



## Diagnostic Algorithm for the Risk of Dermatitis Occurrence in Athletes

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### Authors' contributions

This work was carried out in collaboration between all authors. Author VAZ designed the study and managed the literature searches, author VGA performed the statistical analysis and wrote the protocol, author KGG managed the analyses of the study, author MVI prepared biophysical test systems, author AGG prepared microbiological test systems, author EEA wrote the first draft of the manuscript. All authors read and approved the final manuscript.

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### ABSTRACT

**Summary:** The investigation had the aim to evaluate the effect of professional sports on the functional condition of the skin in order to develop a diagnostic algorithm for the risk of skin diseases occurrence in athletes. We examined 182 people: 126 athletes and 56 non athletes within the period of 2013 to 2014. Athletes were divided into 3 groups comparable in the sex and age composition, with the average age of 23.4±0.6 years old. The 1<sup>st</sup> group comprised 77 athletes of

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water sports (swimmers, water polo players and pentathletes), the 2<sup>nd</sup> group comprised 49 not aquatics athletes. We used microbiological tests: Method of contact inoculation, washing off method, a testing system in the real time PCR format and biophysical tests: Corneometry and sebumetry.

**Results:** The species composition of the staphylococcal microflora in the 1<sup>st</sup> and 2<sup>nd</sup> groups ( $\chi^2=22.7$ ,  $p<0.001$ ), as well as that in the 1<sup>st</sup> and 3<sup>rd</sup> groups ( $\chi^2=12.8$ ,  $p<0.05$ ) was positively different. In the 1<sup>st</sup> group *S. aureus* prevailed, in the 2<sup>nd</sup> group the *S. epidermidis*, and in the 3<sup>rd</sup> group - both. The highest dissemination of the *Malassezia* species yeast was revealed in the 1<sup>st</sup> group (61.5%) and in the 2<sup>nd</sup> group (61.8%). The frequency for revealing *P. acnes*, *granulosum* and *avidum* both in athletes and in the control group was 100%. The indices of corneometry and sebumetry on the athletes skin, independently of the water factor effect, were positively lower than in the 3<sup>rd</sup> group ( $t=1.7$ ,  $p<0.05$ ).

**Keywords:** Athletes in aquatic and non-aquatic sports; functional condition of the skin.

## 1. INTRODUCTION

Professional activity in the sport of high achievements is characterized by a high probability for the athletes to be subjected to the effect of harmful and dangerous factors of the operating environment and of the operating process, mainly of a higher heaviness and intensity of their labor [1]. There are some transient states that weaken a human organism and cause the origination of diseases. Among these are: Physical and emotional overstrain, incomplete recovery after loads, stress, unfavorable and sharply modifying environment conditions, that are inherent constituents of the professional sport [2]. Various factors of chemical and physical origin are able to have an effect on the onset and on the course of professional skin diseases. A mechanical injury of the integuments promotes the penetration of irritants, including allergens, from the environment. Often athletes contact a whole set of substances that comprise chemical compounds with an irritating, sensitizing and toxic effect, able to reinforce the effects of each other [3]. Individual reactivity of the integument depends on the condition of the barrier function, which is determined by the composition of the epidermis lipids, concentration of chlorine ions, acidity, as well as by the genetic ability of cells to produce antimicrobial peptides [4].

Healthy skin is a good barrier against various agents, but under unfavorable conditions, it loses its protective function. The water-lipid mantle protects the skin against penetration of exogenous substances and pathogenic microorganisms as well as protects the same against losses. In the case of disturbance of the skin barrier function, not only the penetrability from outside is increased but that from inside as

well, that is why the determination of the water transcutaneous loss level and of its content in the skin represents an important characteristic. Disturbance of structure or function of any component of the epidermal barrier, such as reduced content of lipids, moistening substances, and decrease of water level in the horny layer to less than 10% results in the origination of xeroderma. In a healthy human, the barrier function is recovered at 60% only after 12 hours, the complete recovery taking 72 hours [5]. In professional athletes, the modifications of biophysical parameters can be more stable, hence the recovery to normal values is highly improbable. At the same time, it is known that after the end of the sport career, the health of the most of professional athletes gets worse abruptly [6]. A group of risks for disturbances of the skin barrier properties is constituted by water discipline athletes, that spend several hours in swimming pools every day. They undergo a regular contact of the skin with disinfectants, which favor dehydration and defatting of the upper epidermis layers, decreasing by the same the protective function and resulting in xeroderma [7].

An important contribution to the protective properties of the integument is made by microorganisms representing the normal microflora of the skin. The most numerous resident groups of microorganisms in this locus are formed by propionic bacteria, staphylococci and the *Malassezia* species yeasts. The equilibrium of these microorganisms on the skin is a condition for the well-being of the ecosystem, while any divergence against the norm of carriers leads both to the onset of various skin diseases and to the manifestation of diseases that initially occur subclinically [8]. Thus, the determination of the composition of the main groups of

microorganisms as well as the study of the biophysical parameters will enable to reveal professional peculiarities of the skin in athletes, which will help to prevent any transformation of transient states to a disease and to preserve the athletes' health for achieving higher results. The aim of this study was to assess the effect of dealing with professional sports on the functional condition of the skin to develop a diagnostic algorithm for the risk of dermatosis in athletes.

## 2. METHODS OF THE STUDY

### 2.1 Participants of the Study

To achieve the goal indicated, we examined 182 people. Between them, the 1<sup>st</sup> group comprised 77 athletes whose professional activity was related to trainings in water, the 2<sup>nd</sup> group comprised 49 athletes the training conditions of which were not related to water, and the 3<sup>rd</sup> group comprised 56 individuals not engaged in sports. The groups were comparable in the members' sex and age composition, with the average age of 23.4±0.6 years old. The members of the 1<sup>st</sup> and 2<sup>nd</sup> groups had a comparable sport experience duration that was 12.2±0.2 years on the average.

Considering the sport specialization, the conditions and the training regime, the 1<sup>st</sup> group was divided into 3 subgroups. The subgroup 1A comprised 22 swimmers, sport swimming being an individual sport where the only trigger factor is water, the subgroup 1B comprised 23 water polo players representing a team sport where, besides the effect of the water factor, a permanent contact between the athletes is present and the 1C subgroup comprised 32 pentathlon athletes for whom swimming is only one of the pentathlon disciplines. The water sports group athletes had everyday trainings in pools presenting the same swimming pool characteristics.

The athletes were examined at several sport facilities: In the track and field athletics arena of the RGUFKSMiT State University, in the pools of the Open Joint Stock Company "Luzhniki" and of the Sports School GBOU DODSN SDUSShOR "Severnyi", in the laboratory "Informational Technologies in Sports" of the Moscow MFTI Institute within the period of 2013 to 2014.

### 2.2 Methods of a Contact Inoculation on Touch Plates

The biological material was picked up from the skin in the middle of the chest. To determine

staphylococcal microflora, we used touch plates representing plastic sterile containers containing selective media. The agar layer of a touch plate was applied to the skin for 20 seconds and then the containers were placed into a thermostat to calculate grown colonies after a few hours. The susceptibility to the antibacterial agents was determined by the disk-diffusion procedure according to the Kirby-Bauer method with the help of standardized disks containing antibiotics.

### 2.3 Washing off Methods

To simultaneously study staphylococcal and yeast microflora, the washing off method was used. Samples were taken from a skin area of 9 cm<sup>2</sup> in the chest middle while rubbing this area with a sterile cotton tampon wetted in an alkali-phosphate buffer. The washing off method we used enabled us to determine the quantitative and qualitative composition of various microorganisms inhabiting the skin, except for propionic bacteria.

### 2.4 PCR Methods

It is known that propionic bacteria form agglomerates that represent groups of some hundreds of bacteria giving, after being inoculated onto a dense nutrient medium, one colony-forming unit, while selective media do not always provide for a positively selective isolation of pure cultures. That is why, to provide a quantitative assessment of the species diversity for propionic bacteria present on the human skin, we used an alternative identification method namely a test system in the real time PCR format. A bacterial DNA was isolated with the use of a set DNA-extran EX-509 (Sintol, Russia) based on the cell lysis with the help of SDS and on the DNA precipitation with isopropanol. The bacterial DNA obtained was analyzed with the help of PCR, the products being detected in real time. For this purpose, hybridized samples TaqMan were used that were labeled with fluorescent dyes. Primers and probes were selected with the use of the NCBI data base for the 16s RNA fragment sequences such to enable to simultaneously determine all the 3 bacteria types. Necessary oligonucleotides were synthesized by the "SINTOL" company (Russia). PCR in real time was carried out in the instrument ANK-32K-4Ts (Institute of Analytical Instrumentation of the Russian Academy of Sciences, Russia). The results obtained were normalized according to the yield percentage of the plasmid initially added to the samples with the insertion of the unique sequence [9].

## 2.5 Biophysical Methods

The moisture level of the superficial skin layers and the lipid content were measured with a "Skin-o-mat" (Cosmomed Corp., Germany). Hydration was determined by the corneometry method, and the volume of skin fat on the skin surface was determined by the sebumetry method. The parameters were measured on 4 areas: front, chest, back, hand. The study was carried out at room temperature, at the state of physical rest, at air humidity of 40-60%.

## 2.6 Statistical Analysis

The results obtained were processed statistically by a program built into Microsoft Excel. The program evaluated the following parameters: Arithmetic means, mean deviations, and correlation coefficients.

## 3. RESULTS AND DISCUSSION

### 3.1. Microbiological Indices

#### 3.1.1 Staphylococci

A comparative analysis of the skin microbiocenosis for the 1<sup>st</sup>, 2<sup>nd</sup> and 3<sup>rd</sup> groups revealed that the species composition of the staphylococcal microflora of the 1<sup>st</sup> and 2<sup>nd</sup> groups ( $\chi^2=22.7$ ,  $p<0.001$ ), as well as that of the

1<sup>st</sup> and 3<sup>rd</sup> groups ( $\chi^2=12.8$ ,  $p<0.05$ ) is positively different. In athletes the activity of which was related to water, the conventionally pathogenic *Staphylococcus aureus* prevailed; in athletes dealing with non-aqueous disciplines, the epidermal *Staphylococcus* prevailed, and in individuals not engaged in sports, both *Staphylococcus aureus* and the *Staphylococcus epidermidis* were detected (Table 1).

A frequent infection with *Staphylococcus aureus* in athletes the activity of which is related to water enables to classify with a group with a high risk of dermatological diseases [10,11]. It was established that *S. aureus* prevailed in swimmers, and in water polo players and in pentathlon athletes *S. aureus* and *S. intermedius* prevailed. The results of the test  $\chi^2$  demonstrated that the species composition of the staphylococcal microflora on the swimmers' skin differs from that of the water polo players and of the pentathlon athletes ( $\chi^2=22.5$ ,  $p<0.001$ ) (Table 2).

In water polo players and in pentathlon athletes the infection with *S. aureus* was superior to the norm, while the swimmers did not show positive differences compared to established limits. It seems to be related to the peculiarities of the sports: In particular, swimmers have no direct contact with other athletes during trainings and competitions, while water polo is a team sport

**Table 1. Occurrence of *Staphylococcus* species detected on the skin of subjects in the groups studied**

Species of staphylococci	Percentage of carriers of the given <i>Staphylococcus</i> species (persons, %)		
	Group I	Group II	Group III
<i>S. aureus</i>	38.0(49.3%)	16.0(32.6%)	18.0(32.1%)
<i>S. saprophyticus</i>	2.0(2.6%)	4.0(8.2%)	3.0(5.4%)
<i>S. intermedius</i>	26.0(33.8%)	4.0(8.2%)	12.0(21.4%)
<i>S. epidermidis</i>	9.0(11.7%)	25.0(51.0%)	12.0(21.4%)
<i>S. haemolyticus</i>	2.0(2.6%)	-	11.0(19.7%)

The I<sup>st</sup> group comprised 77 athletes of water sports; the II<sup>nd</sup> group comprised 49 not aquatics athletes; the III<sup>rd</sup> group comprised 56 non athletes

**Table 2. Occurrence of *Staphylococcus* species detected on the skin of the athletes engaged in aquatic sports**

Species of staphylococci	Percentage of carriers of the given <i>Staphylococcus</i> species (persons, %)		
	Group A	Group B	Group C
<i>S. aureus</i>	11.0(50.0%)	10.0(43.5%)	18.0(56.2%)
<i>S. saprophyticus</i>	-	-	2.0(6.3%)
<i>S. intermedius</i>	2.0(9.1%)	11.0(47.8%)	12.0(37.5%)
<i>S. epidermidis</i>	7.0(31.8%)	2.0(8.7%)	-
<i>S. haemolyticus</i>	2.0(9.1%)	-	-

The subgroup 1A comprised 22 swimmers; the subgroup 1B comprised 23 water polo players and the 1C subgroup comprised 32 pentathlon athletes

where the contact between the athletes is inevitable. According to the Student's criterion, the level of infection with *S. aureus* was the highest in pentathlon athletes and was positively different from that of the swimmers ( $t=1.8$ ,  $p<0.05$ ), which can also be related to the fact that besides swimming, the athletes are trained as well with other disciplines of the modern pentathlon.

The study of the *S. aureus* susceptibility to methicillin (oxacillin) showed that methicillin resistant strains of *S. aureus* (MRSA) were revealed only in athletes the activity of which is related to water, which does not correspond to the data of other authors that revealed the MRSA strains as the most often in representatives of disciplines not related to water [12,13]. However, we revealed MRSA-strains as well in the pentathlon athletes for whom swimming is only a part of pentathlon while other disciplines making part of the modern pentathlon (racing, fencing, shooting and running) have their effect on the skin microbiocenosis. It is consistent with literature data about the MRSA strains spreading in athletes dealing with fencing [14]. On the basis of the data obtained, one can select medicines to treat dermatosis associated with *Staphylococcus aureus*: The 1<sup>st</sup> group athletes have to avoid macrolids or chloramphenicol, the 2<sup>nd</sup> group athletes have to avoid as well tetracycline-based drugs, while the pentathlon athletes have to exclude oxacillin due to a high widespread of the MRSA strains (Table 3).

### 3.1.2 *Malassezia* yeast

It was revealed that the highest infection with *Malassezia* was revealed in the groups of athletes both for water sports (61.5%) and for non-aquatic sports (61.8%). Between the 1<sup>st</sup> group athletes, the highest occurrence frequency of the *Malassezia* species yeast was revealed in pentathlon athletes (87.5%), it was of 50% between the swimmers, and the least infection with *Malassezia* was observed in water polo athletes (36.4%). In the 2<sup>nd</sup> group, the highest degree of the *Malassezia* occurrence was observed in soccer players, these indices having a significant statistical difference with those of the control group ( $p \leq 0.05$ ). In the 3<sup>rd</sup> group, the infection with *Malassezia* was significantly lower (47.0%) (Table 4).

According to our observations, the clinical picture of various malasseziosis in athletes has some differences. Their manifestations are most often multiple, symmetrical, they are located on the neck, chest, back, abdomen and in the axillary cavities. Chronic eruptions are represented as maculae: On the chest and abdomen of a brownish color, 0.3 to 1 cm diameter, with rounded shapes that alternate on the back with whitish color maculae of a higher size and of whimsical configurations. The absence of seasonal fluctuations and a scarce desquamation on the maculae surface are to be classified with the peculiarities of the heterochromatic lichen formation.

**Table 3. Sensitivity of *St. aureus* to antibiotics and antiseptics in the Groups**

	Group I	Group II	Group III
Oxacillin	2.81±0.34	2.60±0.48	2.75±0.38
Cefuroxime	2.85±0.27	3.00±0.00	2.92±0.15
Cefoperazone	2.85±0.27	3.00±0.00	3.00±0.00
Cefotaxime	2.92±0.15	3.00±0.00	2.92±0.15
Gentamicin	2.19±0.87	2.80±0.32	2.67±0.50
Neomycin	2.15±0.78	2.80±0.32	2.83±0.28
Tetracycline	2.19±0.68	1.40±0.64	2.25±0.75
Doxycycline	2.38±0.76	1.00±0.00	2.50±0.58
Azithromycin	1.12±0.21	1.20±0.32	1.33±0.44
Clarithromycin	1.12±0.20	1.00±0.00	1.33±0.44
Erythromycin	1.08±0.14	1.20±0.32	1.00±0.00
Roxithromycin	1.08±0.15	1.00±0.00	1.00±0.00
Clindamycin	2.35±0.65	2.40±0.72	2.42±0.78
Lyncomycin	2.62±0.56	2.60±0.64	2.92±0.15
Ciprofloxacin	2.85±0.27	3.00±0.00	2.92±0.15
Ofloxacin	2.92±0.14	3.00±0.00	2.92±0.15
Chloramphenicol	1.69±0.80	1.40±0.48	1.58±0.68
Fusidin	2.77±0.37	2.8±0.32	2.67±0.50

Revealing micellar forms of the *Malassezia* yeast has a prognostic importance to assess the welfare of a considered ecosystem [15].

**3.1.3 Determination of propionic bacterial species**

The determination of the species diversity for propionic bacteria on the skin of athletes by the quantitative PCR method showed that the frequency of revealing the three species of propionic bacteria: *Propionibacterium acnes*, *granulosum* and *avidum* in a considered skin area both in athletes and in the control group was of 100%. It is not conform to literature data obtained with the use of traditional methods where this index for *P. acnes* varied from 46 to 100%, for *P. granulosum*, from 0 to 85%, and for *P. avidum*, from 0 to 52% [16]. Besides, the infection (on the average) represented: In the group of athletes: *P. acnes* of  $1.6 \cdot 10^5$  cells/cm<sup>2</sup>, *P. granulosum* of  $9.4 \cdot 10^2$  cells/cm<sup>2</sup>, *P. avidum* of  $5.8 \cdot 10^4$  cells/cm<sup>2</sup>, in the control group, *P. acnes* of  $3.8 \cdot 10^5$  cells/cm<sup>2</sup>, *P. granulosum* of  $9.4 \cdot 10^2$  cells/cm<sup>2</sup>, *P. avidum* of  $7.7 \cdot 10^4$  cells/cm<sup>2</sup>. As it appears, in the control group said index was 2 times higher than that of the group of athletes only in the case of *P. acnes* (Table 5).

No significant correlative relationship was observed between the abundance of propionic bacteria and the biophysical indices in all the groups. So, our proposed method for studying the subpopulation composition of propionic bacteria provides for additional possibilities in the assessment of the skin microbiota condition. The main difference from existing methods is that the bacteria genome is determined regardless of their viability.

**3.2 Biophysical Indices**

While determining the moisture of superficial skin layers, decreased indices were observed in most of the examined people. The corneometry

method gave the data as follows: The hand skin was very dry in the 1<sup>st</sup> and 2<sup>nd</sup> groups and dry in those of the 3<sup>rd</sup> group. The skin of the front in the 1<sup>st</sup> and 3<sup>rd</sup> groups was found dry, and in those of the 2<sup>nd</sup> group as very dry. In the 2<sup>nd</sup> and 3<sup>rd</sup> groups, the measuring of the chest skin hydration demonstrated a normal skin, while in athletes the activity of which is related to water, it was dry. The skin of the back in all the athletes was found dry, and it was normal in individuals not engaged in sports. In the 2<sup>nd</sup> group, the skin hydration was assessed as follows: The hand and front skin was dry in swimmers, while it was very dry in water polo players and in pentathlon athletes. The chest skin in pentathlon athletes and in water polo players was found dry, in the swimmers it was normal, while the skin of the back was very dry in pentathlon athletes and normal in swimmers and in water polo players. Trustworthy differences were found between the swimmers and the water polo players (p<0.05), as well as between the swimmers and the pentathlon athletes (p<0.001). Thus, between all the athletes, the pentathlon athletes demonstrated the most significant modifications of the corneometry indices: The skin of the chest was dry, the skin of the hand, front and back was very dry. The corneometry indices modifications in the swimmers were less manifested: The skin of the hand and of the front was dry, the skin of the chest and the back being normal (Table 6).

The determination of the lipid content on the skin surface showed that in all the examined people, the skin was dry. The lipid content indices in athletes of non-aqueous sports were lower than in athletes training in swimming pools (t=1.8, p<0.05). The most significant decrease of indices was revealed in pentathlon athletes (t=1.7, p<0.05). The corneometry and sebumetry indices of the athletes' skin, independently of the water factor effect, were positively lower than those of individuals not engaged in sports (t=1.7, p<0.05) (Table 7).

**Table 4. Occurrence of *Malassezia* detected on the skin of subjects in the groups studied**

Percentage of carriers of <i>Malassezia</i> (%)			
Group I (n = 77)	61.5%	Group A (n = 22)	50.0%
Group II (n = 49)	61.8%	Group B (n = 23)	36.4%
Group III (n = 56)	47.0%	Group C (n = 32)	87.5%

**Table 5. Determination of propionic bacterial species**

	Group III	Group I, II
<i>P. acnes</i>	$3,8 \cdot 10^5$ cells/cm <sup>2</sup>	$1,6 \cdot 10^5$ cells/cm <sup>2</sup>
<i>P. granulosum</i>	$9,4 \cdot 10^2$ cells/cm <sup>2</sup>	$9,4 \cdot 10^2$ cells/cm <sup>2</sup>
<i>P. avidum</i>	$7,7 \cdot 10^4$ cells/cm <sup>2</sup>	$5,8 \cdot 10^4$ cells/cm <sup>2</sup>

**Table 6. Determination of the moisture of superficial skin layers (standard units)**

Skin localization	Group I	Group II	Group III
Hand	26.9±1.70	26.5±1.49	35.6±2.90
Front	46.9±2.35	42.4±2.19	50.4±2.50
Chest	53.3±3.39	57.7±3.93	68.3±2.18
Back	51.9±3.13	46.3±1.97	72.3±2.17

Considering the fact that the washing off method used to determine the infection with staphylococcal and micellar microflora was carried out on a skin area in the middle of the chest, we used the corneometry and sebumetry indices of the same area in order to reveal correlative relations. A direct mean power correlation was revealed between the corneometry indices and the skin infection with *S. intermedius* ( $r= 0.7$ ) in the 2<sup>nd</sup> group patients, and an inverse mean power correlation was revealed between the corneometry indices and the skin infection in the 3rd group patients with *S. aureus* ( $r= -0.7$ ). An inverse mean-power correlation was revealed in water polo players between the age and the corneometry indices ( $r= -0.7$ ), a direct mean-power correlation was revealed in water polo players between the corneometry and sebumetry indices ( $r = 0.76$ ), a direct mean-power correlation was revealed in pentathlon athletes between the skin infection with *S. aureus* and the sebumetry indices ( $r= 0.62$ ), a direct mean-power correlation was revealed in swimmers between the infection with *S. epidermidis* and the corneometry indices ( $r= 0.69$ ).

Contrary to the generally accepted opinion about a high correlation between the volume of the *Malassezia* yeast and the lipid content, we obtained the data as follows: Correlation factor ( $r$ ) between the occurrence and the sebumetry, assessed after comparison of all the examined groups was equal to 0.447, the same index between the skin infection degree and sebumetry was of 0.425. At the same time, correlation is observed between the degree of skin infection and the skin hydration  $r = 0.694$ . However, no relationship between the occurrence of *Malassezia* and the hydration was observed,  $r = 0.135$ . A direct mean-power correlation was observed between the occurrence and the infection degree  $r = 0.582$ , as well as a high correlation between the age and the occurrence  $r = 0.773$ . Decrease of biophysical indices enables to arrive at a conclusion of the insufficiency of the epidermal barrier, while the prevailing content of *Staphylococcus aureus* in athletes of water

sports, at the conclusion of a disturbance in the colonization resistance of the skin. The consequence of the disturbances revealed resides in the development of the skin dryness and in an eventual infection. In turn, recovery of the skin barrier function is accompanied by a lower degree of infection with *Staphylococcus aureus* and the appearance of saprophyte strains [17].

First stage of the pre-nosological diagnosis of the athlete skin is the determination of just biophysical indices. When following the methods we have carried out, it is advisable to start the assessment of the functional condition of the skin just with the measuring of the skin hydration by the method of corneometry and with that of lipid content on the skin surface by the method of sebumetry. We have developed a diagnostic algorithm that can be recommended for carrying out a profound medical examination of athletes.

As shown in the diagram, at a normal level of skin biophysical indices in an athlete, regardless of the specialization, further diagnostic search is not advisable. When revealing some decrease of biophysical indices, it is recommended, at a next stage, to determine the skin microbiocenosis condition according to the methods as follows:

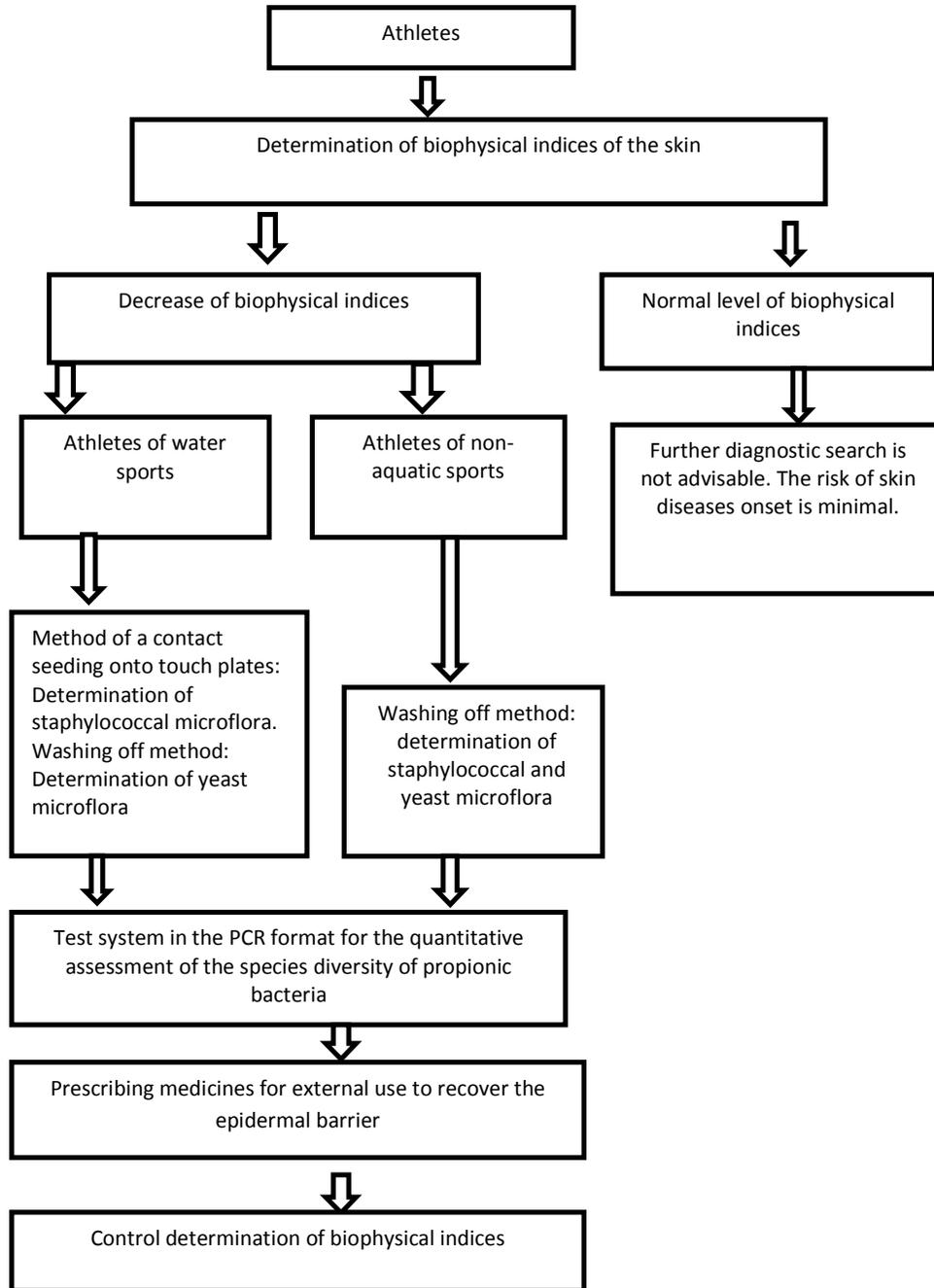
For the athletes whose activity is not related to water: determination of the species composition and the degree of skin infection with staphylococcal and yeast microflora by the washing off method.

For the athletes of water sports: The method of a contact inoculation on touch plates to determine the species composition and the degree of skin infection with the staphylococcal microflora, and determining the frequency of occurrence and the degree of infection with yeast microflora by the washing off method.

A test system in the real time PCR format to carry out the quantitative assessment of the species diversity of propionic bacteria in athletes of both groups.

**Table 7. Determination of the lipid content on the skin surface (mkg/sm<sup>2</sup>)**

Skin localization	Group I	Group II	Group III
Hand	1.0±0.13	1.3±0.48	3.0±0.72
Front	64.5±5.52	87.8±7.61	91.0±13.10
Chest	27.5±3.09	21.7±2.79	35.4±3.64
Back	29.4±3.17	15.4±1.52	38.2±6.06



**Diagram of the diagnostic algorithm for the risk of dermatosis onset in athletes**

The algorithm provided enables to reveal the groups of risks for onset of dermatologic diseases.

#### 4. CONCLUSION

Thus, professional sport activities have a significant effect on the functional condition of the skin that changes depending on the conditions and the regime of training. It is to note that between all the athletes we have examined, the pentathlon athletes have the most manifested decrease of biophysical indices as well as a high degree of skin infection with the conditionally pathogenic *Staphylococcus aureus*, which enables to classify them in a group with a high risk of the dermatosis development. Using the data obtained, it is possible to give practical recommendations to doctors, coaches and their athletes. According to this diagnostic algorithm, it is easy to solve the problem of prescribing medicines for external use that recover the epidermal barrier. In this case, it is advisable to control the biophysical indices not earlier than 3 weeks after starting the treatment with medicines for external use. When revealing skin diseases related to *S. aureus* it is obligatory to determine the susceptibility to antimicrobial medicines, in particular the MRSA strains. When selecting antibiotics for the 1<sup>st</sup> group athletes, it is necessary to avoid macrolides and chloramphenicol, and for the 2<sup>nd</sup> group athletes, the use of tetracycline medicines is to be avoided as well, due to the existence of resistant strains. It is of current interest to further study, at our opinion, the functional skin condition in athletes of various sports to allow an early diagnosis and to prevent the development of professional dermatosis.

#### ETHICAL APPROVAL

Ethical expert's opinion about this research was approved by the decision No 31 of the local Ethics Committee of the FGU VNIIFK Institute on the 17.08.2010. All the athletes gave written informed consent before the study.

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#### COMPETING INTERESTS

Authors have declared that no competing interests exist.

#### REFERENCES

1. Suvorov VG, Achkasov EE, Kurshev VV, Lazareva IA, Sultanova OA, Krasavina TV. Legal and organizational principles of medical rehabilitation of patients with occupational diseases. *Sports medicine: Research and Practice*. 2014;1:74-79. (in Russian).
2. Polievskiy SA, Ivanov AA, Grigorieva OV, Sivtsev IN. About the diagnosis and monitoring of the physical health and of the sport condition for athletes students. *Theory and Practice of the Physical Culture*. 2005;3:24-26. (in Russian).
3. Chikin VV. Peculiarities of the dermatosis development in people having contacts with substances presenting an irritating and allergenic effect. *Medicine of Labor and Industrial Ecology*. 2001;11(12-16) (in Russian).
4. Zaborova VA, Arzumanyan VG, Gurevich KG, Terekhova MV. Effect of the physical culture and sport exercises on the integument condition in people dealing with water sports. *Russian Journal of Cutaneous and Venereal Diseases*. Moscow. 2012;1:56-58. (in Russian).
5. Ernandes EI, Margolina AA, Petrukhina AO. Lipid barrier of the skin and cosmetics. Third edition, completed. Moscow: Clavel Company. 2005;400. (in Russian).
6. Ivko OA. Effect of the sport traumatism on the life quality of sport veterans at middle and old ages: Ph.D. in biol. Dissert. St. Petersburg. 2007;107. (in Russian).
7. Goriachkina LA, Kashkin KP. Clinical allergology and immunology. Moscow: Miclosh. 2009;273-287. (in Russian).
8. Shenderov BA. Medical microbial ecology and functional diet. Social, economic and clinical consequences of the unbalance in the microbial ecology of the man and the animals. Moscow: "Grant". 1998;2:412. (in Russian).
9. Globa AG, Alekseev Ial, Arzumanyan VG, Zaborova VA, Guridov AA. Application of the real time PCR method for the quantitative determination of some species of propionic bacteria inhabiting the skin of humans. *Biomedical Chemistry*. Moscow. 2012;5(58):608-612. (in Russian).

10. Barna Z, Kádár M. The risk of contracting infectious diseases in public swimming pools. A review. *Ann Ist Super Sanita.* 2012;48(4):374-386.
11. Bonini M, Bodina A, Bonali D, Bascucci B, Pellino P, Castaldi S. Investigation and comparison of behaviours of adults and children in swimming pools. *Ann Ig.* 2011;23(4):319-328.
12. Bowers AL, Huffman GR, Sennett BJ. Methicillin-resistant *Staphylococcus aureus* infections in collegiate football players. *Medicine & Science in Sports & Exercise.* 2008;40(8):1362-7.
13. Buss BF, Mueller SW, Theis M, Keyser A, Safranek TJ. Population-based estimates of methicillin-resistant *Staphylococcus aureus* (MRSA) Infections among High School Athletes—Nebraska, 2006–2008. *The Journal of School Nursing.* 2009;25(4): 282-291.
14. Centers for Disease Control and Prevention (CDC) Methicillin-resistant *Staphylococcus aureus* infections among competitive sports participants: Colorado, Indiana, Pennsylvania and Los Angeles County, 2000–2003. *MMWR Morbidity and Mortality Weekly Report.* 2003;52(33): 793-795.
15. Zaborova VA, Arzumanyan VG, Gurevich KG. Malasseziosis in athletes. *Russian Journal of Cutaneous and Venereal Diseases.* Moscow. 2013;6:55-59. (in Russian).
16. Cogen AL, Nizet V, Gallo RL. Skin microbiota: A source of disease or defence? *Br. J. Dermatol.* 2008;158(3): 442–455.
17. Gysleva OR. Morphological characteristic of microbial communities and peculiarities of the epidermal barrier in patients with the atopic dermatitis: Ph.D. in boil. Dissert. GOU VPO “Military Medical Academy. St. Petersburg. 2011;127. (in Russian).

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