AN UPDATE ON DEHYDRATION IN ATHLETES

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Fluid and electrolyte imbalances can compromise physical performance of professional athletes. We have conducted a study to understand how aware athletes are of their hydration status and how they deal with dehydration. First, we surveyed 51 athletes (mean age of 20.4 years) specializing in different sports, including ice hockey, water polo, tennis and figure skating, using a questionnaire. Next, we analyzed the anonymized results of the laboratory tests run on the samples of 30 athletes specializing in futsal. We focused on hemotocrit and sodium levels and urine specific gravity as indirect indicators of hydration status. Survey results demonstrated that 86 % of the participants lacked knowledge of wise approaches to replenishing fluid or electrolytes after physical exercise, did not adequately control fluid intake and developed various degrees of dehydration. We noticed that awareness of hydration status negatively correlated with professional qualifications of the participants. Retrospective analysis of laboratory tests showed that hypohydration prevailed among high-class athletes: at least 73 % of them showed signs of dehydration. We emphasize the need for elaborating unified clinical recommendations on rehydration for Russian athletes that should be further approved by doctors and coaches.

Keywords: hydration status, dehydration, rehydration, high-class athletes, carbohydrate-electrolyte solutions

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К ВОПРОСУ ОБ АКТУАЛИЗАЦИИ ПРОБЛЕМЫ ОБЕЗВОЖИВАНИЯ В СПОРТЕ

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Нарушение водно-солевого баланса — это фактор, лимитирущий физическую работоспособность профессиональных спортсменов. Нами было проведено исследование с целью определения степени информированности атлетов по проблеме дегидратации в спорте. На первом этапе было проведено с помощью разработанного авторами опросника анкетирование 51 спортсмена (средний возраст — 20,4 года) со специализацией в различных видах спорта: хоккее на льду, водном поло, большом теннисе, фигурном катании. На втором этапе были проанализированы деперсонифицированные данные лабораторных исследований 30 спортсменов со специализацией в мини-футболе: оценивали косвенные признаки гидратационного статуса — гематокрит, содержание натрия в крови, удельную плотность мочи. По результатам анкетирования была констатирована низкая информированность 86 % спортсменов по вопросам рационального восполнения потерь жидкости и минералов вследствие физических нагрузок, что служит одной из важнейших причин неконтролируемого потребления жидкости и развития обезвоживания различной степени. Отмечена зависимость уровня информированности от спортивной квалификации атлета. При ретроспективном анализе данных лабораторного тестирования была ориентировочно установлена распространенность гипогидратации среди спортсменов высокой квалификации: вероятные признаки дегидратации имели место по меньшей мере в 73 % случаев. В России следует разработать и внедрить национальные клинические рекомендации по регидратации в спорте, которые были бы одобрены медицинским и тренерским сообществом.

Ключевые слова: гидратационный статус, дегидратация, регидратация, спортсмены высокой квалификации, углеводно-электролитные растворы

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The balance of fluids is as important for physical capabilities of athletes as their energy metabolism intensity [1, 2]. Various body fitness indicators depend on qualitative and quantitative characteristics of hydration, i.e. saturation of body with liquids. Hydration disorders, from subclinical hypohydration to dehydration, also affect them drastically. That is why hydration status can help assess physical and functional condition of athletes.

Effective rehydration solutions that help maintain and restore fluid balance in particular and water-salt balance in general, are essential for optimizing the recovery of athletes after strains of training and competition. Evidence-based studies found that carbohydrate-electrolyte solutions (CES) are superior to low-salinity water in rehydration, which means they can boost the mentioned recovery of athletes and possibly improve their performance [3]. According to the International Society of Sports Nutrition (ISSN), CES can be used to accelerate rehydration, restore the volume of electrolytes and maintain the endurance levels [4]. Nutritionists have defined the optimal composition of such solutions, which are classified as sports drinks. They should contain at least 2 carbohydrates and sodium, the only mineral that requires no mandatory replenishment [5]. Other minerals, especially potassium can join the composition, too, but that is an option. The reason behind the optional character of the inclusion is that the body retains acceptable volumes of potassium even when the strain is significant, i.e. lasts for 8 days in a row and results in up to 3 to 4 liters of sweat generated, and the potassium consumption is down to 30 % of the recommended daily intake. Secondly, there is no conclusive evidence backing the negative effect low levels of potassium, magnesium and calcium may have on physical endurance. There is significant number of Consensus Statements [5, 7–11] that regulate CES consumption and aim to develop the rational consumption algorithms.

Despite the attention coaches and medical doctors throughout the world pay to the water-salt balance problem, and regardless of the extremely wide range of commercial sports drinks available on the market, hypo- and dehydration is still a condition diagnosed quite often both in professional athletes and people regularly going in for sports. According to Sponsiello et al [12], only 37 % of the examined athletes were hydrated properly, and according to V.A. Kurashvili, [13], up to 91 % of professional competitive sports athletes (basketball, handball, football) begin their training session while dehydrated. This being said, athletes often disregard dehydration: 65 % of runners going long and super long distances did not attach any importance to the possible problem [14]. It should be noted that these data were obtained through interviewing 419 men and women participating in the Chicago Marathon, most of whom have been practicing long distance running for at least 10 years.

The level of hydration is an indicator defined by individual properties of the athlete's anthropometric data, instrumental and laboratory testing parameters, eating habits, social and cultural status, confessional identity [8]. However, the researchers behind paper [8] did not take into account the awareness of athletes of fluid deficiency caused by physical strain and ways to replenish that deficiency.

Designing this study, we aimed to identify the relationship between awareness about body hydration regimen rationalization as one of the characteristics of eating habits found in a quite specific social group (top tier athletes) and established laboratory methods of hydration status of athletes.

METHODS

There were two stages to the study.

First stage implied surveying 51 professional athletes with the help of a questionnaire we developed. There were slightly more men than women among the respondents: 53 % versus 47 %. Age-wise, the distribution was as follows: athletes 16–18 years old — 51 %, 19–21 years old — 18 %, 22–24 years old — 12 %, 25 years and older — 20 %. The mean age was 20.4 years. The athletes practiced various sports: ice hockey, water polo, tennis, figure skating. 9 respondents were Masters of Sport of International Class, 5 -- Honored Masters of Sports.

The questionnaire contained 19 questions grouped into 6 clusters.

- Cluster 1 (questions 1–5): general information about the athlete (sex, age, anthropometric data, practiced sport and skill level, current training focus and intensity);
- Cluster 2 (questions 6–7): self-assessment of the water-salt balance status during and after training sessions, awareness of the average fluid loss per a training session;
- Cluster 3 (questions 8–11): how does the athlete replenish fluid loss during training sessions;
- Cluster 4 (questions 12–15): how does the athlete replenish fluid loss after training;
- Cluster 5 (questions 16–18): how does the athlete replenish fluid loss during competitions;
- Cluster 6 (question 19): what brands of special water-salt balance normalizing sports drinks does the athlete prefer.

The second stage implied a retrospective analysis of the laboratory tests results that indirectly described the hydration status of athletes. We studied the depersonalized data obtained through in-depth medical examinations of 30 top tier athletes practicing futsal; none of those athletes filled the first stage's questionnaire. We took 3 indicators as markers of shifts in the water-electrolyte balance: hematocrit (volume of erythrocytes in blood) as recorded in the general clinical blood test; Na^+ content in blood; specific density of urine. The array of laboratory test results was provided by the Clinic of Sports Medicine of the Moscow Scientific and Practical Center for Medical Rehabilitation, Restorative and Sports Medicine of the Moscow Department of Health.

RESULTS

The survey revealed various levels of awareness of de/rehydration occurring when practicing sports, from an almost complete ignorance (sports requiring complex coordination efforts) to the decent levels of awareness (competitive sports). The key problem was the lack of information on the water-electrolyte balance assessment methods and data on how much fluid should an athlete consume before, during and after training sessions and competitions. That said, it should be noted that 86 % of athletes drink during long training sessions/competitions, which is a positive sign.

As a rule, the greater the qualification of an athlete is, the more he/she knows of the perspiration-related fluid loss and the better he/she can manage the hydration status. However, even top tier athletes generally underestimated the fairly simple ways of monitoring the body's moisture saturation, which are weighing before and after training session; grading the urine color against the template [15] published to the website of University of West Alabama's Athletic Training & Sports Medicine Center; identification of the urine's body composition and specific gravity.

Only 7 athletes of the 51 surveyed took time to establish the individual fluid loss after training sessions, which is 14 % of the respondents (Figure 1). It should be noted that members of this extremely small group, while training/competing, generally consumed 50 to 70 % of fluid lost to physical exertion. Figure 2 shows the actual fluid loss due to training activities, and figures 3 and 4 show that most athletes do not consume enough fluid to compensate for that loss, especially after the sessions.

The most popular fluid to restore the water-salt balance among athletes is drinking water. More often than not, it is coaches that insist coaches on such a choice; they are wary of CES due to their composition because of the risk of violation of anti-doping rules.

As for the special CES, the surveyed athletes prefer products procured by the management following orders placed by the team. The share of CES made in Russia is below 20 %.

Quite often, athletes take commercially available sports drinks (iso- and hypotonic types) with drinking water; some of them do this consciously, relying on some information (unfortunately, not always justified).

The results of analysis of the laboratory tests data that indirectly prove the water-electrolyte balance is broken were rather unusual.

The hematocrit reference value (47 %) was exceeded in one case only, while 23 out of 30 futsal players exhibited border values (44–46 %). Thus, in 80 % of athletes the liquid fraction of blood tended to grow smaller, which can be considered a sign of hypohydration.

Fifteen athletes had hypernatremia, which is a probable indicator of hyperosmotic hypohydration, i.e. prevalence of fluid loss over the mineral component (above 152 mOsmol/kg H_2O). 5 athletes returned border values (146–152 mOsmol/kg H_2O). Seven athletes had normal sodium content in their blood (135–145 mOsmol/kg H_2O); 2 athletes suffered from hyponatremia. These 2 athletes had a hypoosmotic condition, but there was no reason to assume hyperhydration ("water intoxication" resulting from consuming large amounts of drinking water) since the specific density of their urine was acceptable (1020).

In 5 athletes, the specific density of urine (due to excess concentration diluted substances) grew to 1025 and above, which may mean dehydration; 11 athletes had the density below 1020, which signals of the optimal level of hydration. Fourteen athletes had the density within the limits of normality (1020–1025). Thus, in about 2/3 of athletes the concentration of substances diluted in urine tended to rise; however, this fact cannot be taken as significant without information on the content of urea, which is more important to urine's osmolality than sodium.

DISCUSSION

Top tier athletes do not know much about fluid deficiency resulting from physical exertion, ways to identify that deficiency and remedy it. This is a factor putting their performance and endurance at risk [1–3]. Our survey proves that the low level of awareness means up to 86 % of athletes do not possess sufficient information to optimize their fluids consumption regimen and thus are unable to manage their hydration status.

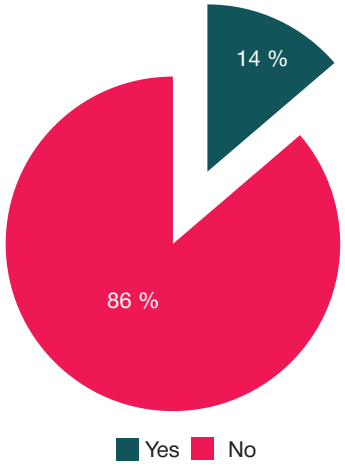

Fig. 1. Awareness of the actual fluid loss due to training activities. Results of surveying professional athletes (n = 51)

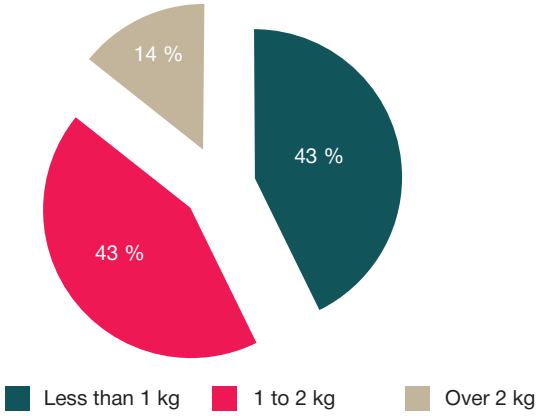

Fig. 2. The average volume of fluid lost during a training session (fact). Results of surveying professional athletes (n = 51)

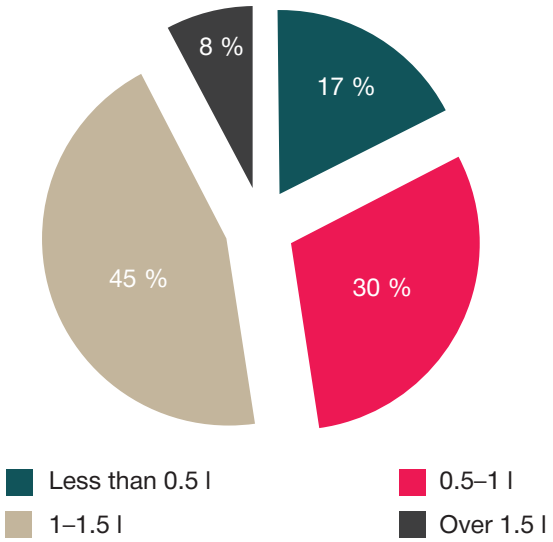

Fig. 3. The volume of fluid consumed during a training session. Results of surveying professional athletes (n = 51)

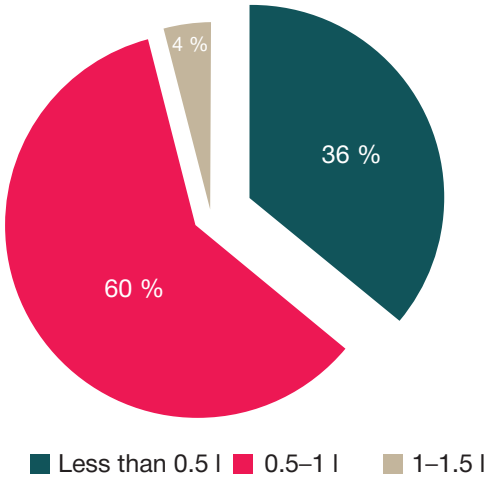

Fig. 4. The volume of fluid consumed after a training session. Results of surveying professional athletes (n = 51)

It should be noted that during training sessions/competition and after them the athletes should consume at least 150 % of fluids they have lost [3, 5]. Consequently, our observations show that no less than 2/3 of athletes, regardless of their drinking regimen motivation (thirst or directions issued by doctors), are at risk of developing hypo-and dehydration. That said, the surveyed athletes typically replenish 50 to 70 % of fluid lost during training sessions and competitions. Burke et al. report similar figures [16]. This means that the common problem is insufficient fluids consumption after physical exertion. All in all, the filled questionnaires we collected allow stating that 73 % of athletes do not consume enough liquids to compensate for the losses, regardless of sport practiced.

As for the results of the retrospective analysis of depersonalized laboratory tests data, 3 athletes exhibited 3 three signs of dehydration, 16 exhibited 2 signs and 8 athletes had just 1 sign. The optimal level of hydration (eughydration) was registered in 4 cases only, which makes 10 % of the sample. This is less than what other researchers found (see study [12], for example, where the share of properly hydrated athletes was 37 %). Our observations are paradoxical, since football in all its variations is a sport that takes nutrition and liquids intake seriously, which is proved by a regularly reissued set of rules [10].

The data obtained through this research signal of athletes underestimating the risk of dehydration and the negative impact it has on their performance; the athletes seem to lack understanding and knowledge of how to keep their water-electrolyte balance at the optimal level. On the national level, this problem is exacerbated by the lack of clinical recommendations on rehydration as applied to practicing athletes, the recommendations that would have been approved by doctors and the coaching community. Development of such recommendations and making them readily available to public could significantly improve the situation.

CONCLUSIONS

The survey conducted as part of this study was designed to achieve both research and didactic goals. The purpose-made questionnaire formed basis for a discussion with sports nutrition specialists; the discussion revolved around the possible reasons behind the great differences in answers, including those given to the question of rational rehydration (or maintaining the status at the desired level) and its role in improving the performance of athletes, most of which took it as an incentive to learn how to keep the water-salt balance in order. The retrospective

analysis of depersonalized laboratory tests data has objectively confirmed the problem exists.

The problem of irrational fluids consumption by practicing athletes is still extremely urgent. In this connection, the most important task to be solved as soon as possible is the development of various instruments to monitor hydration status, instruments that can be used both in laboratory settings (like stationary equipment to analyze body composition, segment-wise and not) and in the "field" (including test strips to determine the specific density of urine, electrolyte composition of sweat and viscosity of saliva, plus the urine color scale). Proper monitoring arrangements would allow development of personalized rehydration programs covering the yearly training cycle stages; such programs could be made up not just for the top tier athletes, who are few, but for the "reserve" sportsmen, too.

References

1. Palmer MS, Heigenhauser GJ, Duong M, Spriet LL. Mild Dehydration Does Not Influence Performance or Skeletal Muscle Metabolism During Simulated Ice Hockey Exercise in Men. Int J Sport Nutr Exerc Metab. 2017 Apr; 27 (2): 169–77.
2. Zubac D, Antelj T, Olujic D, Ivancev V, Morrison SA. Fluid balance and hydration assessment during the weight-stable preparation phase in elite youth boxers. J Sports Sci. 2017 Apr; 35 (8): 719–26.
3. Shirreffs SM. Hydration in sport and exercise: water, sports drinks and other drinks. Nutrition Bulletin. 2009 Dec; 34 (4): 374–9.
4. Campbell B, Wilborn C, La Bounty P, Taylor L, Nelson MT, Greenwood M, et al. International Society of Sports Nutrition position stand: energy drinks. J Int Soc Sports Nutr. 2013 Jan 3; 10 (1): 1. doi: 10.1186/1550-2783-10-1
5. Report of the Science Committee on Food on composition and specification of food intended to meet the expenditure of intense muscular effort, especially for sportsmen (Adopted by the SCF on 22/6/2000, corrected by the SCF on 28/2/2001) [Internet]; [cited 2017 Nov 6]: 50 p. Available from: https://www.mattilsynet.no/mat_og_vann/spesialmat_og_kosttilskudd/sportsprodukter/report_of_the_scientific_committee_on_food_on_composition_and_specification_of_food_intended_to_meet_the_expenditure_of_intense_muscular_effort_especially_for_sportsmen.2847/binary/Report%20of%20the%20Scientific%20Committee%20on%20Food%20on%20composition%20and%20specification%20of%20food%20intended%20to%20meet%20the%20expenditure%20of%20intense%20muscular%20effort,%20especially%20for%20sportsmen
6. Rylova NV. [Food safety in sport]. Vestnik NTsBZhD. 2014; 19 (1): 51–6. Russian.
7. Casa DJ, Clarkson PM, Roberts WO. American College of Sports Medicine Roundtable on Hydration and Physical Activity: Consensus Statements. Curr Sport Med Rep. 2005 Jun; 4 (3): 115–27.
8. Lopez RM, Casa DJ. Hydration for Athletes: What coaches can do to keep their athletes healthy and performing their best. Coaches' quarterly/Winter 2006 [Internet]; [cited 2017 Nov 6]: 3 p. Available from: https://www.wiaawi.org/Portals/0/PDF/Sports/Wrestling/hydration4athletes.pdf
9. American College of Sports Medicine, Sawka MN, Burke LM, Eichner ER, Maughan RJ, Montain SJ, et al. American College of Sports Medicine position stand. Exercise and fluid replacement. Med Sci Sports Exerc. 2007 Feb; 39 (2): 377–90.
10. Nutrition for football: A practical guide to eating and drinking for health and performance. Based on an International Consensus Conference held at the Home of FIFA in Zurich, Sep 2005, Updated Jan 2010 [Internet]; [cited 2017 Nov 6]: 33 p. Available from: http://resources.fifa.com/mm/document/footballdevelopment/medical/51/55/15/nutritionbooklet_neue2010.pdf
11. Position Statement and Recommendations for Maintaining Hydration to Optimize Performance and Minimize the Risk for Exertional Heat Illness [Internet]. National Federation of State High School Associations (NFHS), Sports Medicine Advisory Committee (SMAC). Revised and Approved Oct 2014 [cited 2017 Nov 6]: 4 p. Available from: http://www.montgomeryschoolsmd.org/uploadedFiles/departments/athletics/health/NFHS%20-%20Position%20Statement%20-%20Heat%20Illness.pdf
12. Sponsiello N, Rucci S, Buonocore D, Focarelli A, Doria E, Negro M, et al. Experimental evaluation of the hydration status during fitness training. Med sport. 2013; 66 (4): 531–44.
13. Kurashvili VA. Sportivnye napitki pomogayut molodym sportsmenam. Vestnik sportivnykh innovatsiy. 2010 Nov; (20): 20. Russian.
14. Sanz de la Garza M, Lopez A, Sitges M. Multiple pulmonary embolisms in a male marathon athlete: Is intense endurance exercise a real thrombogenic risk? Scand J Med Sci Sports. 2017 May; 27 (5): 563–6. doi: 10.1111/sms.12680
15. Am I Hydrated? Urine Color Chart [file on the Internet]. The University of West Alabama; Athletic Training & Sports Medicine Center; c2017 [cited 2017 Nov 6]: 1 p. Available from: http://at.uwa.edu/admin/UM/urinecolorchart.doc
16. Burke LM. Fluids: Facts & Fads. Aspetar Sports Medicine Journal. 2012 Aug; 1 (2): 88–93.

Литература

1. Palmer MS, Heigenhauser GJ, Duong M, Spriet LL. Mild Dehydration Does Not Influence Performance or Skeletal Muscle Metabolism During Simulated Ice Hockey Exercise in Men. Int J Sport Nutr Exerc Metab. 2017 Apr; 27 (2): 169–77.
2. Zubac D, Antelj T, Olujic D, Ivancev V, Morrison SA. Fluid balance and hydration assessment during the weight-stable preparation phase in elite youth boxers. J Sports Sci. 2017 Apr; 35 (8): 719–26.
3. Shirreffs SM. Hydration in sport and exercise: water, sports drinks and other drinks. Nutrition Bulletin. 2009 Dec; 34 (4): 374–9.
4. Campbell B, Wilborn C, La Bounty P, Taylor L, Nelson MT, Greenwood M, et al. International Society of Sports Nutrition position stand: energy drinks. J Int Soc Sports Nutr. 2013 Jan 3; 10 (1): 1. doi: 10.1186/1550-2783-10-1
5. Report of the Science Committee on Food on composition and specification of food intended to meet the expenditure of intense muscular effort, especially for sportsmen (Adopted by the SCF on 22/6/2000, corrected by the SCF on 28/2/2001) [Интернет]; [дата обращения: 6 ноября 2017 г.]: 50 с. Доступно по ссылке: https://www.mattilsynet.no/mat_og_vann/spesialmat_og_kosttilskudd/sportsprodukter/report_of_the_scientific_committee_on_food_on_composition_and_specification_of_food_intended_to_meet_the_ expenditure_of_ intense_muscular_effort_especially_for_sportsmen.2847/binary/Report%20of%20the%20Scientific%20Committee%20on%20Food%20on%20composition%20and%20specification%20of%20food%20intended%20to%20meet%20the%20expenditure%20of%20intense%20muscular%20effort,%20especially%20for%20sportsmen
6. Рылова Н. В. Безопасность питания спортсменов. Вестн. НЦБЖД. 2014; 19 (1): 51–6.
7. Casa DJ, Clarkson PM, Roberts WO. American College of

Sports Medicine Roundtable on Hydration and Physical Activity: Consensus Statements. Curr Sport Med Rep. 2005 Jun; 4 (3): 115–27.
8. Lopez RM, Casa DJ. Hydration for Athletes: What coaches can do to keep their athletes healthy and performing their best. Coaches' quarterly/Winter 2006 [Интернет]; [дата обращения: 6 ноября 2017 г.]: 3 с. Доступно по ссылке: https://www.wiaawi.org/Portals/0/PDF/Sports/Wrestling/hydration4athletes.pdf
9. American College of Sports Medicine, Sawka MN, Burke LM, Eichner ER, Maughan RJ, Montain SJ, et al. American College of Sports Medicine position stand. Exercise and fluid replacement. Med Sci Sports Exerc. 2007 Feb; 39 (2): 377–90.
10. Nutrition for football: A practical guide to eating and drinking for health and performance. Based on an International Consensus Conference held at the Home of FIFA in Zurich, Sep 2005, Updated Jan 2010 [Интернет]; [дата обращения: 6 ноября 2017 г.]: 33 с. Доступно по ссылке: http://resources.fifa.com/mm/document/footballdevelopment/medical/51/55/15/nutritionbooklet_neue2010.pdf
11. Position Statement and Recommendations for Maintaining Hydration to Optimize Performance and Minimize the Risk for Exertional Heat Illness [Интернет]. National Federation of State High School Associations (NFHS), Sports Medicine Advisory Committee (SMAC). Revised and Approved Oct 2014 [дата обращения: 6 ноября 2017 г.]: 4 с. Доступно по ссылке: http://www.montgomeryschoolsmd.org/uploadedFiles/departments/athletics/health/NFHS%20-%20Position%20Statement%20-%20Heat%20Illness.pdf
12. Sponsiello N, Rucci S, Buonocore D, Focarelli A, Doria E, Negro M, et al. Experimental evaluation of the hydration status during fitness training. Med sport. 2013; 66 (4): 531–44.
13. Курашвили В. А. Спортивные напитки помогают молодым спортсменам. Вестн. спорт. инноваций. 2010 ноябрь; (20): 20.
14. Sanz de la Garza M, Lopez A, Sitges M. Multiple pulmonary embolisms in a male marathon athlete: Is intense endurance exercise a real thrombogenic risk? Scand J Med Sci Sports. 2017 May; 27 (5): 563–6. doi: 10.1111/sms.12680
15. Am I Hydrated? Urine Color Chart [файл из интернета]. The University of West Alabama; Athletic Training & Sports Medicine Center; c2017 [дата обращения: 6 ноября 2017 г.]: 1 с. Доступно по ссылке: http://at.uwa.edu/admin/UM/urinecolorchart.doc
16. Burke LM. Fluids: Facts & Fads. Aspetar Sports Medicine Journal. 2012 Aug; 1 (2): 88–93.