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Neuromuscular Aspects of Anticipation in Preparing the Body for the Contact Structure in Motrice Performance

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Anticipation is a crucial factor in acquiring motor skills. Generally, the anticipation involves the presence of a proactive control. The success of some actions in the sporting events depends on the player's ability to quickly perceive the situations and to react immediately on them. In this context, anticipation refers to the response triggered by a stimulus before it appears. The difference between the anticipation and reaction rest in the fact that the reaction occurs after the stimulus appears, as for the anticipation, the neuromuscular mobilization occurs before the moment triggered by the appearance of the stimulus. Both concepts are interrelated. Therefore, an optimal anticipation will lead to an apparently very good reaction response, using different, by nature and location, mechanisms in the psycho-neuro-motor chain. The goal of this research paper is to highlight certain objective elements in the dynamic training of the body forfuture contact and, after that to obtain an indicatory optimal anticipation, with the intention to use it in the primary selection phase in sports, demanding highly coordination skills.

Keywords: anticipation, contact, electromyography, muscle, contraction

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Introduction

Anticipation is a widely studied phenomenon in different disciplines, such as biology, psycho-neurological studies, social sciences, engineering, artificial intelligence, micro and macro economics etc.

Anticipation can be found in all life aspects. For reasons of survival, nature evolves in advance, although sometimes we are aware of certain elements of anticipation, and sometimes not. Many phenomena are taking place in our minds before we realize it.

There isvarious evidence pointing out that animals can anticipate future events. Initially their behavior relies on instinct and, afterwards on conditioning and learning. Certainly, this ability is also found in human beings. Animals often make anticipatory movements to compensate for slow reaction times (Badler, 2006). In human beings, anticipation underlies the evolution, both as an individual and as a species. Through anticipation, humans intent to predict reactions and events preparatory to the triggering of the stimulus event.

Since 1980, many authors studied this phenomenon and integrated these processes in the „anticipatory systems"'field of study

A group of experts (Palo, 2002) from various fields, conducted a joint project attempting to define the qualities of anticipation in their fields. They concluded that, regardless the field of study, anticipation has the same qualities and the same purpose (Fig. 1).

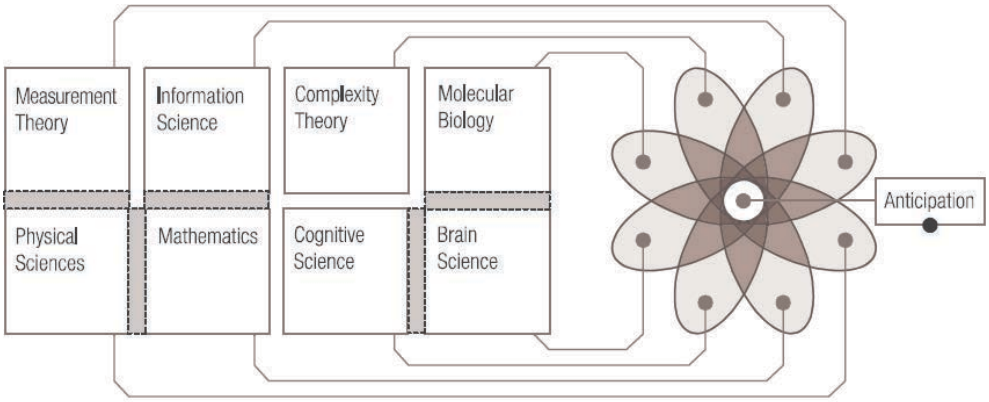

Figure 1. Anticipation resulting from various fields of study (Palo, 2002, p.6)

In literature, anticipation appears as *bereitschaftspotential* or BP, *readiness potential* or RP or *pre-motor potential* meaning the potential training or shorter anticipation.

Robert Rosen (no year), Mihai Nadin ((b), no year), Daniel Dennett (no year) and others have approached certain aspects of anticipation. Mihai Nadin tried to approach anticipation from different points of view, that lays emphasis on computation. In 1999, Mihai Nadin published the paper „Anticipation - A Spooky Computation", aiming to explain the basic concepts related to the anticipation. He also built a special website dedicated exclusivelyto anticipation concept (www.anticipation.info).

Anticipation integrates both possibilities (the possibility that something might or might not happen) and probabilities. In general, we are very good at dealing with probabilities and statistics, but we have a problem in dealing with possibilities, to which we have paid enough attention.

Klir, quoted by Riegler, asserts that systems "... are able to develop a model of their environment and use it in an anticipatory manner [...] are usually referred to in the literature as an anticipatory systems." (Riegler, 2001, p. 535).

Daniel Dubois (1998) explains anticipation from an intuitive point of view, presenting an analogy between natural and computer systems capable to generate a series of computations which could anticipate various activities and events.

In 2009 Ferret indicated that the "state of the system includes potentiality, which reflects the role of possible future states in the current one" therefore this potentiality encompassed in the state and/or structure creates anticipatory act.

According to Glenn O. Allgood (no year. p. 3) anticipation is a complex behavior exhibited by all life forms. It is an ability of an organism to make controlled decisions based on „known" future events (predictable). This behavior is engendered by adaptation and learning, and provides a reasoning mechanism.

Judith Rosen (no year), citing Robert Rosen's work, *The theory of anticipation systems* postulates that all organisms have encoded information pertaining to self and environment, and the behaviors generated by these encodings - acting as a set of predictive models - are purely „instinctive" in contradiction to what we tend to believe that we rely far more on what we call „learned behaviors" than on instinctive ones. (p. 8)

In various studies from 1991 to 2002, Barnes and his collaborators have tried to highlight, athe eye anticipatory control in acordance with the hand anticipatory control in humans. Subjects' responses recorded values between 100-150ms after the stimulus onset, however with repeated stimulus at regular intervals, anticipatory movements started to build up. They analyzed the pattern of anticipatory responses and their velocity. They concluded that subjects perform natural anticipatory movements before the stimulus onset. They also registered an increased anticipatory velocity up to 100 ms with repeated stimulus at regular intervals. (Barnes, 1991; Barnes, 1997; Barnes, 2002)

Accuracy and anticipatory velocity depend on the ability to select and utilize properly the visual cues from the environment. Various models were proposed by many authors regarding the effective use of visual cues in different sports, such as tennis (Farrow, 2000), badminton (Abernethy, 1989), karate (Williams & Elliott, 1999; Mori, 2002) and football (Savelsbergh, 2005).

Riegler classified anticipatory mechanisms into different types:

- *inborn* and
- *acquired intelligent anticipation*.

Inborn anticipation is closely related to innate instincts, e.g. hibernation, bird migration, etc. *Intelligent anticipation* refers to all life experiences of a human being. Consequently, each experience develops an internal model in the mind, and the cerebral cortex is responsible for storing this information, dependent on their nature, in long-term or short-term memory. Therefore, depending on the problem, the brain gives an answer. If the problem is known, the mind already has an internal model of the solution and the answer will be faster. If there is a new problem, the brain will create a new internal model of the solution and will provide an answer. (Riegler, 2003; Riegler, 2001).

The most interesting thing about anticipation is that players are not aware of response's parameters. Abernethy says that players act with an instinctive subconscious perception. Top athletes presentanticipatory responses almost instantaneously, not acknowledged (Abernethy, 1989). A litterature review shows that some authors have addressed the neural mechanism of anticipation appearance, others being concerned by the determinants of the anticipation mechanism. In this research paper, we intend to study the way the muscle is structurally prepared to anticipate the actions..

Knowledge regarding the the anticipation of contact can be used especially in contact sports, where anticipating the touch can decide the victory and/or the technical accuracy of the motor motion (handgrip, catch etc.).

Structural anticipation can be defined as a set-up of the elements, so it can trigger the preparedness of an action based on internal or external cues. This training represents a differentially set-up of the intensity level in different muscle groups to be involved in taking contact and in further controlling of the proper action.

Anticipation is considered a crucial factor in the acquiring of motor skills. Generally, it involves the presence of a proactive control. Hence, considering the meaning given in this paper, anticipation refers to triggering a response to a situation before it appears.

Methods

For this project, we used an electromyograph type Miomonitor IV built by DELSYS company with 16 channels. To gather the electrical values of muscle activity we used both electrodes and pressure sensors. Recordings from pressure sensors are acquired simultaneously with the values of EMG electrodes.

Using only sEMG and two pressure sensors, we tried to redo MGM-15 test (Miron Georgescu Modified-15 Method)(Hillerin, f.a.). On each leg, we used 7 single differential surface parallel-bar EMG electrodes (www.delsys.com/Products/EMGSensors.html). We analyzed the major muscle groups of thigh and calf, such as: rectus femoris, vastus lateralis and vastus medialis, biceps femoris, tibialis anterior and gastrocnemius lateralis and medialis. The 14 bipolar electrodes (DE-2.3 type) were fixed with adhesive tape on the skin to capture the accuracy and efficiency of the associated muscle activity.

Each pressure sensor, or force resistive sensor (www.delsys.com/Products/Biosignal.html) was positioned in each leg at the front of the outer sole and was connected to the electromyograph. Recording the sEMG signals simultaneously with the pressure ones through the same device insures the synchronicity of data.

ThesEMG data acquisition was performed having a frequency of 1 kHz (every 1 ms). For isokinetic calibration correction and filtering by RMS method [RMS= $\left(\frac{1}{S}\sum_{1}^{S} f^2(s)\right)$½, where: S-length window (points) and f (s)-data

window], the data was processed by the Miomonitor IV program (by DELSYS company) and subsequently exported into Excel and into a program in Matlab R2009B with license number 626 214.

The experiment was conducted on:

- 26 junior female athletes (judo)
- 17 senior male athletes (handball)
- 15 senior female athletes (handball) and
- 14 junior female athletes (handball).

To assess the differences given by the specificity and the nature of sports, we chose both an individual and a team sport. The team sport was studied according togender (male/female) and age (junior/senior) criteria.

Results and discussion

After editing out the unnecessary collected data, they were exported to Excel where proceedings were initiated to establish contact or lack of contact. Once the contact was delimited, we were able to establish the anticipatory timings of contact per muscle group performing a vertical jumping test MGM-15 and the amplitude of muscle contraction during the contact with the ground. Anticipatory timing is defined below as the time between the onset of muscle contraction preceding the contact and the contact itself (Fig. 2).

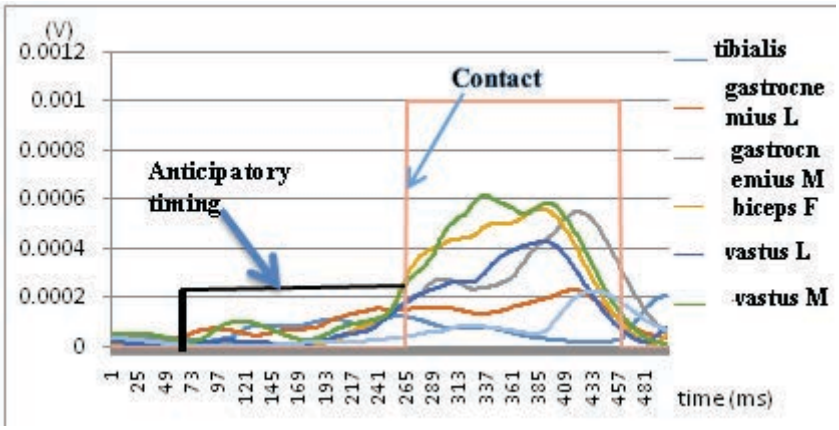

Figure 2. Muscle in a contact event

Using the Student test we calculated the significance of the difference between the mean values of the anticipatory timings , at the lateral symmetry level (left/right) of lower body muscles. The obtained results are represented in Table 1:

Table 1

Significance of the difference between the mean values of the anticipatory timings at athletes

	tibialis	gastro. m.	gastro. l.	biceps. fem.	vastus l.	vastus m.	rectus fem.
Judo J.	N	0.9	N	N	N	N	N
Handball S.B	0.95	0.99	0.9	0.99	N	0.999	0.975
Handball S.F.	N	N	N	N	N	0.975	N
Handball J.F	N	N	0.975	N	N	0.95	N

In junior female judo athletes we discovered significant differences only between the mean values of the anticipatory timing recorded on the left and right gastrocnemius medialis muscle, with a confidence level of 0.9. The remaining muscles tested have no significant differences between the right and the left.

At senior male handball athletes were recorded significant differences between the right and the left, of the mean values of the anticipatory timing on multiple muscle groups:

- tibialis anterior with a confidence level of 0.95;
- gastrocnemius medialis with a confidence level of 0.99;
- gastrocnemius lateralis with a confidence level of 0.9;
- biceps femoris with a confidence level of 0.99;
- vastus medialis with a confidence level of 0.999;
- right rectus femoris with a confidence level of 0.975.

At senior female handball athletes, the mean value of the anticipatory timing shows significant differences between the right and the left, only on vastus medialis muscle, with a confidence level of 0.975.

At junior female handball athletes, vastus medialis presents a significant difference with a confidence level of 0.95 and gastrocnemius lateralis muscle presents significant differences between the right and the left, with a confidence level of 0.975. The remaining tested group of muscles have no significant

differences of the mean value of the anticipatory timing performed on all athletes.

Knowing the parameters of the measured data, the additional information on the tested athletes regarding their general athletic performance, training regime, their role in the team, their experience, etc., can be a starting point for the selection of the proximate values to reality for center clusters.

In this regard, we illustrated graphically the following combinations:

1. To observe the differences between two sports at the same age group and gender (junior female), we presented the anticipatory timings for junior female judo and handball athletes;

2. To analyze the differences related to age disparity in the same sport and gender, we represented the anticipatory timings for junior female handball athletes and senior female handball athletes;

3. To analyze the influence of age on performance in the same sport, we mapped graphically the anticipatory timings for senior female handball athletes, respectively senior male handball athletes;

4. Finally, to understand the similarities and differences highlighted by the performance regarding the anticipatory timings of all tested athletes, we plotted the graph with all measured data (junior female judo athletes, senior female handball athletes, junior female handball athletes, senior male handball athletes).

In all of these associations we have considered three anatomical points of view:

a) Left-right symmetry, illustrated by the values of anticipatory timings for the gastrocnemius lateralis muscle on both legs;
b) Lateral-medial muscular symmetry, illustrated on the right leg, between the gastrocnemius lateralis muscle and gastrocnemius medialis muscle;
c) Agonist – antagonist balance illustrated on gastrocnemius lateralis muscles and tibialis anterior on the right leg.

To identify the intrinsic (or spontaneous) grouping of performances in a set (cluster) of similar values we used a clustering method. By this way, comparing the results of the algorithm implementation for each situation described above with raw data obtained as a result of the measurement, we can distinguish both the representative performances for the age group, sport and gender of the

subjects and the athletes who recorded atypical anticipatory timings , outside the group to which they belong.

To simplify the comparative analysis, we reproduce below a graphical illustration of the measured values and the results of clustering algorithm. Therefore, the first figure displays the performances measured at anticipation level and the second figure – the grouping of values (anticipatory timing) based on the similarity between them.

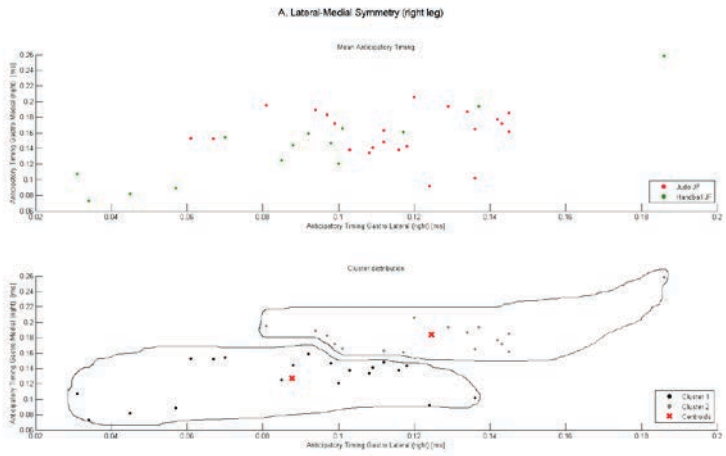

Figure 3. Distribution and clustering of the anticipatory timings at junior female (judo and handball athletes) at lateral-medial symmetry

In the functional symmetry between the gastrocnemius medialis and gastrocnemius lateralis muscles on the right leg (Fig. 3) at junior female judokas and junior female handball players we noticed visible differences between the sport distribution (Figure 3) and the clustered distribution based on the group belonging to the anticipatory timings (Figure 4). As a result, in the first group of clusters we can identify six female judokas and two female handball players and the second group – a mixed one - includes the remaining athletes from the two sports. None of the two sports could be distinguished by the specific qualities which could make a clear evidence of the anticipatory differences due to different qualities of the practiced sport.

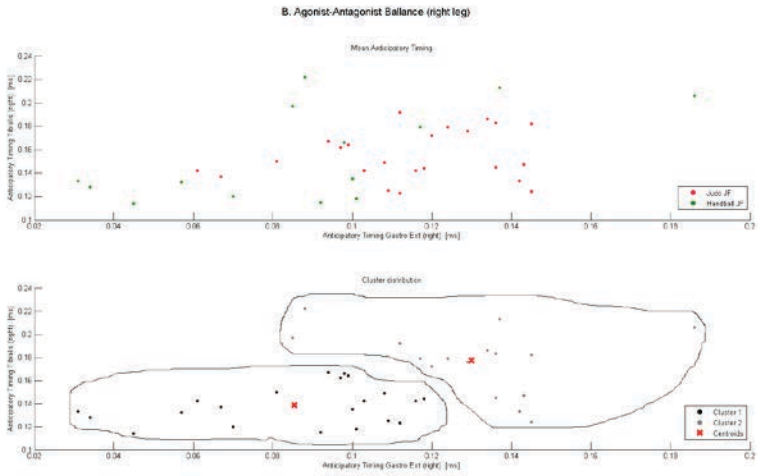

Figure 4. Distribution and clustering of the anticipatory timings for junior female athletes (judo and handball) at agonist/antagonist symmetry

At functional symmetry level of the agonist/antagonist balance in gastrocnemius lateralis muscle and tibialis anterior, on the right (Fig. 4), at junior female judokas and junior female handball players presents a more pronounced grouping, especially at female judokas. In the clustering grouping , most of the female judokas are included in the second group, except for a few female athletes, and female handball players are slightly more scattered. A pronounced distribution in handball players can be explained by the difference in qualities due to the position in the team, while the qualities of female judokas are homogeneous.

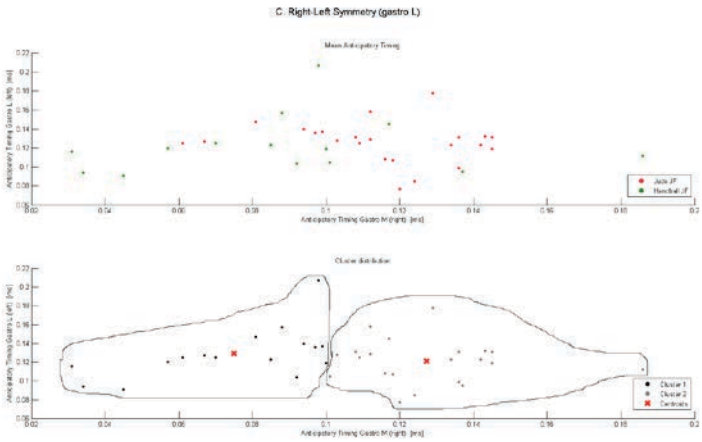

Figure 5. Distribution and clustering of anticipatory timings for junior female athletes (judo and handball) at lateral symmetry

Comparing the left and right in the gastrocnemius lateralis muscle, (Fig. 5), at structural anticipatory level it was not noticed a clear distinction given by the sport. The two groups obtained by clustering are a combination of both sports without significant difference between them. Therefore, two judo female players and 11 handball female players have anticipatory qualities belonging to the second group, whilst the remaining athletesare part of the first group.

It is worth mentioning that in all three cases presented here (Figures 3, 4 and 5), two female handball players are characterized by the lowest mean value, also by the highest mean values of the anticipatory timings in the examined muscularity.

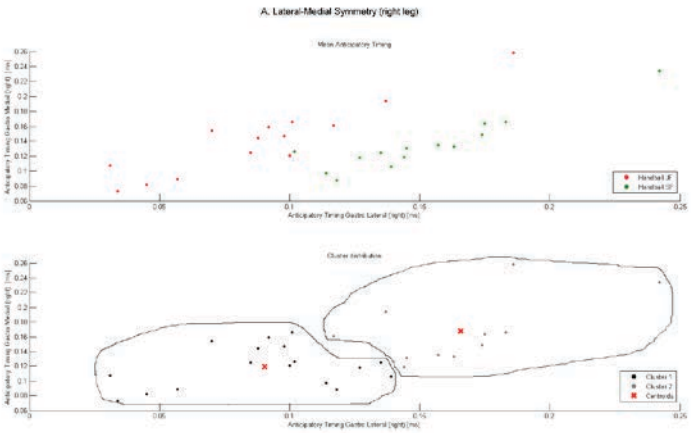

Figure 6. Distribution and grouping of the anticipatory timings of junior and senior female handball players at lateral/medial symmetry

Making the difference between two teams, from the same sport, with different training level, we can see in Figure 6 a clear distinction of the mean values of the anticipatory timings between junior female and senior female players. Senior females present higher mean values of the anticipatory timings to the gastrocnemius lateralis muscle, whilst junior females present lower mean values of the anticipatory timings except for a few athletes that present the qualities observed in senior female players. Using the clustering method, they were divided into two distinct groups: the majority of junior female athletes were distributed in the first group, and the senior females - in the second group. It should be noted that three juniors were distributed into seniors' group with higher anticipatory timings. Data collected from the MGM-15 test shows that, these three junior female athletes presents the best values of the average power per unit parameter on both legs. Thus, we can assume that it is a probability to be a connection between the level of psychomotor training and the level of structural anticipation.

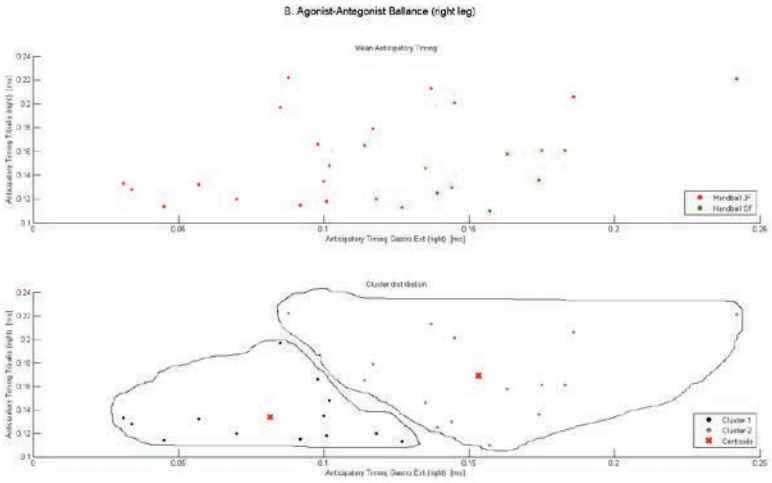

Figure 7. Distribution and grouping of the anticipatory timings for junior and senior female handball players at symmetry of the agonist/antagonist level

In agonist/antagonist balance given by the gastrocnemius lateralis and tibialis anterior muscles, the distribution of mean values of the anticipatory timings is clearly differentiated at junior and senior levels. In terms of clustering data, the distribution is obvious; the first group is dominated by the juniors and the second group – by the seniors. The second group presents a greater mean values of the anticipatory timings. Also, the same three junior female athletes (shown in Figure 7), belong to the second group of clusters.

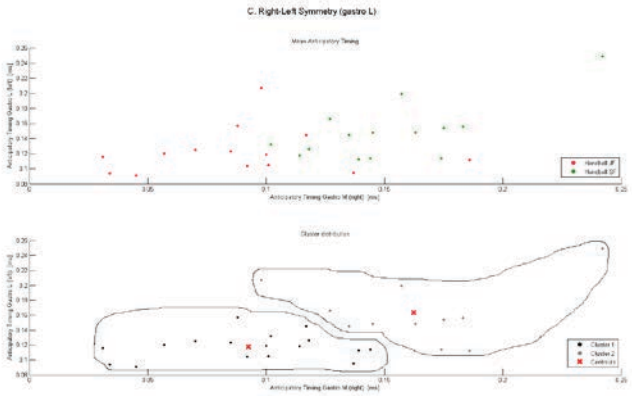

Figure 8. Distribution and grouping of the anticipatory timings for junior and senior female handball players at lateral symmetry

At lateral symmetry, the distribution of the data reveals the same results presented in Figure 7. It is clear that different qualities of the anticipation level stand out between junior and senior female athletes, mainly due to their experience and the psycho-neuro-motor training.

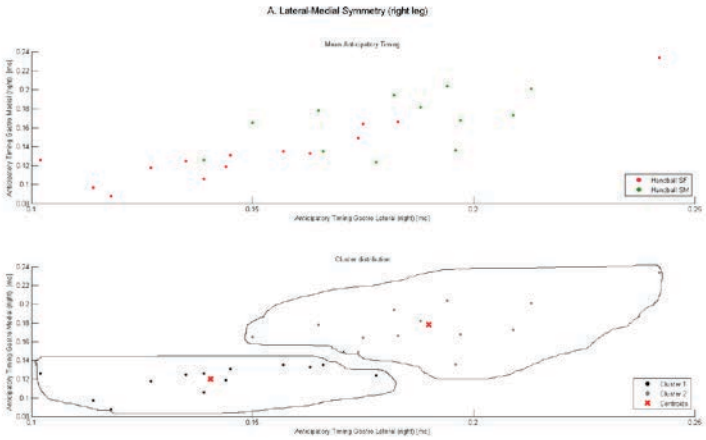

Figure 9. Distribution and grouping of the anticipatory timings for senior male and female handball players at lateral/medial symmetry

Comparing the gender of seniors the Figure 9 shows that most of the males present better mean values of the anticipatory timings than females. It should be noted that one female athlete has the highest average level of the anticipation, surpassing the performances of men. The interesting fact is that when she was tested on MGM-15 she didn't present exceptional physical qualities.

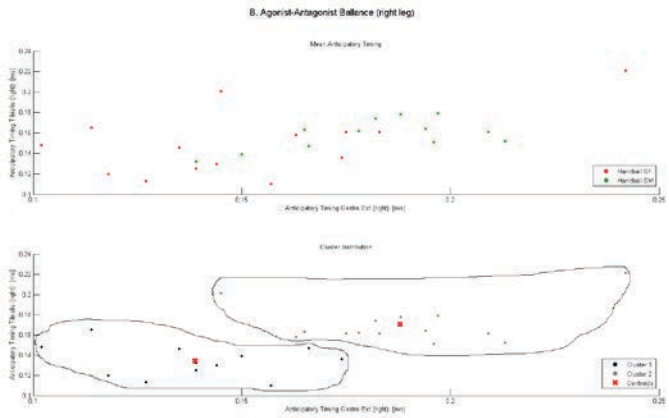

Figure 10. Distribution and grouping of the anticipatory timings for senior male and female handball players at the agonist/antagonist symmetry

In terms of functional symmetry, the agonist/antagonist balance represented, in the Figure 10 shows that most women's mean values of the anticipatory prediction timings are lower than men's. In the grouping obtained by clustering, only two men are part of the second group of clusters with smaller mean values of the anticipatory timings. Most of the men fall into the first group of clusters showing higher mean values of the anticipatory timings.

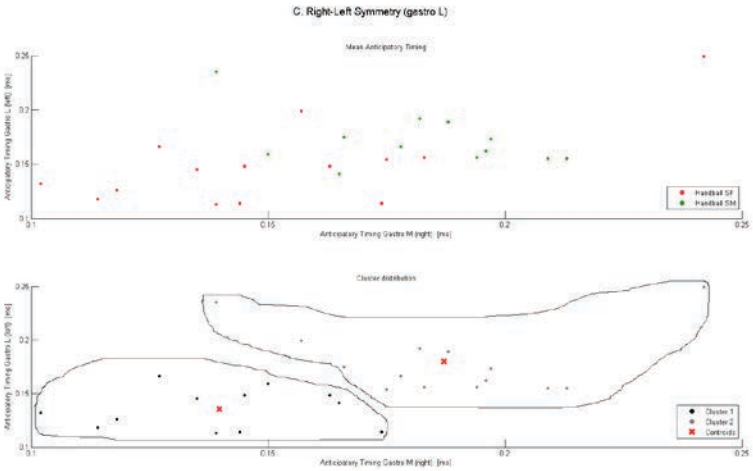

Figure 11. Distribution and grouping of the anticipatory timings for senior male and female handball players at lateral symmetry

The results represented in Figure 10, are confirmed by those represented in Figure 11, which, at the left/right lateral symmetry shows the same qualities for both men and women.

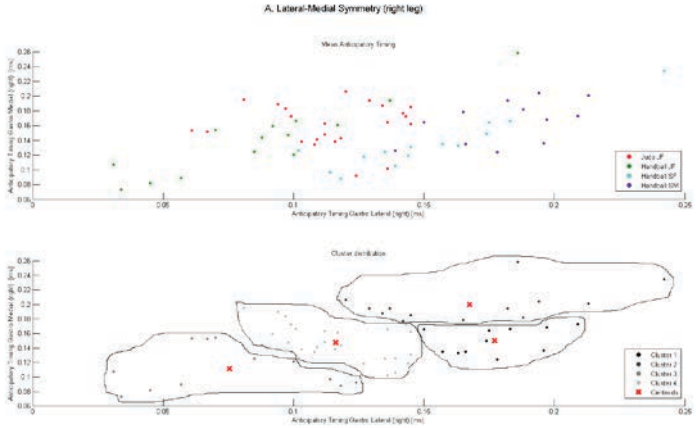

Figure 12. Distribution and grouping of the anticipation timings for all tested athletes at the lateral/medial symmetry

At the symmetry level in gastrocnemius lateralis and gastrocnemius medialis muscles represented in Figure 12, we see the ascending order according to the percentage of the mean values of the anticipatory timings as follows: junior female handball players, junior female judokas, senior female handball players and senior male handball players. This underlines the fact that using this method differences between groups of tested subjects can be highlighted, differences caused by the sport specific skills, by experience and training level. Thus, from the clusters represented in Figure 13 we notice that:

The first group of clusters includes most senior female and male handball players;

The second group of clusters encloses mainly senior male handball players;

In the third group of clusters we can identify mostly junior female handball players;

And in the fourth group are found most junior female judokas and senior female handball players.

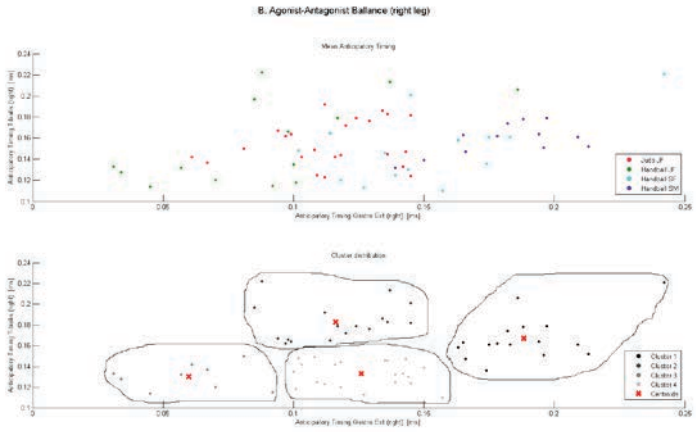

Figure 13. Distribution and grouping of the anticipatory timings for all tested athletes at agonist/antagonist symmetry

In agonist/antagonist balance at the gastrocnemius lateralis muscle and tibialis anterior muscle (see Figure 13), we found a similarity with the data represented in Figure 12. We noticed that the data acquired from junior female judokas are more compact at the group level than the rest of the tested teams.

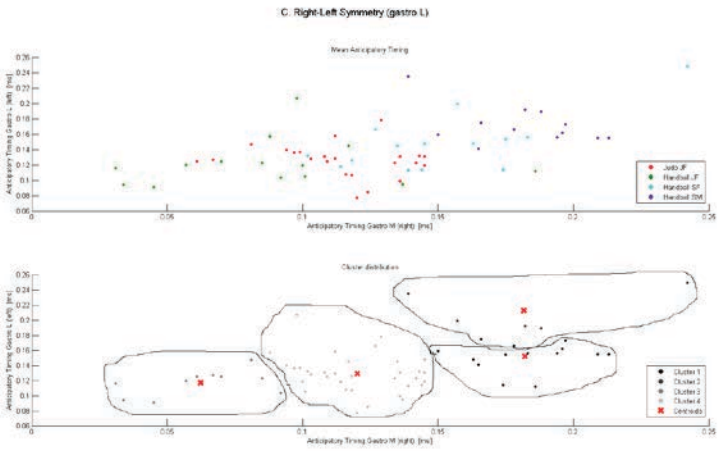

Figure 14. Distribution and grouping of the anticipatory timings for all tested athletes at lateral symmetry

We discovered this similarity also at the lateral symmetry level (Figure 14), which strengthens the idea that the experience and the level of training can lead to an increasing level of the structural anticipation, and probably related to the quality of motility. Consequently, in the future we have to check the following assumption: once the motric experience is acquired, the anticipatory timings in the calf are increased, in order to enable the physical restructuring of the knee injury on the upper layers.

Using the clustering method we have demonstrated that certain aspects of the structural anticipation can be highlighted, and that this aspects make the difference between sports and athletes, even if we failed to highlight the ability aspects.

Conclusions

There is an individual variability in characteristic parameters of structural anticipation. In team sports, the biceps femoris muscle works together with the muscles of the calf versus individual sports, where is a clear differentiation between the mean values of the anticipatory timings of the thigh and of the calf.

Differences in the dominance of certain structural features of the anticipation related to practiced sport can be revealed.

In terms of age or the stage of training we can highlight particular aspects of the structural anticipation.

There were significant differences in the left/right anticipatory timings that can reveal the level of lateral and functional symmetry of the athletes. In regard to the rest of the sports tested in this research, in gymnastics no significant differences at laterality right/left level can be found.

Even if the number of subjects is relatively small, the study results are indicating, with a significant degree of probability, that there is a connection between the evolution of anticipatory timings and the psychomotor training level.

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