of sunscreen per cm², or 30 g for the whole body. The use of lesser amounts of sunscreen results in lesser protection. Sunscreens of an SPF of 15 or more, with ingredients shielding from both UVA and UVB, should be applied 30 minutes before sun exposure and 15 to 30 minutes after sun exposure. It should be reapplied after swimming, toweling, or excessive sweating, and every 1-2 hours. Failure to use sunscreens properly results in ineffectiveness of the sunscreen. The beneficial effect of the proper use of sunscreens in protecting against the development of UV-induced DNA damage, which is the precursor of skin neoplasms, adds further support to the need for the use of sunscreens (8).

There are, however, concerns for the use of sunscreens. These concerns include allergic and irritant reactions to, and possible absorption of, toxic ingredients. Moreover, the use of sunscreens may give the user a false sense of security, thereby allowing the subject to indulge in sun exposure. The need for supplemental vitamin D, especially in children, has to be examined. The cost of sunscreens and protective clothing and the inconvenience of applying sunscreens properly, of wearing apparel that is restrictive in colors and fashion, and of changing one's lifestyle, all are apt to decrease the effort for photoprotection. Another concern is that some sunscreens, especially titanium dioxide, can generate reactive energy-containing molecules. If these concerns are kept in mind, the judicious use of sun protection is essential (8).

Given the high levels of exposure noted in outdoor activities, skiing, triathlon and cycling, it can be assumed that the archers should use UV protective measures, including sun-protection factor 30 broad-spectrum sunscreen (2, 6, 7 and 9).

Conclusion

Archers, referees, field crew, volunteers and coaches should be aware of hazards caused by UV radiation. Adequate protection by sunscreens and clothing are essential. Educational activities should be carried out to make all parties aware of the hazards of sun exposure involved in archery. A suitable sports dress (including hat) can offer high-quality protection against UV radiation. Adjusting training and competition schedules with low sun exposure seem to be a reasonable recommendation.

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Keeping archery a clean sport: the FITA anti-doping programme

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Why an anti-doping programme in archery ?

The world of sport has long been blighted by the problem of drug use and misuse. Doping practices have been used since the ancient times; there are a lot of tales about it. In modern times, the success, the awards, the glory, the personal and economic rewards have increased, in some athletes, the desire to win at all costs. To gain a competitive advantage, these athletes are tempted by the use external aids, to enhance the performance that genetic ability or training can not allow them to reach.

Luckily, archery has always been perceived as a clean and low risk sport in terms of doping practices, and this can be easily explained:

- although it is a traditional and world-wide sport, accessible to the great majority of people, its popularity and awareness with the spectators, the media, the sponsors and the public in general do not reach the levels of established "top sports" in the global sport picture, whether or not they are part of the Olympic programme. Hence a much lower level of pressure put on the athletes.

- archery does not require much physical stamina, nor violent and strong muscular efforts. As a consequence, the performance-enhancing effects of many of the prohibited substances in the World Anti-Doping Agency (WADA) list could be questionable in archery, and one can ask what would be the interest for archers to take that risk.

In the past four years, archery exposure has dramatically increased, with, for instance, the implementation of a World Cup circuit since

2006, in addition to the existing international competitions; - TV coverage generating 950 million viewers; - a www.archery.org traffic of almost 1.3 million visits in 2007, and the increasing and continuous support of prestigious sponsors. Of course this doesn't mean that doping practices go necessarily together with these very encouraging trends for the sport, but at least, this imperatively justifies the need to make every effort to maintain archery at its current low risk level and keep it as a clean sport. This is a duty owed to all the sport stakeholders.

Archery is a sport of concentration and precision, requiring strong self control and the ability to resist to stress. To achieve success in archery the athletes must be in an excellent mental state during competition and this is why all top archers devote a great part of their preparation to mental training. A strong individual uses mental self-regulation. This level of control is not easy to achieve and requires hundreds of hours of lasting work by the archer. Still, weaker individuals may be tempted to help themselves by taking prohibited substances to enhance their performance. There are many drugs and medicines providing performance-enhancing effects in these areas, and athletes who want to cheat could certainly turn to them.

FITA has always been at the forefront of the fight against doping. It was one of the first International Federations (IFs) to test for alcohol in a systematic way. It introduced out-of-competition testing in 1998 and in 1999 was the first IF to have the World Anti-Doping Agency (WADA) conduct its out-of-competition testing. At its 2003 Congress, FITA adopted the World Anti-Doping Code (the Code), and its anti-doping rules in compliance with its responsibilities under the Code have been implemented since April 2004. FITA has been part of the WADA Pilot Project and now the User Group for the online Anti-Doping Administration and Management System (ADAMS), which it has implemented since early 2005.

Nowadays, no sport can pretend it is 100% free from illegal doping practices. Keeping archery as a low risk and clean sport requires FITA to present evidence of its program to all stakeholders inside and outside the archery family.

Hence, based on the Code, through its anti-doping rules, FITA has given itself the tools to implement an exhaustive anti-doping programme that fits archery specificity, while complying with the requirements of harmonization prevailing in the Code.

What does the FITA anti-doping programme consist in ?

The definition of doping:

Doping is the occurrence of an anti-doping violation, and the following constitute anti-doping rule violations:

1. The presence of a prohibited substance and its metabolites or markers in an athlete's bodily specimen.
2. Use or attempted use of a prohibited substances or a prohibited method.
3. Refusing to submit to sample collection.
4. Violation of availability for out-of competition testing.
5. Tampering with doping control.
6. Possession of prohibited substances or prohibited method.
7. Trafficking in any prohibited substances or prohibited method.
8. Administration of a prohibited substance.

The Prohibited List of substances and methods:

This list is published and revised by WADA, generally on an annual basis, after consultation with all stakeholders, including IFs.

A substance or method shall be considered for inclusion on the Prohibited List if the substance is a masking agent or meets any two of the following three criteria:

- it has the potential to enhance or enhances sport performance,
- it represents a potential or actual health risk, or

- it is contrary to the spirit of sport as defined in the introduction to the Code.

The Code makes it very clear that a particular sport can not seek exemption from the basic list. The premise of this decision is that there are certain basic doping agents which anyone who chooses to call himself or herself "an Athlete" should not take. WADA may add additional substances or methods to the Prohibited List for particular sports, but this will be also reflected in the single Prohibited List.

Also, the Code makes it very clear that the question of whether a substance meets the criteria can not be raised as a defense to an anti-doping rules violation. For example, it cannot be argued that EPO detected would not have been performance enhancing in archery.

Which substances are performance enhancing in archery?

Let's consider two substances defined as specific to archery, as per the 2008 WADA list:

Alcohol

FITA is one of the few IFs to have alcohol as a performance enhancing substance in competition, and to systematically test for it. The presence of 0.10 g/L of ethanol in expired air is considered by FITA as an anti-doping violation, the competitor will be withdrawn from the competition and proper sanctions may be applied.

Alcohol suppresses certain brain functions, and at very low doses it reduces tension, inhibition and self control.

Competitors could misuse alcohol for psychological reasons, to increase confidence or reduce pain. It is more commonly used to reduce stress, tension and hand tremor which would obviously be beneficial in archery.

However, the issue of alcohol misuse in sport is complex, not only in archery, due to wide spread use (and abuse) of it in the general community.

FITA strongly advises its athletes not to consume any alcohol during 12 hours prior to a competition.



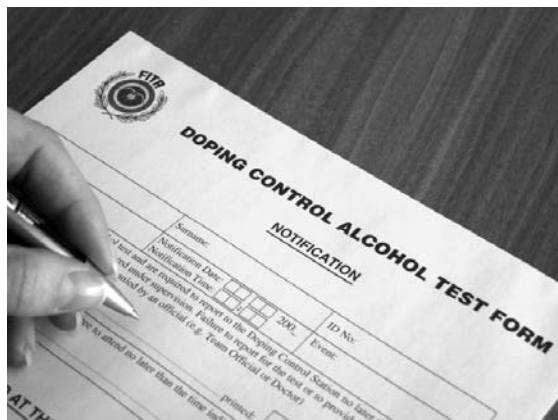
Beta-blockers

Beta-blockers have been prohibited substances in archery since 1985, as they may be used as performance enhancing substance. They are prohibited in and out of competition, in order to take into account its effects during training.

Beta-blockers act by blocking the effect of natural stimulants (catecholamine's) on the beta adrenergic receptors. These receptors are located in the heart, lungs and blood vessels. It is considered that beta-blockers enhance performance by reducing tremulousness, anxiety and tachycardia (fast heart rate) that athletes experience just before a competition. Conversely, beta-blockers impair performance in endurance events because they block the increase heart rate and thus cardiac output necessary to perform to one's maximum.

Adverse effects of beta-blockers include bradycardia (slow heart rate), inability to increase cardiac output when exercising, fatigue, depression and asthma.

Athletes use these substances to reduce anxiety and tremor, as well as to produce reduction of the heart rate and of arterial blood tension. Beta-blockers would be particularly popular among archers because a slower heartbeat gives the shooter more time to aim between heartbeats. The FITA MSSC has always been very concerned with the use of beta-blockers for alleged medical reasons, since it clearly enhances performances in archery (see below the issue of Therapeutic Use Exemptions).



Cannabinoids: performance enhancement or social use ?

Cannabinoids include both Marijuana (the dried leaves and flowers of the Cannabis Sativa plant) and Hashish (the dried resin extracted from the leaves).

Cannabinoids are prohibited in competition in all sports. A concentration of THC (tetrahydrocannabinol) greater than 15 ng/mL constitutes an anti-doping rule violation.

Many sports challenge their presence on the list since, as with beta-blockers, their effect would rather lower the sport performance than enhance it. The behaviour of elite competitors, who are influential role models for young people, can have a significant impact on them, as they admire them and aspire to emulate their sporting heroes, especially their actions and attitudes. High profile competitors should remember that they are regularly in the media and their actions can and do impact on many people. However, in archery, the performance-enhancing effect is also retained, since cannabis may evoke a subjective feeling of relaxation, lower heart rates, provoke euphoria and enhance sensory perception.

FITA continuously reminds its Athletes that cannabinoids are detected for several months after being used.

The use of illegal drugs brings all sport into disrepute and can ruin a sporting career. In addition to cannabinoids other "social drugs" such as cocaine, amphetamines and heroin are banned by all sports. The action taken by governing

bodies that test for these “social drugs” can include rehabilitation and treatment to assist competitors to overcome their drug problems.

Therapeutic Use Exemptions:

Athletes with a documented medical condition requiring the use of a prohibited substance or a prohibited method must obtain a Therapeutic Use Exemption (TUE).

Since January 2006, FITA has outsourced the management of its TUEs to the private independent anti-doping service provider IDTM. Each application is reviewed by a TUE panel which includes the Chair of the FITA MSSC and two other independent experts appointed by IDTM.

All FITA Registered Testing Pool (RTP) athletes and all athletes participating at international events must obtain their TUEs from FITA.

In addition, FITA gives the possibility to its Member Associations to use the IDTM service for their national level athletes, at cost.

FITA also applies a mutual recognition policy with WADA recognised National Anti-Doping Organisations (NADOs), on the condition that a copy of the certificate of approval from the NADO is provided.

TUEs applications must be received at least 21 days before the beginning of an event. Strict guidelines must be fulfilled to grant TUEs. The criteria set out in the WADA Standard that shall be considered by the TUE panel Members are the followings:

- The athlete would experience significant health problems without taking the prohibited substance or method,
- The therapeutic use of the substance would not produce significant enhancement of performance, and
- There is no reasonable therapeutic alternative to the use of the otherwise prohibited substance or method.

As guidance the panel can also refer to the medical guidelines established by WADA, based

on a pathology approach, and the internal FITA policy. As for examples:

- no TUE should be granted on a lifetime basis.
- pathologies requiring beta-blockers: FITA applies the principles in the statement made by the MSSC in October 2006 (see below). The panel will carefully consider the possibilities of alternative treatments and if no other solution can be found it is recommended that TUEs for beta-blockers are not accepted at least for the athletes in the FITA RTP.

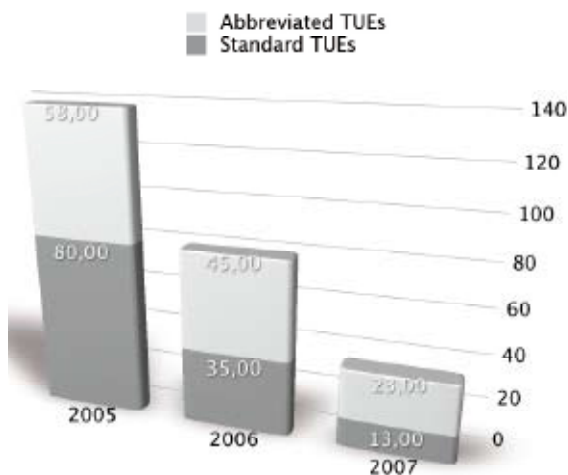
FITA MSSC Statement on beta-blockers (October 2006)

- *The FITA Medical & Sport Sciences Committee (MSSC) is in the opinion that there can be pathologies where only beta-blockers can be administered. However, it acknowledges also that many pathologies can be treated with substances other than beta-blockers that are not on the prohibited list of substances and methods.*
- *Therefore the MSSC recommends the FITA TUE panel a strict application of the World Anti-Doping Agency (WADA) Standards for granting TUEs for beta-blockers. This is to include the formal conclusion that there is no therapeutic alternative to the use of beta-blocker, based on provision by the applicant of a comprehensive medical history, results of examinations, laboratory investigations and imaging studies relevant to the application.*
- Banned substances administered as premedication prior to a surgical treatment: the TUE should not be granted for longer than one month.
- Retroactive TUEs (after a Doping Control resulting in an Adverse Analytical Finding): the principles which are well described in the WADA Standards and Guidelines will fully apply (need for emergency treatment or exceptional circumstances). Otherwise TUE applications have to be submitted as soon as a pathology requesting the use of prohibited substance or method has been diagnosed.

In the past months, FITA had serious concerns on how TUEs are delivered retroactively by certain NADOs to the national-level athletes, thus clearly showing provisions in national laws that are not in compliance with the Code.

TUE decisions are subject to further appeal according to the provisions of the Code and the FITA anti-doping rules.

Evolution of FITA TUEs in the past three years

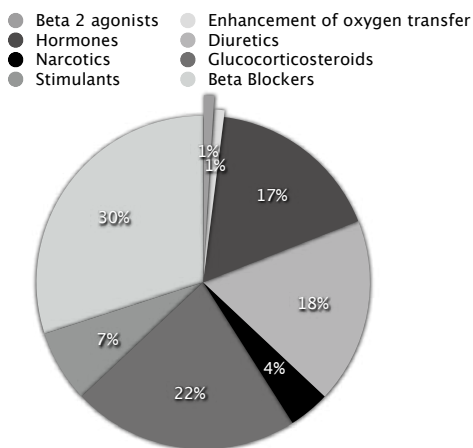


The current trend is for more Member Associations to refer to their national TUE authority. However, in both 2006 and 2007, the national athlete TUE applications received by FITA represented approximately 50% of the total applications received.

In 2007, seven Member Associations used FITA/IDTM services for their national TUE management, as opposed to 11 in 2006.

Which are the substances involved in archery TUEs ?

Standard TUES 2005-2007



Over the past three years 13 % of all applications have not been granted because of incomplete files, no response to requests for additional information. Only one application has been formally denied, and one application has been cancelled.

Testing programme:

FITA Testing programme includes both in and out of competition tests:

These tests are conducted by authorized sample collections agencies and performed in accordance with the WADA International Standard for Testing and the FITA anti-doping rules. Urine samples are shipped to WADA accredited laboratories for analysis and all analytical results are sent simultaneously to FITA and WADA.

In competition

For all FITA events, a minimum number of tests is defined in the FITA anti-doping rules, and then finalized by the MSSC in coordination with the Events Organizing Committees. Tests on medalists are combined with random and/or target testing. Under current FITA rules, a competition starts on the first day of competition.

The number of in competition tests has grown from approximately 100 in 2005 and 2006 to a total of 170 in 2007, certainly never reached before by FITA. This is due to the combination of the newly created World Cup and the Indoor and Outdoor World Championships. In addition some organizers went beyond the FITA requests in terms of number of tests conducted

Out of competition

Out of competition tests can be conducted anytime, anywhere, and without notice, on any athlete affiliated to FITA and its Member Associations.

According to the provisions of the Code, FITA has established a Registered Testing Pool (RTP) of those top level elite athletes who are required to provide up to date whereabouts information to FITA. The RTP is regularly updated as per the provisions in the FITA anti-doping rules, depending on the results of major events and world rankings. In the period leading up to the Olympic Games, all athletes obtaining a quota place for their country are also included in the RTP. The list of athletes in the FITA RTP is published on the FITA

website. The number of athletes it comprises vary approximately from 100 to 180.

Athletes are required to provide their whereabouts information through the WADA on line system, ADAMS (Anti-Doping Administration and Management System), on a quarterly basis. Any whereabouts received are automatically shared with WADA for the purpose of its own out of competition anti-doping programme. Thanks to training sessions organised at FITA events, a personalized and continuous approach of high quality contact and service to athletes involved, as well as to their Member Associations and coaches, the average response rate is no lower than an approximate 90% at each quarter.

However, FITA has set up a procedure for the management of the failures to submit, including a series of formal written warnings, for which a combination of three in a consecutive 12-month period may lead to the allegation of an anti-doping rule violation.

A total amount of approximately 60 out of competition tests are conducted each year, combining WADA and FITA's own tests.

Each year, 1 to 5 missed tests are recorded. Similar to the failure to submit whereabouts, a combination of three missed tests in a consecutive 12-month period may lead to the allegation of anti-doping rule violation.

Results management:

FITA has the responsibility of the individual management of all Adverse Analytical Findings (AAFs) results of tests conducted at international events, including, since April 2008, all Continental and World Ranking events.

For this purpose, the FITA Executive Committee has appointed an Anti-Doping Administrator, and, should the result management process lead to the allegation that an anti-doping violation may have been committed, an independent Anti-Doping Panel, consisting of a Chair, being a lawyer, and five other anti-doping experts. For each case assigned to the FITA Anti-Doping Panel for adjudication, the Chair shall appoint three members to hear the case.

For AAFs arising at the national level, FITA has the responsibility to monitor the case

management by the relevant national responsible body.

WADA's role is to monitor the results management, and, should the case occur, the hearing and sanctioning process followed or reported by FITA, and to assess it once the process is completed.

FITA Anti-Doping Panel and national disciplinary bodies decisions may currently vary from a warning to 2 years ineligibility, in addition to the disqualification of the results of the event in the case of an anti-doping violation arising as outcome of an in competition test. They are subject to further appeal according to the provisions of the Code and the FITA anti-doping rules.

Archery Adverse Analytical Findings 2005-2007:

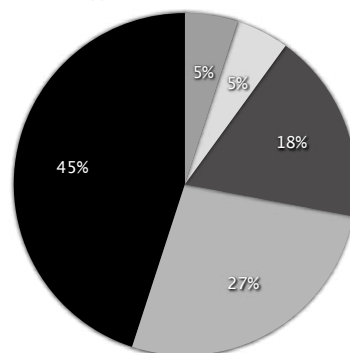
	AAF	Dismissed	Sanctioned	Sanctioned in %
2005	24	9	15	63 %
2006	10	6	4	40%
2007 (*)	12	7	4	33%
TOTAL	46	22	23	50 %

(*) Note: One of the 2007 AAF is still pending and has not come to an official conclusion at the time this article is written

Between 2005 and 2007, 22 AAFs case were dismissed for the following reasons:

Archery Adverse Analytical Findings Dismissed 2005-2007

- No Athlete's fault or negligence
- Test invalidated
- Physiological or pathological conditions (pregnancies)
- Elevated T/E ration which IRMS proved no exogenous origin
- Valid Tue (*)

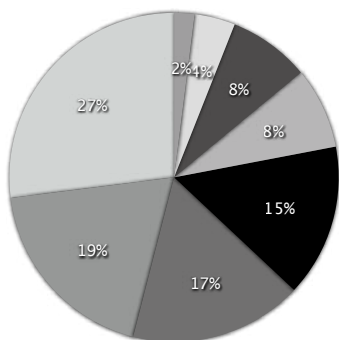


(*) Note: for 2 among of these TUEs FITA is in the opinion that the case was not managed in compliance with the Code by the relevant NADO

The 46 AAFs from 2005 to 2007 were found for the following substances:

All Adverse Analytical Findings 2005-2007

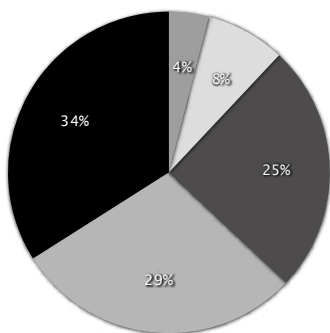
- Glucocorticosteroids
- Stimulants
- Anabolic Agents
- Cannabinoids
- Beta 2 agonists
- Hormones
- Beta-Blockers
- Diuretics



The 23 cases sanctioned between 2005 and 2007 are for the following substances:

Substances in relation to cases sanctioned 2005-2007

- Anabolic Agents
- Beta-Blockers
- Cannabinoids
- Stimulants
- Diuretics



Information and Education:

FITA is doing its best to inform and develop clean sport awareness among all its stakeholders (athletes, coaches, Members Associations, Events Organisers).

- For coaches, for example, a dedicated chapter on anti-doping matters has been included in the FITA Coaches Manual level 2, an official recommendation on anti-doping rules violation that may be alleged against Athletes Support Personnel has been published, and a large promotion of the WADA Coaches Tool Kit, released in 2007, has been made among Member Associations.



- A specific chapter has been developed in the FITA Organisers Manual, to address the requirements to FITA Events Organising Committees, especially in terms of Doping Control Station, contracts with sample collection agencies, number of chaperones requested. These topics are also regularly addressed during the FITA Organisers Seminars.

- For athletes, the MSSC has organised several information sessions in the past years, especially at Junior Events, and WADA information leaflets and athletes guides are systematically displayed at Doping Control Stations at FITA events. ADAMS training sessions have been already mentioned above in this document.

However, the general and most important communication tool for anti-doping matters can be found:

- in the FITA monthly newsletter „FITA Info”, published on the FITA website in French and English, and sent directly to hundreds of stakeholders upon request.

- in the “Clean Sport” section on the FITA website www.archery.org, which includes continuously updated key documents and policies on the FITA anti-doping programme, news, useful links, etc...-

Research:

As discussed above, although the use of doping substances are rare in sports requiring fine tuned motor movements, there are rumours that some archers tend to use such medicines that diminish anxiety and reduce body sway during shots. This may positively affect shooting performance. The FITA MSSC has decided to carry out a project in order to find out whether there is such an effect of anxiolytic substances on performance. This project has started in 2007, in cooperation with the WADA Accredited Turkish Doping Control Centre, the Faculty of Medicine Pharmacology

Department, the School of Sports Sciences and Technology at the Hacettepe University in Ankara, Turkey, the Ankara University Faculty of Medicine Sports Department, and the Turkish Archery Federation. A research group is planning to perform a double blind study on elite archers in order to evaluate the effects of a benzodiazepine on athletic performance. The analysis method(s) with regard to the benzodiazepine(s) and their metabolite(s) will be developed and optimized in the laboratory. After the validation of the method(s) in urine due to EUROCHEM and ICH Guidelines, the samples will be analyzed in the laboratory. The results will be submitted to WADA for further studies, if necessary.

The WADA on-line Anti-Doping Administration and Management System (ADAMS):

FITA has been involved in the early stages of the development of this online management tool, first, as part of Pilot Project Working Group, and now as part of the User Working Group. After a start with the RTP athlete's whereabouts management, in January 2005, all aspects of the FITA anti-doping programme are now managed through this system. However, FITA is of the opinion that this tool will become fully operational only when the users network is expanded and includes all NADOs and WADA accredited laboratories.

Looking at the future

In 2006, a wide consultation process for the revision of the 2003 Code was launched by WADA, in which FITA took an active part. At the World Anti-Doping Conference held in Madrid in November 2007, a new version of the Code was unanimously approved by all stakeholders, including NADOs, National Olympic Committees, governments and IFs. The new Code will come into effect as of 1 January 2009, and important new Code related Standards, such as Testing and Therapeutic Use Exemptions, have been released by WADA in mid-May 2008.

FITA has therefore started the review of its current anti-doping rules and related procedures to maintain them Code compliant beyond the 1 January 2009.

Without going into the details, the main changes include:

- Increased sanctions in doping cases involving aggravating circumstances, with a spectrum of anti-doping rules violations that can lead to a 4-year ban for a first serious doping offence,
- Greater flexibility: for example lessened sanctioned are possible where the athlete can establish that the substance involved was not intended to enhance performance,
- Specified substances (substances which are particularly susceptible to unintentional anti-doping rules violations because of their general availability in medicinal products which are less likely to be successfully abused as doping agents): the revised Code now provides that all prohibited substances, except substances in the classes of anabolic agents and hormones and those stimulants so identified on the Prohibited List, shall be "specified substances" for the purposes of sanctions,
- Mandatory provisional suspension after AAF through analysis of the A sample at least on substances that are not specified substances,
- Harmonization and standardization of rules for the provision of athletes whereabouts information and missed tests: athletes in RTP will be required to specify one hour each day during which they can be located at a specified location for testing. Also, the revised Code formalizes that any combination of three missed tests and/or failures by an athlete to provide accurate whereabouts information within an 18-month period shall constitute an anti-doping rule violation,
- Elimination of the concept of Abbreviated TUEs: all athletes needing to use inhaled Glucocorticosteroids (GCS) and beta2agonists for asthma must have a medical file recorded into ADAMS; athletes part of an international RTP will need a Standard TUE for those substances. For other athletes, it is at the discretion of the IF or the NADO to deliver a TUE or to approve a retroactive TUE in case of an AAF. For non inhaled, non systemic GCS a simple declaration of use will be required.

- Code signatories shall implement information and education programs
- Athletes Support Personnel who participate in a competition organized by the IF or its Member Associations will be required to agree to be bound by anti-doping rules in conformity with the Code as a condition of participation.

Throughout this article, we have tried to demonstrate how the FITA commitment to maintaining archery as a clean sport, through its comprehensive anti-doping programme, is both an ongoing process, and a continuous challenge. The FITA MSSC is proud to take it up, and will pursue its efforts together with the anti-doping and archery communities.

Acknowledgements

I would like to express my gratitudes to Dr.Karol Hibner, Dr.Emin Ergen, Dr.Carlos Hermes, Dr.Jean-Claude Lapostolle and Ms.Nancy Littke for contributions and help.

Useful links

FITA website www.archery.org – „Clean Sport” section

WADA website www.wada-ama.org, and in particular:

The Prohibited List:

<http://www.wada-ama.org/en/prohibitedlist.ch2>

Therapeutic Use Exemptions:

<http://www.wada-ama.org/en/exemptions.ch2>

Information resources for athletes:

<http://www.wada-ama.org/en/dynamic.ch2?pageCategory.id=442>

Education:

<http://www.wada-ama.org/en/dynamic.ch2?pageCategory.id=262>

Revised Code:

<http://www.wada-ama.org/en/dynamic.ch2?pageCategory.id=735>

International Standards:

<http://www.wada-ama.org/en/dynamic.ch2?pageCategory.id=268>

Links with National Anti-Doping Organisations:

<http://www.wada-ama.org/en/dynamic.ch2?pageCategory.id=245>

A psychological approach model:

Advanced Autogenous Training in Archery

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1. Introduction

This study was designed to determine the effect of psychological preparation, as a complimentary part of training, to improve the average performance of competitive archers.

The project was presented to all partners at an informative session. During the initial session, with all subjects in the room, I spent several minutes explaining what my plans were. I explained that, because of their interest in a psychological intervention in their training and my passion with regards to this topic and in archery, I have obtained permission to develop a training program using autogenous exercises, to introduce these exercises to this group and to collect and study the data that I will collect. .

Some subjects then chose to drop out following this session. Seven subjects, six male and one female, continued with the study as described and became the test group. The data from this group was then compared with the five subjects, 4 male and one female, in the control group.

The autogenous training consists in a technique of psychic concentration, that allows the individual to modify psychic and somatic situations enhanced with the visualization, we would practice this technique one day to the week and that, at the end of every training they would have had to compile a “diary” that picked up the data

related to the feelings they experienced. The data of the “diary” would be anonymous so they would be able to express their thoughts freely and not be judged by anyone else.

The subjects in the study group attended an advanced autogenous training session one day a week before their actual shooting training. The advanced autogenous training was carried out in a dressing room adjacent to the gym. A second room next to this one was used by the author to control the lighting and read the sequences of the relaxation theme to the subjects. The subjects laid down on a big mat and listened to the music provided.

A great deal of attention was paid to the choice of this last: the music had to enhance the feelings that were transmitted by the relaxation exercise. It was important to contain some constant tones to avoid diverting feelings provoked by an increase or a diminution of the rhythm and encourage the subjects to relax. My choice was “-Tranquil Moods - the power of relaxation; Whales of the pacific”, the sound of waves breaking against the rock-cliffs and accompanied by the mystical songs of dolphins and whales. When the subjects had reached a visual calm, when they had stopped speaking and moving indicating a readiness to proceed, slowly and with a very peaceful voice I began to read the pre-arranged sequence.

The attendance of the subjects was inconsistent. Whether related to job or personal interruptions they were unable to be present every week and some sessions were missed. Some subjects dropped out after beginning the program and other subjects joined in the midst of the series of the programmed sessions. The solution devised to deal with this inconsistency in attendance was to always begin with the same initial sequence. This allowed me to continue to observe good results and to allow the athletes who did attend repeated sessions to begin to understand how effective the sessions were and become more motivated to attend.

2. The Sequence of the Mental Training

The sequence of relaxation exercises were designed by respecting the standard format of autogenous training sessions in the literature and

were enhanced with the visualization of activities related to the targeted sport of archer.

The exercise sequence began with the subjects assuming a comfortable position and gaining control of their heart rate and respirations. Subsequently the subjects were asked to imagine having the body full of water until they could feel the skin ready to burst by the pressure: this image was associated with the visualization of the tension that one feels when the muscles are fully contracted and stiff. They were then instructed to allow the water to flow out of the body and muscles through their fingers and toes, and using gravity allow all the water to exit their body. As soon as water goes down, the whole body is freed from the tension remaining, allowing the sequence to end in a state of calmness. To this point, the subject would feel lighter, having been freed from the weight of the tension, and ready to undertake an imaginary flight. They were then encouraged to fly over landscapes that, for each individual, arouse feelings of calm: they then see a log cabin and enter for a rest on a comfortable armchair. On a table in front of the armchair, they find a sheet of paper with a magic pen: they may write anything they want. What they write will remain a secret as this pen has a magic ink that disappears as soon as the words are written. Which better occasion, then, to be able to discharge all their thoughts, tensions and worries?

The feeling that they will try to achieve will be that of liberation and of calm and they will be able to begin their visualization to improve their athletic performance.

However the session does not end at this moment, because, if the subject still has some hesitation or tension remaining, another strategy is proposed: to put the sheet in a safebox, to lock it and to throw the key in a beautiful brook that is found outside the log cabin. In this way a real separation happens with the problems and they can proceed to the next step in the exercise.

The subjects are instructed to go on a walk and, in an enormous clearing that resembles the field of competition, they see a target on the horizon: the target is enormous, it seems that it is easy to strike the center that pulsates recalling the heartbeat; the colors are extremely bright. The

desire to shoot becomes so intense that a bow materializes so close to the subject, they grasp it and prepare to perform the sequence of the perfect shot dreamed of by every archer. Every single movement is performed with the maximum care to detail and the whole action results in the perfect ending: exceptional feelings and a perfect shot is manifested with a memorable center.

These feelings of satisfaction and control are so strong that the subject is motivated to repeat them in training, taking in hand their own bow and repeating down to the least details those sequences that these beautiful moments have given him.

Some moments of silence follow the exercises allowing the body to resume normal rhythm and awaken as the subjects are encouraged to focus on the varied parts of the body, beginning from the feet and ending with the head, trying to perceive initial heaviness again, subsequently the hands and the feet were moved and, when they feel ready they were asked to open the eyes. The whole sequence lasted approximately twenty minutes.

Not all the subjects woke at the same time. Generally, this happened within a couple of minutes and if I saw that someone didn't appear to be moving, I drew near to the party and I repeated the sequence of awakening.

3. Conclusion of the Sequence Exercise

Once that all the subjects were conscious and aware, they were allowed to remain still in the faint light: the arms and the legs were stretched well and they took advantage of that sense of calmness that resided in them. Slowly the door was opened allowing more and more light to enter until arriving at a normal illumination.

While in this position we began a small exchange of information. I asked them if they had succeeded in visualizing what they were proposed or if they had succeeded in perceiving the feelings as described. The answers depended a lot on the degree of "seniority" to the sessions: how much practice they had acquired, if they had taken the exercise seriously, and if they had succeeded in relaxing completely. Generally in the first session the most sincere described falling into a nice

sleep and that they had felt relaxed. However, they would come back to me after their shooting practice and indicate that the session had been very good. Apparently, even though they thought they had only slept, the muscles had relaxed completely, on an unconscious level, they had received and incorporated the positive messages and repeated this on the field.

Following this discussion, the subjects moved into the next room, gathered their equipment and proceeded with their normal shooting practice session.

4. The Diary

At the end of the training, the subjects and control group were asked to complete a diary (see appendix A) which allowed them to keep record of their state of mind. It was composed of four parts: (1) personal data: the date, times of sleep and name of the athlete (most athletes used a nickname to ensure anonymity); (2) The second part included a description of the athletes mental state when they arrived at the venue. (3) The third part contained some practical data about the archery training such as the distance from which they shot, the number of the arrows, the duration of the training, if they had performed the mental preparation exercises and whether the session was a practice or a competition. (4) The fourth part included an analysis of their feelings following the practice. They were to note how motivated they were to practice or compete, did they have

their mind on anything other than the task at hand and to evaluate how the session went. They were to comment on whether they had anything happening that may interfere with the success of this shooting session, their level of concentration and anxiety levels. The athletes were then to complete a plan that would help maximize their shooting next session.

The “diary” has been formulated in the manner to be more understandable and easy to fill in, to avoid that the subjects, already reluctant to perform the assignment at the house, they took as it excuses the difficulty to compile it: the affirmations were short sentences, formulated in positive manner and the degree of judgment of these was given by a staircase numerical placed side by side to the same sentence with some indexes that went from zero to seven.

The “diary” was concluded with a look to the future, pointing out the next appointments and, very importantly to identify something positive found during the training. I have noticed that this last point helped the athletes to let go of the negative feelings and to gather on the positive things and keep these in their mind for the future.

The diary was designed to be very simple to complete in order to prevent the subjects complaining about it being too time consuming and failing to follow through with the note keeping. The sentences were short, formulated in a positive manner and the scoring scale was an eight item scale indexed from zero to seven.

APPENDIX A TRAINING DIARY

Date: _____

How much have I slept this night?: _____

My name is (you can put a nickname here): _____

ATTITUDE

HOW DO I FEEL PHYSICALLY TODAY? 0 1 2 3 4 5 6 7

HOW DO I FEEL MENTALLY TODAY 0 1 2 3 4 5 6 7

WORKOUT

SHOOTING DISTANCE..... meters

NUMBER OF ARROWS SHOT ...

DURATION OF TRAINING..... hours

TODAY'S JOB/TASKS/COMMITMENTS/OBLIGATIONS _____

HAVE I PRACTICED MY MENTAL TRAINING? YES NO

HAVE I PARTICIPATED TO A COMPETITION? YES NO

GOALS EVALUATION

WHY IS IT IMPORTANT FOR ME TO REACH THE OBJECTIVE?

BEFORE ARRIVING TO TRAINING:

- I had other thoughts 0 1 2 3 4 5 6 7

- I felt like shooting 0 1 2 3 4 5 6 7

NOW THAT THE TRAINING IS ENDED:

- My objective have been reached 0 1 2 3 4 5 6 7

because:

- the persons bothered me 0 1 2 3 4 5 6 7

- my concentration was: 0 1 2 3 4 5 6 7
- my material worked: 0 1 2 3 4 5 6 7
- my technical gesture was: 0 1 2 3 4 5 6 7
- my anxiety was: 0 1 2 3 4 5 6 7

I WILL TRY TO IMPROVE:

- Asking silence from others 0 1 2 3 4 5 6 7
- Assembling with myself more 0 1 2 3 4 5 6 7
- Checking the material 0 1 2 3 4 5 6 7
- Facing/Crossing again the action mentally 0 1 2 3 4 5 6 7

NEXT TIME I WILL WORK ON: _____

A POSITIVE THING THAT I HAVE LEARNED IS _____

5. My Hypothesis

I hypothesized that by analyzing the diaries of the subjects, in time, some changes in the way they perceive their own feelings accompanied by an increase of the use of the imagination and the mental revision would be apparent. Initially

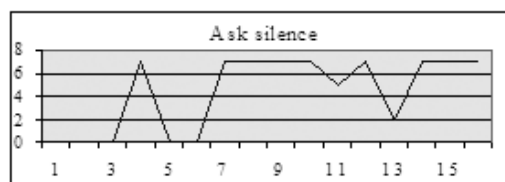
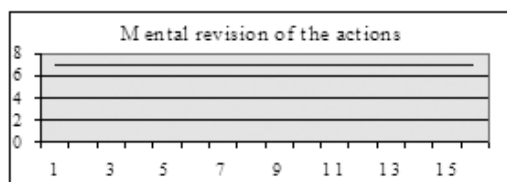
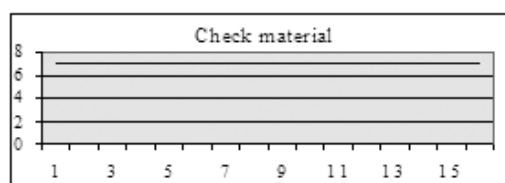
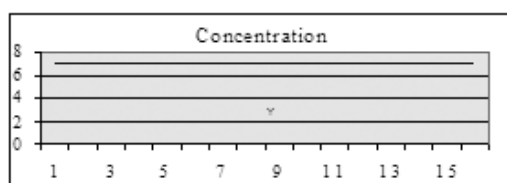
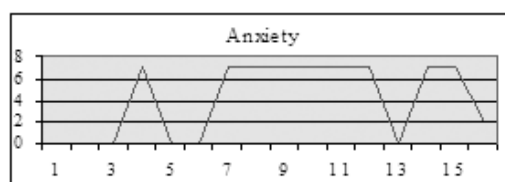
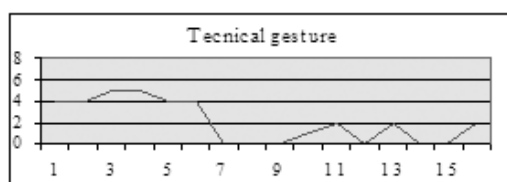
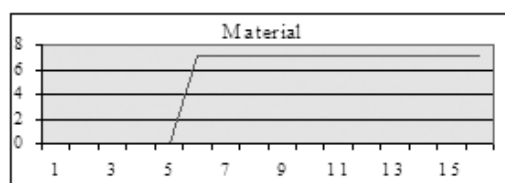
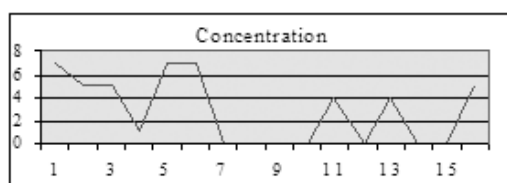
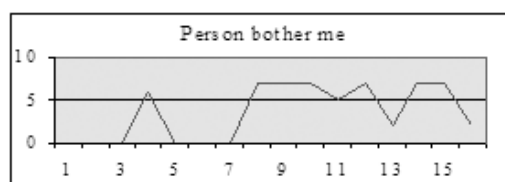
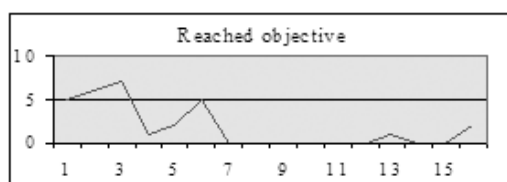
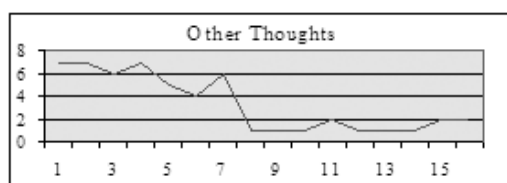
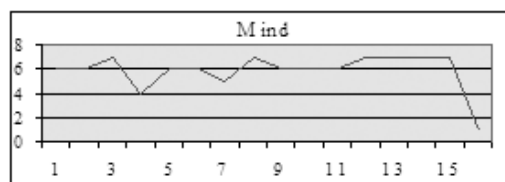
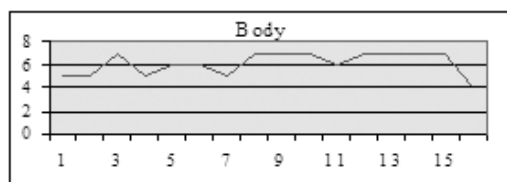
I planned to only study the experimental group and to go to analyze the course of the “diaries”, however I decided to also form a control group, to be able to make a comparison, between subjects that have participated in the experimentation and subjects that have not. The control group was not

Table 1. Summary of diaries

SUBJECT: BE Experimental group		<div><div>average 1</div><div>average 2</div><div>average 3</div></div>											adv tat	adv 1	adv 2	adv 3
		Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	Day 10	Day 11				
Body	FS	3	4	5	6	6	7	1	6	7	5	6	5,09	4,50	5,00	6,00
Mind	MT	3	4	5	6	6	7	2	6	7	6	6	5,27	4,50	5,25	6,33
Other thoughts	AP	7	4	1	1	0	0	6	2	1	2	2	2,36	3,25	2,00	1,67
Desire to throw	VT	0	4	5	6	6	7	2	6	6	6	6	4,91	3,75	5,25	6,00
Reached objective	MR	1	4	6	6	7	7	3	7	7	6	6	5,45	4,25	6,00	6,33
The persons bother me	PI	4	1	0	0	0	0	0	0	0	0	1	0,55	1,25	0,00	0,33
Concentration	C1	2	5	6	6	7	7	2	6	7	7	7	5,64	4,75	5,50	7,00
Material	MA	2	5	6	6	6	7	2	7	7	5	5	5,27	4,75	5,50	5,67
Tecnical gesture	GE	5	6	6	6	6	7	2	7	7	7	5	5,82	5,75	5,50	6,33
Anxiety	AN	4	2	3	0	0	0	0	0	1	0	0	0,91	2,25	0,00	0,33
I ask silence	CS	0	0	0	0	0	0	0	0	0	0	0	0,00	0,00	0,00	0,00
Concentration	C2	3	4	5	6	6	7	7	7	7	7	7	6,00	4,50	6,75	7,00
Check material	CM	4	5	5	6	6	7	7	7	7	7	7	6,18	5,00	6,75	7,00
Mental revision	RA	0	2	7	7	7	7	7	7	7	7	7	5,91	4,00	7,00	7,00

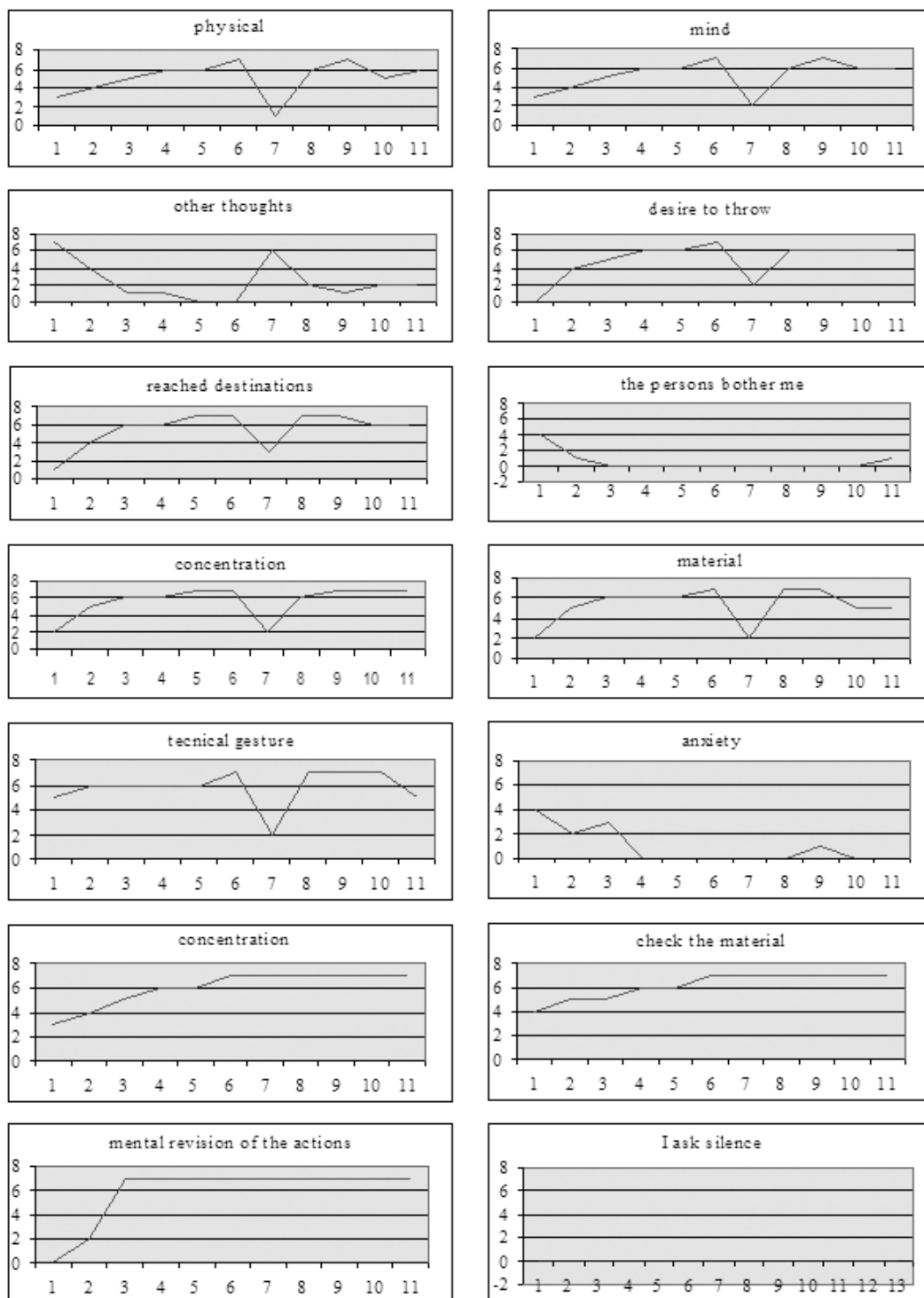
Example of a subject of the control group

Couise of tooth of shark



Example of a subject of the experimental group

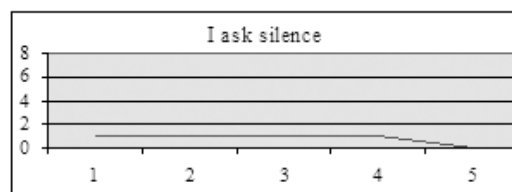
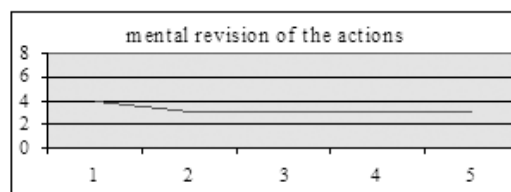
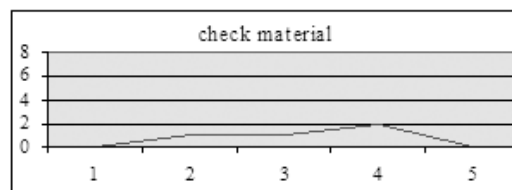
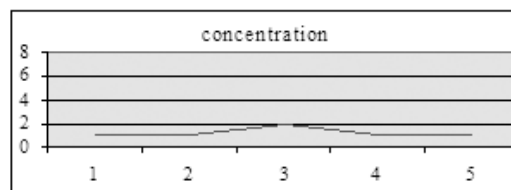
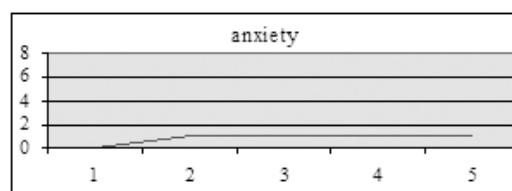
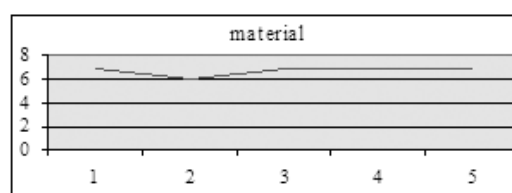
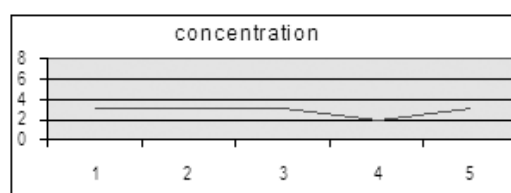
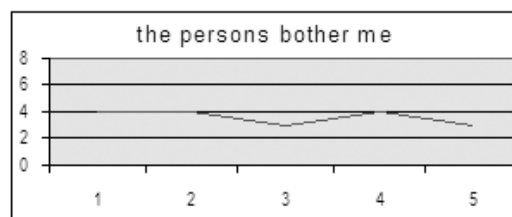
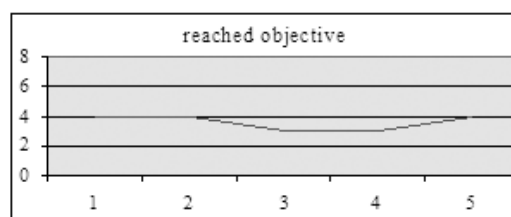
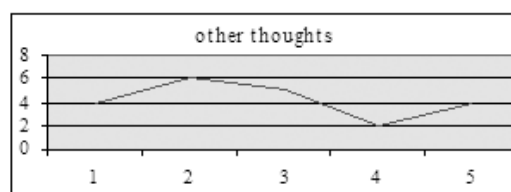
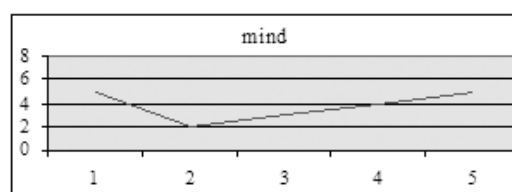
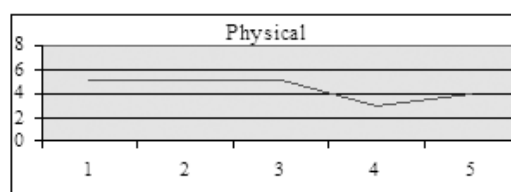
Graphic of course of the variable in the time



Example of a subject of the control group

Linear couise

Graphic of couise of the variable in the time



involved in this type of mental training session as I felt it too difficult to blind these subjects to the actually training effects. The control group may have been involved with another type of mental training exercises and I wanted to determine if autogenous training was more effective than the program they were involved in.

Completed the scheme, I have gathered them in three groups that represented three periods from to take in consideration. This subdivision has been done, gathering the diaries in base to the date of compilation. This has allowed me, to compare the initial situation with the final one so that to be able to see the changes. In the final columns, I have inserted the averages of the periods and the averages of the data (Table I).

6. The Analysis of the Data

Analyzing graphs that expressed the course of the single variable in time, I was able to observe some notable variable differences between the experimental group and that of control: the experimental group introduced in general the same course pattern, increasing or decreasing, while control group variables presented a certain stability in the time (the graphs had a flat course), or they were represented by a course to “shark tooth” In the two following pages, I have brought

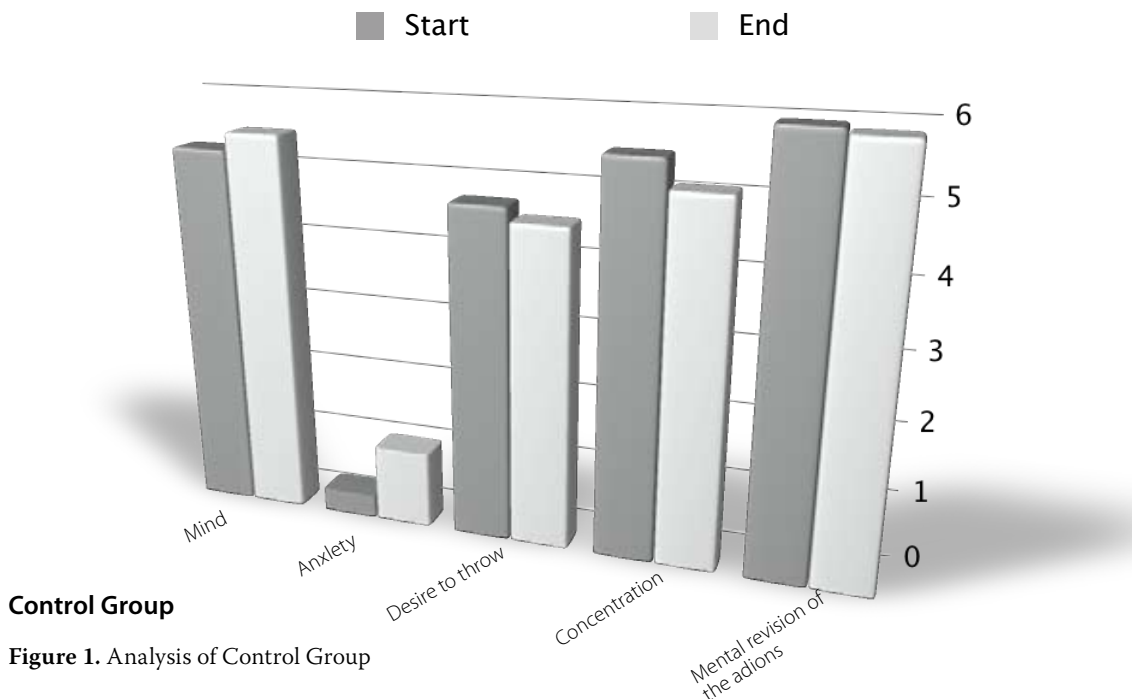
the example of a subject of the experimental group and two subjects of the group of control respectively one with course to “shark tooth” and the other with flat course.

The interpretation that I have given to the courses of the two groups has been that, the experimental group has been influenced by a variable day-person to the behavior of the group. The control group course graph didn't suffer from any external factors. I have provided a graph for every subject, for each of the fourteen variables studied, in order to be able to analyze the course of the same in a temporal relationship. In ordinate (x axis) I have represented the points assigned to the single variable, while in abscissa (y axis) we find the temporal scale. By unifying all the points, I have obtained a continuous line that expresses the course of the variable in the time.

To be able to analyze the variability of the collected data from the group, I have proceeded to apply a t-test for dependent variables that allowed me to identify the significant variable for every group. Now, I have analyzed them individually.

The control group (Fig. 1):

1. The variable that identifies an increasing course is: to feel mentally well raises from 5.47 to 5.60 and the anxiety scale from 0.41



to 1.20. These results make us to deduce that, despite the subjects identify an increase in the score measuring “to feel mentally well”, their management of the anxiety level is critical.

2. The decreasing course is verified in the “desire to shoot” score, that changed from 4.75 to 4.66, in the “to use of concentration” score, that goes from 5.60 to 5.26, and in the “mental revision” score, from 6.20 to 5.90.

It can be said that, if a systematic revision of the actions supported by the autogenous training is not performed, an effect of chain that involves a diminution of the concentration and the consequent diminution of the desire to shoot is verified.

The experimental group (Fig. 2):

1. Concerning the meaningful variables group, the only one which introduced a decreasing course was the technical gesture score (self evaluation of sequences of a shot) that has dropped from 5.09 to 4.99.

This means that, the subjects who practiced autogenous training have automatised the technical gesture and therefore they did not have to pay more attention to it in order to improve their performance.

2. The remaining variables below, introduce all one increasing course;
 - the body from 4.33 to 5.94;
 - the mind from 4.07 to 5.45;
 - the application of silence as it surrounds the archer from 1.11 to 1.89;
 - the concentration from 4.04 to 6.40;
 - the control of his own material from 3.92 to 4.94;
 - Finally the mental revision of the actions goes from 2.92 to 6.85.

The revision of the athletes mental process helps to increase concentration and leads to automatization of the gestures that, in time, requires less control over it. If the subject is able to implement this ability he/she will acquire a great deal of self-esteem and feel better consequently either physically or mentally.

A more detailed analysis has been carried out by comparing a single variable within two groups. The following is the comparison between the first and the last (third) period of observations.

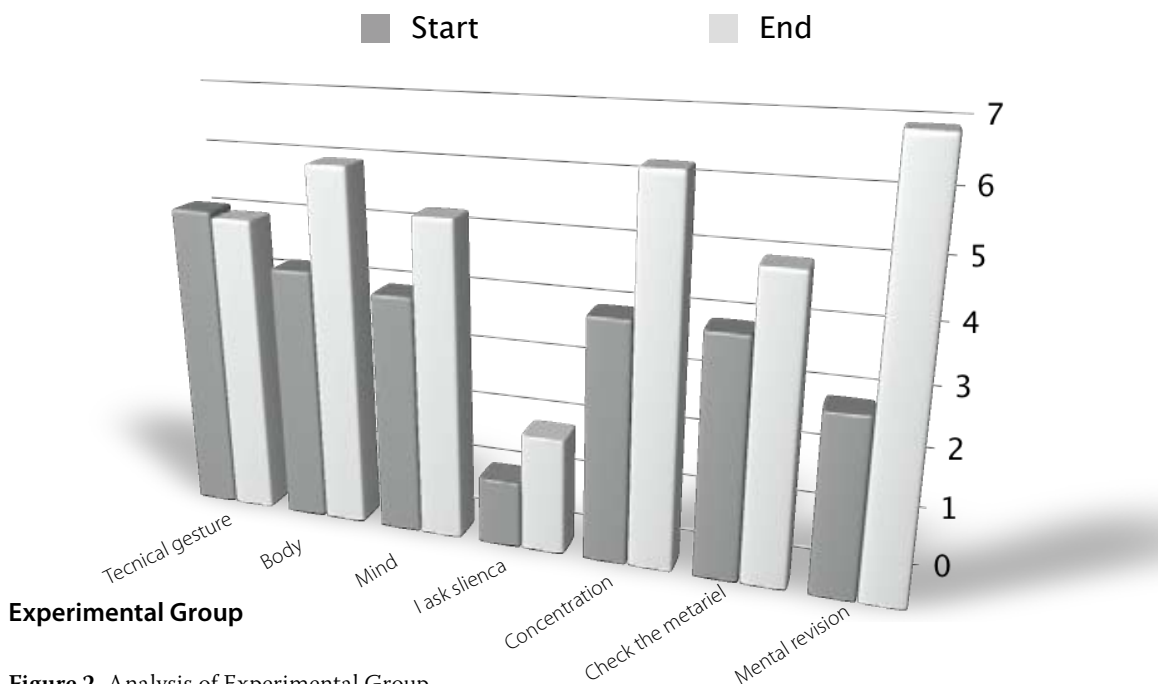


Figure 2. Analysis of Experimental Group

Body

The data attributed to this variable is about the subjective feeling of the archer related to his/her physical wellness. One can notice that the increments in the experimental group is greater than that of controls ($p < 0.05$). Evidently, the increase in the concentration and the use of visualization allows the athlete to identify a sequence of shooting, that employs correct muscle groups and avoids the firing of incorrect muscles like antagonists creating an undesired pattern (Fig.3) .

Concentration 1

This data is related to the extent to which the subject feels concentration during training. The subjects of the experimental group, although this has presented greater initial values, 4.85 against 4.19, experimentation induced an increase of the values equal to 0.57 against a 0.09 of the group of control ($p < 0.1$). This shows that, the experimental group used the techniques more, probably because they became familiar with the benefit of it (Fig. 4).

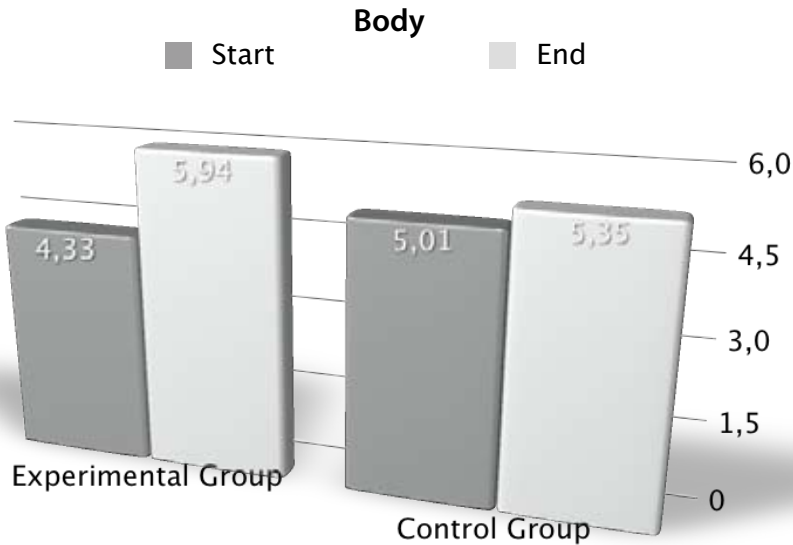


Figure 3. Analysis of Body Image

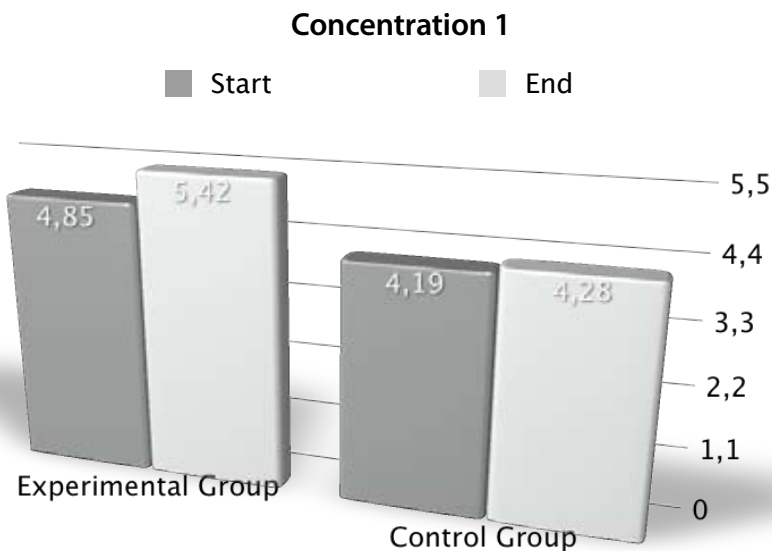


Figure 4. Analysis of Concentration 1

Check the material

Checking material is important to achieve high performances. It can be noticed that, on average, the values of experimental group were lower than that of control group. There is an increased attitude of material control in both groups in equally, but with more emphasis within the controls that has increased from 5.40 to 6.40, when compared to the experimental group that presented a value of 4.29 to 5.26, $p=0.06$. This explains that, control group sets higher emphasis on the exogenous factors (Fig. 5).

Concentration 2

This data is about the subjective feeling of the archers regarding the effect of concentration on their performance obtained through the technique. As it is well underlined from the graph, for this variable we have a double result: an inversion of tendency between experimental group and control group. A significant increase of the values inside the experimental group was noted ($p<0.01$). It is clear that, the experimental group has learned how to use the concentration to overcome problems. On the contrary, control group values show a decline ($p<0.01$) (Fig. 6).

To review the Actions:

The archers follow a mental sequence which is repeated before shooting the arrow. This is a well-known athletic strategy. The meaning of this variable is to allow the athlete to concentrate on posture, muscles, while coping with distracting exogenous factors and related feelings. I introduced this variable through the techniques of advanced autogenous training in order to enhance performance by better coping abilities.

As for the concentration 2, an inversion of tendency and a notable increase of the value of the data can be noticed in the experimental group. The most meaningful value is obtained by the increase between average initial and final values (2.92 and 6.85, respectively). As the archers started to use the technique, concentration and visualization of thoughts and positive images, they attain pre-determined objectives and this stimulates them to apply the technique in a constant manner over time.

The control group failed to invert this attribute and declined significantly (from 6.20 to 5.9, $p<0.01$), as shown in the graph. Therefore, control group subjects were influenced by external variables like checking the materials as was discussed earlier (Fig. 7).

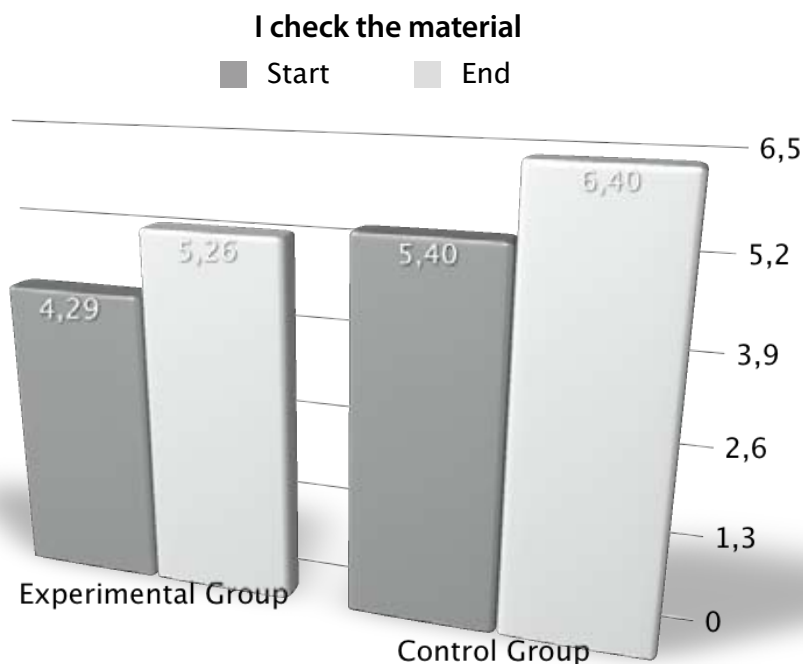


Figure 5. Analysis of Material Control

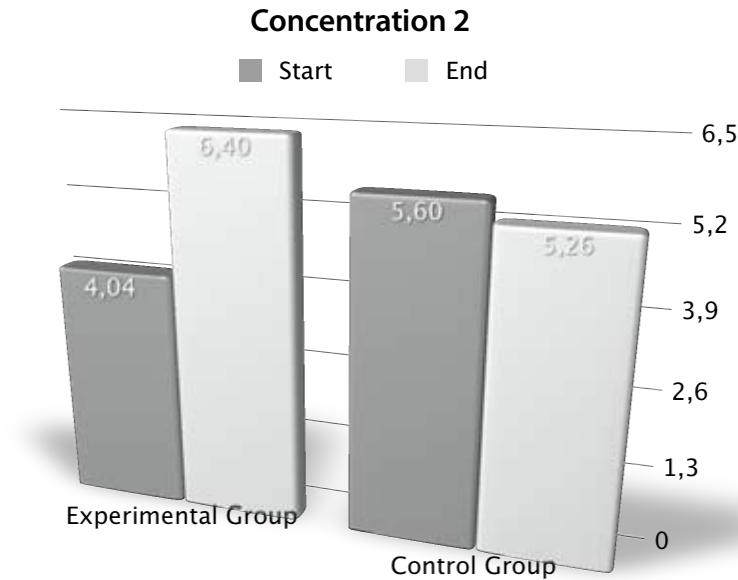


Figure 6. Analysis of Concentration 2

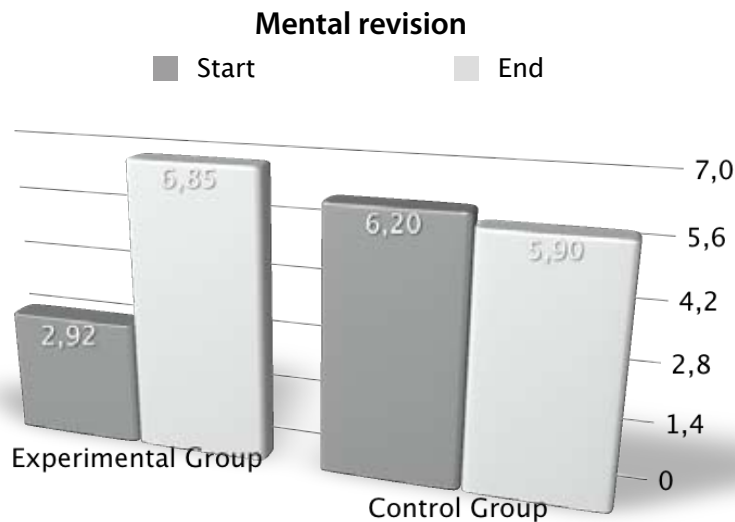


Figure 7. Analysis of Mental Revision

In the last analysis, if we consider the daily course of the variable, we can exemplify it in the following pie chart. The variables can be clustered in four groups. By grouping the accumulated data, homogenous behavior of a single variable can be analyzed and taken into consideration for its effectiveness.

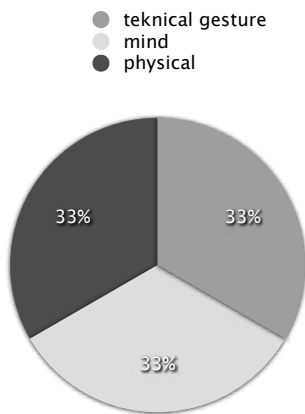
We can achieve this by:

1. The first group includes “physical” [FS], “mind” [MT], “desire to shoot” [VT], “reached

objective”[MR], “to feel concentrated” [C1], the “check the material” [MA] and “control of the technical gesture” [GE].

This group includes all the variables that allow the athlete to shoot well, or to complete a correct athletic gesture, to feel physically well and to adhere to a positive mental feeling. These variables provide a correct equilibrium among these factors. The variables that belong to this cluster are in direct relationship with each other.

Optimal “triad” for the training in archery



2. The variable “others thoughts” [AP] it is not correlated with any other parameters.
3. The third cluster, includes the “the persons bother me” [PI], the “anxiety” [AN] and the “to ask silence” [CS]. The variable here is very much individualized. They shoot badly. Those varying results are mainly due to the factors of Mind and Gesture of the “triad”. Obviously, as for the first cluster, the variable of this group are correlated closely: when the athlete has been bothered by someone he reacts asking silence; the lack of concentration creates an anxiety.
4. To conclude, the fourth cluster includes the answers regarding the improvement and reaching the future aims, like the “recourse to the concentration” [C2], the “control of the material” [CM] and the “mental revision of the actions” [RA]. The contained variable inside this cluster represent some tools to indicate the disposition of the subjects that they want to improve.

If we analyze the meaningful differences, between the clusters of the experimental and control groups only the fourth cluster represents noteworthy results. The average of the three variables in the cluster of experimental group raises from 3.63 to 6.06 during third sequence. This means that, the subjects pay a great deal of attention to concentration, material control and mental revision of the actions. The control group subjects introduce a decreasing course of

the average of the three variables, in the fourth cluster, from 5.29 to 4.92 ($p < 0.01$). This underlines that, control group, not having been affected by the same training, shows a tendency to pay less attention to the important variables like the concentration and the mental revision of the actions, breaking that optimal equilibrium of the “triad”.

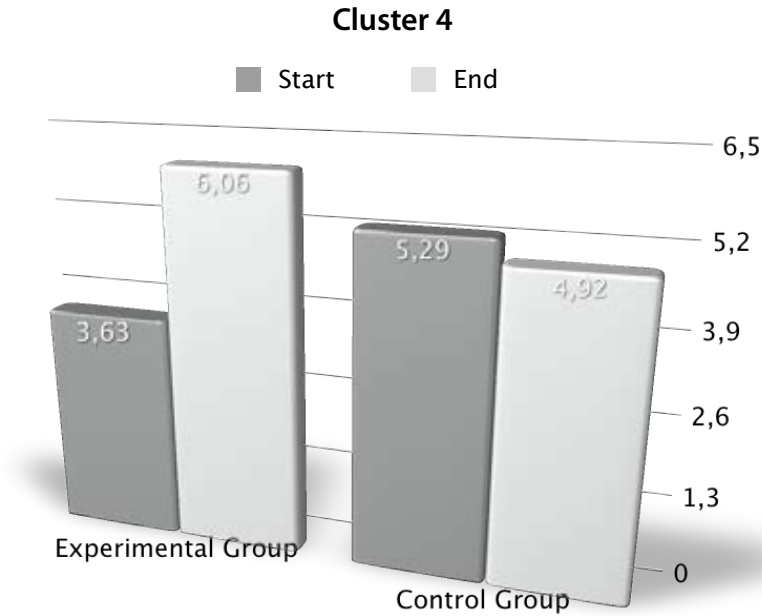
Now you can find an example on the pie chart graphs of a subject from the experimental group. Every graph represents the distribution of the values of the analyzed variable, relative to a single day of training. You can notice that there is a homogeneous behavior inside the cluster: if the value of a variable increases other variable inside the same cluster has the same behavior. In the first graph to the left, four clusters are represented, with the numbers **from 1 to 4**.

7. Conclusions

Based on my findings, I believe that my hypothesis has been shown to be valid and that substantial differences between the study group and the control group were observed. The greatest changes were observed in the variable that relates to the mental aspect. With great satisfaction I noticed that the study group began to use the technique in subsequent training session immediately following their initial introduction to the technique.

There has been a substantial change in the course of the variable “Revision actions” as evident in the graphs course in time, while, in the control group, the variable being considered has shown to be flat or without changes. In the experimental group, besides the variation of which above, I have also noted an increase in the concentration, because the subjects used more concentration in the resolution of possible problems or situations of sudden crisis and due to attacks of competition panic. The subjects have reached a great degree of familiarity with mental techniques.

I was pleased to note that the techniques of autogenous training as applied to the experimental group, has allowed the subjects to complete their preparation, allowing them to close the circle” by employing the activities of mental



preparation, physical preparation and technical preparation necessary to attain the maximum athletic performance. In the control group, the subjects have given great emphasis to those variables externally checked (as the control of the materials), leaving out the variable not completely

under voluntary control (as the concentration and the revision of the actions). By omitting this part of the triad that is more difficult to manage, but that brings the athlete to completeness in the preparation that the results may not allow the athlete to achieve maximum levels of success.

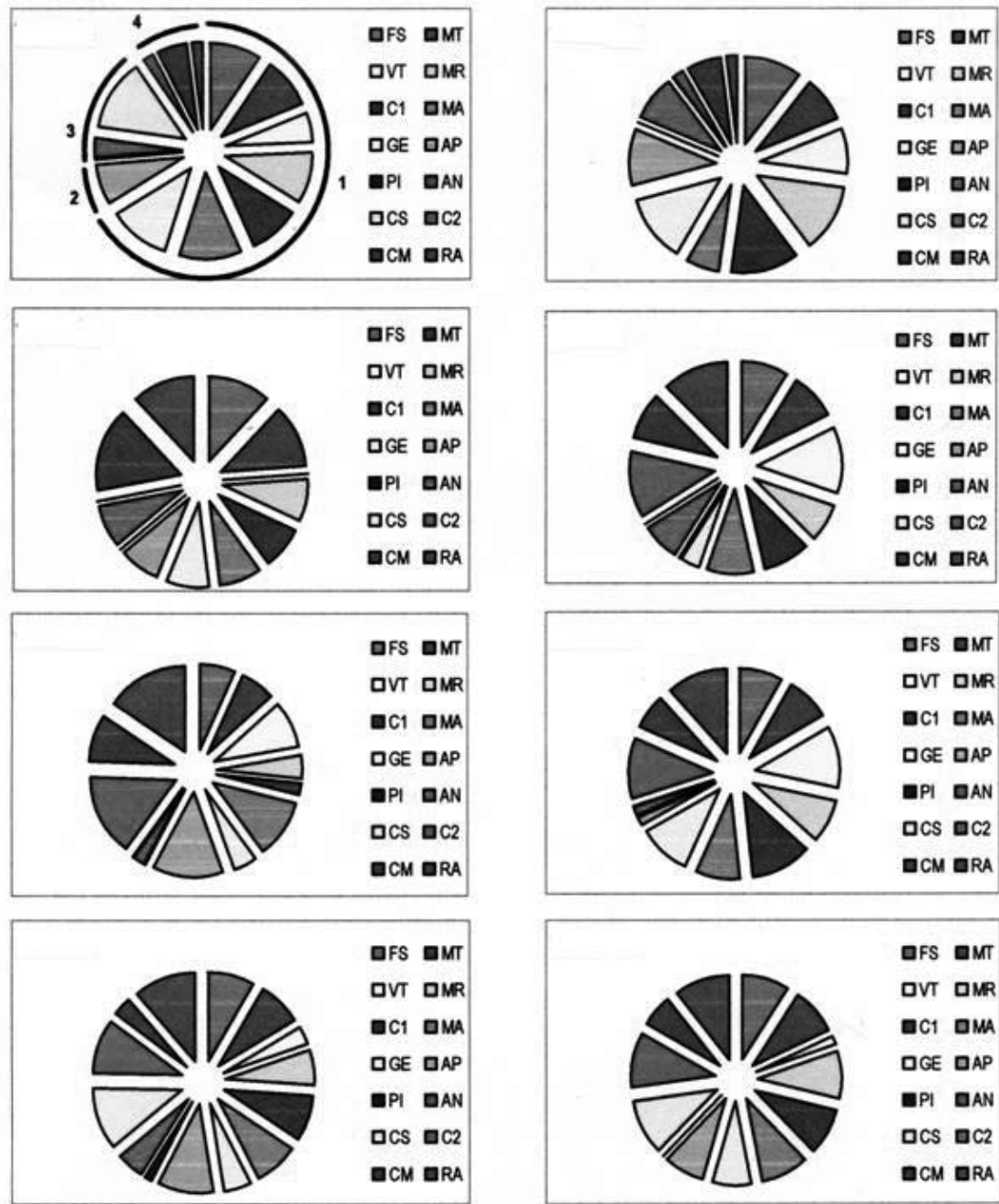


Figure 8. Clusters of parameters and distributions according to variables.

The Travelling Archer- Stay Healthy on the Move

"Individual Experience"

William David Hutchinson

BA, MB, BCh, BAO, FRSI, Member of faculty of Sports & Exercise Medicine RCSI/RCPI

Since "9/11" more and more obstacles to travel by air around the world have been created, especially if you need to carry sporting equipment with you. Apart from the expense of excess baggage fees there are many other considerations which must be raised for archers who wish to compete in distant countries. This is not a subject that has been featured in too many Sports Medicine books and yet it is of primary importance to travelling teams and their managers. Some of the subjects which you should consider when preparing to compete overseas are as follows –

Is my passport in date and do I need a visa?

Will I need insurance cover?

Are there medical risks I need to consider before I travel?

Are there any medical risks involved in long haul travel?

What about tropical diseases – how do I avoid them and still have a competitive edge?

What regulations do airlines have with regard to transporting sports equipment?

When I arrive will I be "Jet Lagged" – what can I use to compensate for this?

How will my performance be affected by hot humid climates?

How can I protect myself from the sun?

How do I avoid becoming dehydrated?

What about competing in a cold climate?

Will competing at altitude be an advantage or a disadvantage?

Passports and visas

It is always wise to check that all passports in the party travelling are well in date and will not expire during the visit overseas. Some countries require that passports and visas must not expire within at least 6 months of the end of the visit to their country. Every country has its own requirements for visitors visas and these are too detailed and change too often to be worth printing here. A Google search on the Internet will provide the latest up to date information for your own country.

Travel insurance

When travelling overseas the risks of falling ill increase and medical services in foreign countries rarely match those in your own. It may be worth considering taking a doctor, nurse or physiotherapist as a member of your party but remember that they may require special defence cover while overseas and should always check this with their defence societies before travel. There are many different companies offering low cost travel insurance and the choice is up to the party travelling depending on their own requirements. It is foolish to travel without insurance cover as the costs of hospitalisation and medical treatment overseas can be very high. If repatriation is required this is also costly.

Medical considerations

Venous thromboembolism will occur in 1 in 6,000 healthy passengers travelling for more than 4 hours. In a recently released study the World Health Organisation recommends that the travelling public should be informed about the risks of long haul travel. Researchers found that the risk increases with the length of travel as well as with multiple flights within a short period and among obese and extremely tall people, women taking oral contraceptives, and the presence of prothrombotic blood abnormalities or variants. The WHO Research Into Global Hazards of Travel (WRIGHT) report based its conclusions on a set of epidemiological findings that tested the human effects of immobility and hyperbaric hypoxia such as occurs in a pressurised airline

cabin. WHO did however issue a press release saying that the risk of venous thromboembolism when travelling remains relatively low. These risks can be reduced by the wearing of graduated compression stockings and by taking a low dose aspirin prior to travel.

Vaccinations

It is always worth checking with your doctor or with a travel clinic well before you are due to travel overseas if you will need vaccinations and prophylactic medication for the region you are travellers to. Few travelers remember that vaccinations will need to be given several weeks in advance if they are to provide effective protection. Different parts of the world have different local infections so there is no “one cap fits all” answer to the problem of travel. Are the vaccinations and antimalarial drugs compatible with competition and the antidoping regulations? Some antimalarials can expose you to the risk of Repetitive Strain Injury problems. Does your doctor know which ones and is he/she on the ball enough to know when to prescribe alternatives? Do you need to use regular prescription medication for a valid medical condition? Prepare ahead and check with your team medical advisor if you need to obtain a Therapeutic Use Exemption (TUE) for any of your medication. ? Don't forget to get your doctor to give you a letter to allow you to carry it with you in the cabin of the aircraft – airport security is now quite strict about this. Are you diabetic and do you need to carry insulin needles? This once again can be a pitfall at airport security – especially if you have to go through a number of security checks.

Airlines and sporting equipment

There is a move in many countries to try to reduce the use of air travel to cut down on carbon dioxide emissions. This results in increasing costs of air travel and includes restrictions on the baggage weight allowances. Unfortunately travelling athletes often have essential equipment to transport that is required for competition and are therefore surcharged for excess baggage. Negotiation with the airline well in advance of travel may be required.

Jet Lag and acclimatization

Jet lag is a syndrome associated with rapid long haul flights across several time zones, characterised by sleep disturbance, daytime fatigue, reduced performance, gastrointestinal problems and generalised malaise. It is caused by a disruption of the “body clock”, which gradually adapts under the influence of light and dark, mediated by melatonin secreted by the pineal gland: darkness switches on melatonin secretion, exposure to strong light switches it off. The symptoms of jet lag tends to be worse on eastward than on westward flights. Taking melatonin can reduce subjective ratings of jet lag on both eastward and westward flights compared with placebo. Hypnotics (zopiclone or zolpidem), taken before bedtime on the first few nights after flying, may reduce the effects of jet lag by improving the sleep quality and duration, but not other components of jet lag. Hypnotics are associated with various adverse effects, including headache, dizziness, nausea, confusion and amnesia, which may outweigh any short term benefits. It is generally agreed that, after westward flight, it is worth staying awake while it is daylight at the destination and trying to sleep when it gets dark. After eastward flight, one should stay awake but avoid bright light in the morning, and be outdoors as much as possible in the afternoon. This will help adjust the body clock and turn on the body's own melatonin secretion at the right time. Melatonin can be prescribed by doctors in special circumstances. Jet lag will usually get better on its own after a few days and allowing time for acclimatization is probably the better option. If the climate and altitude at the destination vary significantly from those at home these are other factors to be taken into consideration when acclimatizing.

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