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Kinematic indicators in combat sports athletes in a pre-competitive dehydrated status

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C Statistical Analysis
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Bibiana Calvo Rico[1ABCDE], José Manuel García García[1ABCDE], Luis Fernandes Monteiro[2BE], Natalia Rioja Collado[1ACD]

[1] Facultad de Ciencias del Deporte de Toledo, Universidad de Castilla- La Mancha, Toledo, España
[2] Facultad de Educación Física y Deporte, Universidad Lusófona de Humanidades y Tecnologías, Lisboa, Portugal

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Abstract

Background & Study Aim: To attain the right weight in competition, most of combat sports athletes who must be included in a determined weight category, resort to the dehydration. The aim of this study was knowledge about influence of three training stages combat sports athletes (base, specific and pre-competitive) on their level of dehydration and their body composition and muscle strength.

Material & Methods: Sixty-four competitive athletes participated in this study: 38 Olympic Greco-Roman wrestlers from Spanish national team; 26 judo athletes from Portuguese national team. By means of Inbody Biospace 230 bio-impedance method, an anthropometric study was practiced to all of them in each phase of the investigation, to know body weight, skeletal muscular mass, and body water and fat mass percent. For the measurements of the muscle strength manifestations, the system Isocontrol 5.2 was used.

Results: One out of every four athletes is usually dehydrated, being women those who tend to dehydrate more than men. The greater dehydration is during the training base stage. Wrestlers tend to dehydrate more than judo athletes. Hydrated athletes have better indicators in the muscle strength manifestations. The most affected indicators in the dehydrated ones are: muscle strength, muscle power and muscle strength production average. The dehydrated ones have smaller values of skeletal muscular mass.

Conclusions: Dehydration in combat sports negatively affects the athletes performance diminishing their muscle strength levels as much in the training as in the competition, being women most prone to dehydrate than men. Wrestlers use more pre-competitive dehydration than judo athletes, reason why it is recommendable a performance protocol to avoid situations that can affect to the athlete health and performance.

Key words: body composition • judo • mezocycle • muscle strength • wrestling • 1RM

Author´s Address: Bibiana Calvo Rico, Facultad de Ciencias del Deporte de Toledo, Universidad de Castilla- La Mancha. Campus Tecnológico de la Fábrica de Armas de Toledo. Avda/ Carlos III s/n. 45071, Toledo, Spain; e-mail: bibiana.calvo@uclm.es

Corporal composition – set of body parameters which defines a person's somatic.

Dehydration – fluid and mineral salts deficiency status which affects the organism, produced by diverse factors: extreme heat situations, self-inferred vomiting, diarrhoeas, strict diets, etc.

Inbody – analysing tool of the body composition which makes an analysis by means of bio-electrical impedance (conduction of the electric current through the tissues) by segmental way and multi-frequency.

Isocontrol – analysing tool of the manifestations of the muscle strength.

Mezocycle – training cycle of medium length, a part of the annual cycle (macrocycle) characterized by dynamic loads and the nature of work in the period of approx. 4 weeks.

Muscle strength – essential and basic physical capacity in combat sports by which the body moving status is modified.

1RM – individual's maximal strength or 1 repetition maximum [33].

INTRODUCTION

Knowing the importance of hydration in all the sports practised at present time, many have been the studies which detailed what to do before, during and after an intense, gentle or moderate exercise, how to recover after a sport competition and even what we must ingest to recover the hydration optimal levels in our organism [1, 2] ensuring energetic recovery and avoiding situations that lead us to unwanted dehydration. [3].

We must consider every sport modality idiosyncrasy, whatever it is, collective type [4, 5], endurance [6] and/or single [7] and so, facing any situation that could be caused, we will value the changes in the organism and we will overcome the dehydration that could be generated. Within the group of the individual sports, not only we must focus our investigations in solving whatever it happens during the competition as a consequence of any possible dehydration but also, we must emphasise the importance of those cases of pre-competitive dehydration, numerous and continuous in time by their nature, as for example in combat sports. In a specific way, as much judo as wrestling are sports that have determining characteristics that make them propitious to foment the situations object of this investigation.

One of the main concerns in sport, as much of athletes, personal trainers or managers at the moment of making the general season schedule, is not only the number of competitions, depending on their objectives that the athletes can or must do, but the conditions they must reach in those competitions. The hydration and dehydration athletes' expectations at physiological level must be very concrete. Any type of imbalance in this sense could be harmful to their performances and health [8, 9].

Weight loss methods and other strategies are usual acts in combat sports; they combine pre-competitive dehydration and nutritional restriction [10] reducing athletes' body mass index [11]. Kovacs and Yorio [12] enumerate dehydration consequences at physiological level: increase of heart rate, reduction of blood supply, reduction of cardiac output and blood pressure, diminution of maximum oxygen consumption (VO2), and even an attack on athletes' organism immune functions [13]. Franchini et al. [14] demonstrate through their investigations how in aerobic performances, alterations assigned to the previous weigh-in dehydration, diminish plasma volume, increase cardiac output and cause disorders of muscle glycogen and in a thermo-regulator level.

Studies made by American College of Sport Medicine [15] demonstrate that a diminution of fluids intake as direct consequence of searching for weight loss through the pre-competitive dehydration, adversely affects in the athletes' health [16]. In search of the right weight for competition, the subject body weight 2% diminution by dehydration, affects negatively sporting performances and besides muscle strength, resistance and coordination reduction [17]. It reduces also superior members isometric muscle strength levels as the combats draw on [18, 19]. But athletes' dehydration does not only affect at a physiological level. Maughan et al. [20], made a study in which, physical and mental tasks accomplishment was affected by both aspects. Lieberman [21], in his studies on the existing relation between dehydration and cognitive function in human being, demonstrates that dehydration levels from 1% of the body weight in ahead, have negative effects in athletes' cognitive performance.

The aim of this study was knowledge about influence of three training stages combat sports athletes (base, specific and pre-competitive) on their level of dehydration and their body composition and muscle strength.

MATERIAL AND METHODS

Participants

The athletes sample was composed by 64 (45 male, 19 female) combat sports athletes, aged between 17 and 35 years old. This doctoral thesis study started with 40 Greco-Roman wrestlers, male and female senior category from the Spanish Olympic wrestling team, and finally it finished with 38 (27 male, 11 female) of them (those who fulfilled all the necessary requirements). The requirements were: evaluations at three different moments of the season; 2 wrestlers were excluded for not complimenting the specific data gathering, as for instance: absence during training and/or competition due to any kind of injury or situation and so they were dismissed.

Also we relied on 40 judo athletes from senior and junior categories from the national Portuguese team – remained 26 (18 male, 8 female), but 14 were dismissed for very similar reasons to the previously mentioned. The subjects sample diminished considerably in the judo modality. Some of them had sports commitments or were injured, so they were dismissed at the moment of the data gathering.

Local Ethics Committee approved the study. Judo athletes, wrestlers and their trainers were all previously informed about the purpose of this investigation, what kind of evaluations would be made and which would be the dates during the season coinciding with their training. We obtained informed consent from all of them to participate in it.

Protocol

The data gathering was made during three specific moments in judo athletes and wrestlers' sporting season: Preliminary period, training base stage **(base)**: (development mezocycle). Preliminary period, **specific** stage: (control mezocycle). Competitive period: in a dehydration condition, previous weigh-in, in the **pre-competitive** moment. To wrestlers group, the evaluations were made at the facilities of the High-Performance Centre (C.A.R.) at Madrid (Spain) and during the "Wrestling Spain Absolute Championship" at Murcia (Spain). To judo athletes, the evaluations were made at the facilities of the C.A.R. at Madrid (Spain), at "Do Jamor Swimming pool" at Cruzquebrada (Portugal) and during "Antonio Matías Memorial Tournament" and "Lisbon Open" at Lisbon (Portugal).

Tools

Within this study we distinguish two sorts of fundamental tools: to evaluate muscle strength different symptoms we used the Isocontrol 5.2 System (Quasar Control. Madrid, Spain). This tool helped us with the test 1RM in banca press. With it we obtained data concerning the variables of: acceleration, muscle strength average, muscle power and muscle strength production average.

Second tool we used to control and to know body composition values was the Inbody Biospace 230 System (CA, USA). This is a Bioelectric Impedance method based on the electric current conduction through biological tissues. This method lies in measuring impedance or opposition to the current flux through body tissues [22-24]. By means of this system we can get the variables of: body weight, skeletal muscular mass, body fat index and body water percent, and body mass index among others.

Both of these tools are easy handling and they are not invasive procedures for the athletes.

We enclosed to these tools a third one, the SPSS 19.0 data sheet including variables extracted from systems files, licensed by the Universidad de Castilla-La Mancha (Spain).

Data gathering protocol

Wrestlers evaluation testing was made during the preliminary hours to the evening training sessions, coinciding with the competition weigh-in time during wrestling championships. To judo athletes, evaluation testing was made before the morning training sessions, close to this discipline weigh-in time.

For the evaluation testing, wrestlers were barefooted and just wearing their jersey as they have to for the official weigh-in during national and international competitions, and for the same evaluation testing, judo athletes were just wearing the underwear, even if during the official weigh-in they can be nude on the scales. They were all evaluated without making previous physical activity and without having food or fluid intake for 2 hours before the measurements, as Martín-Moreno et al. [25] recommends to. They were also requested to urinate and defecate to be free of organic waste [26].

At the moment of the evaluation testing, athletes were standing, setting both of their heels and their metatarsus on the Inbody 230 base electrodes. They were holding with both hands the electrodes and their elbows were separated from trunk. Before and after every measurement, electrodes were cleaned and dried, as well as feet and hands of the subjects [27].

For the accomplishment of muscles strength test by means of the Isocontrol system through 1RM in banca press exercise, we count on an encoder of 200 cm and 2 n of resistance at the bar shifting level vertical. Athletes exercised with free weight and so, the loading discus we used were previously calibrated with a tensionmetric cell suspended at a high place (column – we considered valid weights those with a deviation less than 0.5%). Protocol to obtain muscle strength and time till the acquisition of maximum strength values during the 1RM shifting is: the first load is 200 grams to obtain the maximum velocity of execution. The load is gaining every 2, 5, 10 or 20 Kg weight depending on the evaluated athletes and execution velocity [28].

Statistical analysis

For the data analysis, different tests were made with the investigation variables, explaining in detail the fundamental importance in hydrated and dehydrated athletes group during training shapes, and also a descriptive analysis of the studied variables.

For the averages differences we made the statistical analysis test *t-Student* for independent samples during

Table 1. Total hydrated and dehydrated group athletes (n = 64) descriptive statistical and of the variables depending on body composition and muscle strength, during the three phases of the study

Variables and indicators	Statistical indicators	Training stage		
		base	specific	pre-competitive
Body composition				
Weight (kg)	Average	73.58	72.92	70.38
	SD	14.99	14.79	14.84
Skeletal muscular mass (%)	Average	34.85	35.29	35.27
	SD	8.33	8.29	8.65
Body water (%)	Average	62.40	62.67	62.88
	SD	4.82	4.19	4.70
Body fat mass (%)	Average	16.86	15.08	13.47
	SD	9.57	5.57	5.87
Muscle strength				
Acceleration (m/s^2)	Average	17.98	20.18	19.83
	SD	4.54	4.19	3.98
Muscle strength average (N)	Average	864.68	995.01	942.06
	SD	479.69	539.94	502.15
Muscle power average (W)	Average	487.33	550.75	524.66
	SD	207.89	196.03	192.11
Muscle strength production (J)	Average	31045.71	52926.23	73419.89
	SD	29698.20	57551.17	164755.63

the three study phases: base, specific and pre-competitive, with the study variables (we respected the typical deviation indicators and the statistical significance levels for 0.01 and 0.05).

RESULTS

The body weight is one of the variables tending to diminish, as the preparation stages to the competition advance (Table 1). For example: base: 73.58 ±14.99; specific: 72.92 ±14.79; pre-competitive: 70.38 ±14.84). The same as it is with body fat mass percent values (e.g.: base 16.86 ±9.57; specific: 15.08 ±5.57; precompetitive: 13.47 ±5.87). Skeletal muscular mass value increases from the base stage to the specific stage (e.g.: base: 34.85 ±8.33; specific: 35.29 ±8.29).

There are no significant differences in body composition variables (Table 2). Nevertheless there are in muscle strength production (p = 0.01), being the number of the hydrated athletes bigger than the number of the dehydrated ones (hydrated n = 36; dehydrated n = 16).

During the specific stage, the *t-Student* test reflects muscle strength production as an important value, with a significant value of p = 0.027 (Table 3). In the same way, the hydrated athletes group exceeds the dehydrated one at all the variables (hydrated n = 42; dehydrated n = 14, for body composition variables; hydrated n = 40; dehydrated n = 14, for muscle strength variables).

Last study phase in which we can observe that, as within body composition variables, the body fat mass percent shows a significance value of p = 0.022 (Table 4). Muscle strength as muscle power have relevant differences at this study phase, being their p values 0.015 and 0.032 respectively. The athletes number in the hydration level keeps being higher than dehydrated athletes number, as much for body composition variables as for muscle strength variables

Table 2. Averages differences during the base stage (*t-Student* test for independent samples) depending on the athletes hydration levels

Variables and indicators	Hydration Levels	N	Average	SD	p
Body composition					
Base weight (kg)	Hydrated	36	75.36	14.52	.482
	Dehydrated	18	70.17	16.52	
Base skeletal muscular mass (%)	Hydrated	36	37.22	7.69	.860
	Dehydrated	18	30.25	8.01	
Base body water (%)	Hydrated	36	65.29	2.54	.993
	Dehydrated	18	56.62	2.48	
Base body fat mass (%)	Hydrated	36	14.51	10.54	.394
	Dehydrated	18	22.75	3.86	
Muscle strength					
Base acceleration (m/s^2)	Hydrated	34	18.58	4.44	.901
	Dehydrated	18	17.26	5.10	
Base muscle strength average (N)	Hydrated	34	1043.92	534.21	.129
	Dehydrated	18	592.88	226.99	
Base muscle power average (W)	Hydrated	34	584.63	186.77	.077
	Dehydrated	18	343.43	141.30	
Base muscle strength production (J)	Hydrated	34	39929.76	36551.21	**.010****
	Dehydrated	18	17864.03	12799.16	

*p<0.05 **p<0.01

(hydrated n = 47; dehydrated n = 15, for body composition; hydrated n = 42; dehydrated n = 13, for muscle strength variables).

DISCUSSION

Skeletal muscular mass value increases from the base stage to the specific stage. This is basically because the muscle strength training base stage in this type of athletes is the work of maximum dynamic muscle strength via the muscular hypertrophy. As pre-competitive stage approaches, this variable level diminishes as a consequence of body weight decrease searching for the right competition weight. The body water percent increases as the training stages follow one another because we find a global descriptive where hydrated athletes percent is bigger than the dehydrated ones percent.

Within kinematic indicators from the base stage to the specific stage, there is a considerable improvement in all muscle strength variables and all of them thoroughly diminish during the precompetitive stage, except muscle strength production, which increases, because the global addition of hydrated and dehydrated athletes' data make indicators grow as it happened with body water percent.

The results during the different phases of the study show as following: base stage (1) more of the 85% of the athletes were in a dehydration situation during this phase of the study; (2) the dehydrated wrestlers and judo athletes confirm smaller indicators than the hydrated ones.

These results agree with the investigations made by García et al. [28] where it is shown that values bigger than 25% of the body weight in judo athletes suppose a confirmed damage to the muscle resistance values as to the muscle strength ones. In the same way Kalman and Lepeley [17] come to the same conclusions observing that a diminution of 2% of the body

Table 3. Averages differences during specific stage (*t-Student* test for independent samples) depending on the athletes hydration levels

Variables and indicators	Hydration Levels	N	Average	SD	p
Body composition					
Specific weight (kg)	Hydrated	42	73.69	14.85	.967
	Dehydrated	14	70.60	14.89	
Specific skeletal muscular mass (%)	Hydrated	42	36.85	8.14	.432
	Dehydrated	14	30.60	7.07	
Specific body water (%)	Hydrated	42	64.71	2.18	.951
	Dehydrated	14	56.56	2.41	
Specific body fat mass (%)	Hydrated	42	12.55	3.31	.946
	Dehydrated	14	22.67	3.76	
Muscle strength					
Specific acceleration (m/s^2)	Hydrated	40	20.42	4.41	.083
	Dehydrated	14	18.98	3.05	
Specific muscle strength average (N)	Hydrated	40	1096.52	588.62	.061
	Dehydrated	14	695.32	204.33	
Specific muscle power average (W)	Hydrated	40	589.53	194.29	.158
	Dehydrated	14	425.24	146.74	
Specific muscle strength production (J)	Hydrated	40	61059.88	60437.65	.027*
	Dehydrated	14	32092.28	45185.96	

*p<0.05

weight loss as a search for the competition weight, diminishes the athletes performance related to muscle strength, muscle resistance and coordination.

Regarding the conclusions related to the study specific phase: (1) muscle strength variables improvements are bigger in the hydrated athletes than in the dehydrated ones; (2) the changes in body composition variables are bigger on skeletal muscular mass, and this one increases in hydrated athletes, being better the wrestlers values that the judo athletes ones.

Some studies show that muscle strength, muscle power and acceleration indicators increase in the specific stage in relation to the base stage as much in the hydrated athletes as in the dehydrated ones, being the hydrated athletes' improvement substantially bigger than in those dehydrated [29, 30].

Finally, the last conclusions in this study are for the pre-competitive stage: (1) the skeletal muscular mass in dehydrated athletes diminish as they get close to the competition; (2) during this stage and with same conditions, the skeletal muscular mass losses in the dehydrated women are bigger than the men ones; (3) muscle strength and muscle power variables decrease in the athletes, as much in wrestlers than in judo athletes and these variables are smaller than the specific stage ones [31, 32].

CONCLUSIONS

Our study indicates that one out of four athletes uses to be dehydrated, being women most prone to dehydrate than men and being wrestlers those who get more dehydrated than judo athletes. These dehydrated athletes represent a higher percentage during the training base stage than in the other two stages.

The hydrated athletes have better indicators than the dehydrated ones during the different muscle strength manifestations, being the dehydrated athletes those

Table 4. Averages differences during the pre-competitive stage *(t-Student* test for independent samples) depending on the athletes hydration levels

Variables and indicators	Hydration Levels	N	Average	Typical Deviation	p
Body composition					
Precompetitive weight (kg)	Hydrated	47	71.79	15.00	.511
	Dehydrated	15	65.96	13.91	
Precompetitive skeletal muscular mass (%)	Hydrated	47	37.05	8.61	.124
	Dehydrated	15	29.70	6.19	
Precompetitive body water (%)	Hydrated	47	64.91	3.02	.910
	Dehydrated	15	56.53	3.06	
Precompetitive body fat (%)	Hydrated	47	11.29	3.70	.022*
	Dehydrated	15	20.31	6.27	
Muscle strength					
Precompetitive acceleration (m/s^2)	Hydrated	42	20.00	3.87	.522
	Dehydrated	13	19.28	4.44	
Precompetitive muscle strength average (N)	Hydrated	42	1023.22	541.45	.015*
	Dehydrated	13	679.82	188.35	
Precompetitive muscle power average (W)	Hydrated	42	565.53	192.02	.032*
	Dehydrated	13	392.62	123.91	
Precompetitive muscle strength production (J)	Hydrated	42	81165.57	185928.06	.420
	Dehydrated	13	48395.38	56124.04	

*p<0.05

who confirm smaller values in skeletal muscular mass. The more affected strength variables when the athletes are in dehydration condition are: muscle strength, muscle power and muscle strength production, being less relevant acceleration capacity loss.

As future lines of investigation we could conduct the same study with athletes who are not engaged with the competition weight but with an aesthetic nature, for example inducing dehydration conditions to improve the aesthetic performances in rhythmic or artistic gymnastics, synchronized swimming, ice-skating, etc.

COMPETING INTERESTS

Authors have declared that no competing interest exists.

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