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ORIGINAL ARTICLE

Orthostatic trials and perceptual responses to daily loads during 25 days of preparatory period 1-day competition and 5 days of recovery period in elite female judokas

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Key words: judokas, bilological control, daily loads

Summary

Introduction. Divergences between athletes and coaches appraisals of training may result in overdosing of exercises during preparatory period and to lead to maladaptation in their training schedules. The aim of this research was to check of usefulness of non-invasive methods of biological control of daily training loads in judo females.

Material and methods. Five elite female senior judokas of various body mass were assigned to participation in the European Judo Championships which was held in Poland. The observations have been conducting every day throughout entire 31-day period, which included 25 day of the preparation, day of competition and 5 successive days of the post-event recovery. Orthostatic trials were conducting in the morning. General evening fatigue (GEF) were recording at 7:30 pm. Daily training load (TL) was estimated based on heart rate responses to the exertions (Andreyev method). Sleep quality (SQ) was rated with the use of 7-poit scale. Each judoka realized the same type of drills and of similar intensities, but their quantity were individually regulated based on the cardiac responses.

Results. There were considerable between-subject differences in heart rate (HR) at supine- and upright and Δ HR. Judokas of the heavier body mass demonstrated higher HR variables. These morning cardiac parameters were alike after workout and rest days, but scores of SQ were significantly poorer after workout days. Scores of GEF were closely related to the TL.

Conclusions The results highlighted huge between-subject variability in orthostatic trials. There were significant relationships between scores of perception of fatigue and TL.

Introduction

An extent of discrepancy between coaches and young athletes regarding of perceptions of internal and external load have been studied by Murphy AP [1]. The results showed that coaches considerable underestimate their appraisal of rating of perceived exertion (RPE) regarding a training session (but not separated drills). Moreover, the regression analyses showed, that 54.5% of variance in coach RPE can be explained by both, intended session exertions and coach drills RPE, while 45.3% of the variance in athlete session RPE can be explained by drills RPE and peak HR. Likewise, the other researchers found differences in sessions RPE between coaches and athletes and these discrepancies depended, in part, on coaches competences and type of sport [2,3]. In general, athletes perceive training loads as significantly harder than what were intended by their coaches [4]. That may lead to maladaptation training and in consequence to impaired physical fitness, and even, to overtraining syndrome. To avoid that risk an objective tools are commonly used for detection of a biological responses to physical loads. Due to development of analytical micro-systems it is possible to determine these blood indices in a one sample of capillary blood (from finger tip or earlobe), which are sensitive to exercises. Thus, changes in the morning blood chemistry are related to responses to physical loads derived from the day before and to rate of overnight recovery. In so doing a coach has got an information about biological readiness to continue a training activity on a current day. Moreover, this way informs about individual athlete`s tolerance to the intended training schedule. The most common serum parameters, which are still used for appraisal of training load are serum creatine kinase, the enzyme, which is a marker of muscle micro-damages, steroidal hormones, testosterone (T), cortisol (C) which regulate rate of endogenous protein metabolism, T/C ratio as anabolic-catabolic index, and urea, which is final product of proteins degradation . Usually, these blood parameters are determined concurrently [5-10]. Diagnostic value of blood indices is enhanced when additionally perceptual parameters are concurrently are determined. As mentioned earlier the most often perceptual index of an single effort is RPE estimated with the blood lactate level [11]. Over last decade the RPE was widely used for monitoring of training session or training period in various sport disciplines [12-15] including combat sports, for instance taekwondo [16-18] and karate [19]. The monitoring of biological responses to a training period in judo is poorly described. In cadet and junior male judokas their long-lasting training program prescribed by the same coach was scheduled based upon monitoring of sessions RPE (sRPE) throughout preparatory and competitive periods. In this study the training loads (TL) was calculated from sRPE and quantified expressed in arbitrary units. Using that procedures the best relationships between TL, the performance at competitions and physical performance at field tests were attained [20]. In the study conducted among female judokas during 2-week period of excessive strain observations of mood state and resting heart rate were utilized. The results of that monitoring suggested accumulation of fatigue [21]. However, it is worth to note that the correct use and interpretation of resting or end-exercise heart rate demands a methodological validation and standardization [22]. Not always a preparatory period results in an improvement of all physical abilities in judokas. It was shown that some abilities like strength or endurance are improved, while the maximal hand grip strength is impaired, as was shown among junior [23] and senior [24] judokas. That phenomenon suggests that excess of specific judo drills engaging these muscles which are responsible for gripping of judogi may lead to local prolonged fatigue and in consequence for partly lost of grip strength. For that reason monitoring of training period in judo should include examination of various biological variables and the meet criteria regarding the load periodization. Such as training schedule gives guarantee an improvement also hand grip strength [25]. Summing up, easy to use, non-invasive and not time-consuming methods of biological monitoring of judo players competition are claimed by their coaches. The aim of our study was twofold, (i) confirmation of usefulness of concurrent four components of daily morning of training loads, morning orthostatic trials, end-exercise heart rate after completing each drill performed during morning and evening training session, perceived fatigue in the evening and sleep quality and (ii) confirmation of the optimal work-to-rest ratio during a preparatory period to a main judo competition. These observation were conducted in elite Polish female senior judokas.

Material and methods

Five elite female senior judokas of various body mass as follows: A-127 kg, B-71.5 kg, C-57kg, D-51.4kg, E-48kg, were assigned to participation in the European Judo Championships which was held in Poland. The observations have been conducting every day throughout a 31-day period, which consisted of successively 25 days of training period, day of competition and 5 days of the post-event recovery. 25-day training period consisted of 15 days with one and or two training sessions, each lasting 2 hours, and 10 days free of trainings. The heaviest training session included very intensive judo drills such as *randori* , individual simulated struggles, ground exercise (*ne-waza*) or 1-minute series judo throws performed with maximal velocity. Training days were separated by rested days, thus, a physical activity fluctuated according to the rule recommending a load periodization [24]. All judokas were equipped with electronic counters for detection of heart rate and realized relative the same training schedule with respect to quality and quantity exercises. The estimation of individual daily training load (TL) was based on measurements of the cardiac responses i.e. it means end-exercise heart rate recorded during first 10 second of the recovery) to each drill performed during morning and/or evening training sessions. According to the Andreyev methods, the various ranges of measured HC correspond to appropriate number of points (P) as follows:

HR/10sec.	>32	31-30	29-28	27-26	25-24	23-22	21-20	19-18
P	8	7	6	5	4	3	2	1

Based on cardiac responses a physical load of an each drill (DL) is given by formula:
DL =P* time duration (minutes), hence, daily TL is a sum of DL which shows total physical activity realized during morning and evening training sessions:

$$\mathrm{TL} = \sum_{i=1}^{i=n} DLi$$ where n is number of daily drills

Daily TL were compared with perception of general evening fatigue (GEF) which was rated with the use of visual analog scale ranging from 0 to 100 mm. GEF was recorded always at 7:00 pm, in a case of evening session it was around 1h after its completion, and 1h after the last struggle of the competition. Each morning, orthostatic trials was conducted c.a. 20 minutes after awakening. HR at supine position was measured before rising, thereafter, HR was measured following 3 minutes after standing up. Morning orthostatic trials showed state of cardio-autonomic system after overnight recovery following training activity of a previous day. HR was measured using fingertip electronic pulse meters. Sleep quality was estimated with the use of 7-point scale ranged from 0-insomnia to 7-deep full sleep without interruptions and disturbances . Two-way analysis of variance ANOVA subject* day was applied for appraisal of differences between days and judokas. Linear coefficient of correlations showed the relationships among the variables.

Results

Mean individual results of orthostatic trials, general evening fatigue, and sleep quality in response to work (n=16, 15 training days + day of competition)) and rest days (n=15, 10 days of preparatory period + 5 days of post event recovery) are displayed in Table 1. Results of the statistical analysis were shown in Tables 2-4. The differences in the variables between days and between judokas are presented in Table 2. The differences in training loads for 15 days of preparatory training, when judokas realized one or two training session per day is shown in Table 3. Relationships between training loads during preparatory period and general evening fatigue for each judoka is revealed in Table 4.

The results showed, that the higher daily activity (workout days) triggered the higher general evening fatigue and somewhat worse sleep quality. The negative effect of work on sleep was revealed also, when day of competition, which resulted in maximal evening fatigue, was excluded from the calculation, however, in this case the effect was weaker. The above between-day changes (GEF and SQ) were similar for each judoka, thus, there were no between-subject differences. That was probably due to strictly regulation of daily training loads via end-exercise monitoring of HR and controlling of duration of each drill during a training session . In contrast to these changes, HR values at supine, upright position and the increments of HR (ΔHR) in the whole group did not depend on type of activity which was realized on a day before the orthostatic task, but there were between-subject differences dependent on body mass. Similar for rest and work days orthostatic responses suggested almost full recovery of autonomic system after nocturnal rest. Perceived general evening fatigue at the

Table 1. HR variables in response to a morning orthostatic stress, general evening fatigue GEF) and sleep quality (SQ) over 31-day period in response to two main types of daily ac-tivity (workout days n=16 and rest days n=15). Confidence intervals for 95% of the data (95%CI) are given in the squared brackets

variable	occasion	judoka A	judoka B	judoka C	judoka D	judoka E
morning HR at supine position	after workout days	63.4±3.8 [61.7-66.8]	62.4±4.0 [60.4-64.5]	61.8±2.8 [60.3-63.2]	58.5±2.9 [57.0-60.1]	48.4±3.3 [46.7-50.2]
	after rest days	66.8±4.2 [64.4-69.1]	63.7±5.0 [60.9-66.4]	61.3±3.3 [59.4-63.1]	57.6±4.6 [55.1-60.1]	46.6±3.2 [44.7-48.4]
	total	65.5±4.7 [63.8-67.2]	63.0±4.4 [61.4-64.7]	61.5±3.0 [60.4-62.6]	58.1±3.7 [56.7-59.5]	47.6±3.3 [46.3-48.8]
	competition	76	60	61	72	47
morning HR at standing position	after workout days	96.0±6.2 [92.7-99.3]	91.2±7.2 [87.4-95.0]	71.2±3.6 [69.3-73.1]	72.6±6.4 [69.7-75.4]	50.6±3.2 [48.8-52.3]
	after rest days	94.5±5.6 [91.3-97.6]	94.6±6.1 [91.2-97-9]	70.5±3.8 [68.4-72.6]	71.1±9.3 [65.9-76.2]	49.4±3.2 47.5±51.2]
	total	95.3±5.9 [93.1-97.4]	92.8±6.8 [90.3-95.3]	70.8±3.6 [69.5-72.2]	71.8±7.4 [69.1-74.6]	50.0±3.2 [48.8-51.2]
	competition	107	110	72	95	52
morning delta HR after	after workout days	31.8±4.9 [29.1-34.4]	28.8±7.2 [25.0-32.7]	9.4±3.3 [7.7-11.2]	14.0±4.0 [11.9-16.1]	2.8±1.3 [2.1-3.5]
	after rest days	27.7±6.9 [23.9-31.5]	30.9±8.3 [26.3-35.5]	9.2±3.9 [7.1-11.3]	13.4±6.7 [9.7-17.1]	2.8±1.4 [2.0-3.6]
	total	29.8±6.2 [27.5-32.0]	29.8±7.7 [27.0-32.6]	9.3±3.5 [8.1-10.6]	13.7±5.4 [11.7-15.7]	2.8±1.3 [2.3-3.3]
	competition	26	50	11	23	5
GEF on	workout days	47.0±14.2 [39.4-54.5]	45.2±14.4 [37.5-52.8]	39.1±8.3 [34.7-43.5]	37.9±10.3 [32.5-43.4]	42.3±12.3 [35.8-48.9]
	rest days	16.9±5.0 [14.2-19.6]	16.1±4.0 [13.9-18.3]	`14.4±3.0 [12.7-16.1]	16.0±3.8 [13.9-18.1]	13.9±2.2 [12.6-15.1
	total	32.5±18.6 [25.6-39.3]	31.1±18.1 [24.4-37.8]	27.1±13.9 [22.0-32.3]	27.3±13.5 22.3-32.4]	28.5±16.9 [22.3-34.8]
	competition	97	89	91	93	89
SQ after	workout days	4.8±1.1 [4.1-5.3]	4.7±1.1 [4.0-5.2]	4.6±1.4 [3.7-5.2	4.9±0.9 [4.1-5.1]	4.9±1.1 [4.2-5.4
	rest days	5.0±0.9 [4.7-5.6]	4.9±0.9 [4.5-5.4]	4.8±0.8 [4.5-5.3]	5.1±0.7 [4.7-5.5]	5.0±0.9 [4.7-5.6]
	total	4.9±1.1 [5.3-4.5	4.8±1.0 [4.4-5.2]	4.7±1.1 [4.3-5.1]	4.9±0.8 [4.6-5.2	5.0±1.0 [4.6-5.3]
SQ at night prior to competition		1	2	1	2	2

Table 2. Analysis of the impact of two sources of variance (subject and two main types of daily physical activity, workout, n=16 vs rest, n=15 days) on the morning HR variables, GIF and SQ

variable	source of variance	df	MS	F-function	p- value	effect size η^2	differences
HR sup	activity type	1	0.3	0.021	0.8811	0.0002	between-subject A,B>C>D>E
	subject	4	**1497**	**100**	**0.0000**	**0.7360**	
HR stand	activity type	1	4.3	0.132	0.7146	0.0009	between-subject A,B>C,D>E
	subject	4	**10454**	**327**	**0.0000**	**0.9007**	
delta HR	activity	1	12.83	0.456	0.5008	0.0032	between-subject A,B>D>C>E
	subject	4	**4572**	**162**	**0.0000**	**0.8182**	
GEF	activity type	1	**34928**	**224**	**0.0000**	**0.6077**	work vs. rest
	subject	4	160.3	1.01	0.3931	0.0026	non significant
SQ	activity type	1	**6.092**	**6.26**	**0.0135**	**6.2581**	work vs. rest
	subject	4	0.335	0.344	0.8479	1.3762	non significant

Table 3 Analysis of the impact of two sources of variance (subject and 15 training days) on TL as expressed as Andreyev`s units

variable	source of variance	df	MS	F-function	p- value	effect size η^2	differences
TL	subject	4	133	0.0110	0.9986	0.0011	ns
	day	14	**$110*10^{3}$**	**13.19**	**0.000**	**0.7676**	**significant 91-580**

Table 4. Correlations coefficients between daily training loads calculated from Andreyev formula (TL) and general evening fatigue perceived during 15 training days in female judokas

correlation coefficients	A n=15	B n=15	C n=15	D n=15	E n=15	all data (n=75)
TL/GEF	**0.7521**	**0.6905**	0.4668	0.4368	**0.8243**	**0.6152**

end of the competition day (1h after the last bout) was almost two-fold higher as compared to mean values recorded during training days. Likewise, sleep quality a night before the competition was almost 2.5 times worse than the average value recorded during other nights. When SQ and GEF were separately analyzed for each judoka by one-way ANOVA followed by post-hoc the Tuckey test, it was appeared, that end-competitive GEF and prior-competitive SQ were significantly differ from the appropriate variables recorded during all 30 other occasions.

Results presented in Table 4 showed good consistency between perceptual responses and scores in daily training loads calculated by Andreyev` method .

Discussion

An orthostatic trial, known also as head-up tilt testing is commonly used in medicine to determine sensitivity of cardiac autonomic system in healthy or cardiac subjects. The testing has a diagnostic value also in subjects suffering from postural orthostatic tachycardia syndrome [26] and for detection of chronic fatigue syndrome [27,28], which is usually associated with impaired cognitive functions [29]. In a practice, these investigations are conducted using a special equipment, head-up tilt table, where examined patient or healthy subject passively changes his/her position from supine to that of various intended slope or to the full (90°) upright. Among healthy young adults (<35 y) heart rate increases rapidly by c.a.13 beats in response to the 60° head-up tilt during first 3 minutes, during longer period (>30 min) the increment of HR reaches c.a. 20 beats, but among a part of the group that challenge led to syncope [30]. The responses of HR we have been recorded after 3-minute standing in female judokas were markedly higher than those reported by Peterson. Although in our investigation we did not use equipment for passive standing, one may assume the single active rising as an physical effort might be omitted as a stimuli of a HR change in well trained athletes, and the various slope (90° instead 60°) was responsible for these scores. There are several factors affecting response to head-up tilt. One of them is starvation. After that 3-day period activity of autonomic system was elevated [31]. The same was reported by the others over 2-day period [32], therefore, that phenomenon should be taken into account during testing athletes, who rapidly reduce their body mass prior to a competition. In contrast to above type of sport and training modality do not affect sensitivity of autonomic system [33].

Due to strictly monitoring and doses of the drills there were no symptoms of neither fatigue nor impaired nocturnal recovery. Although in the evening perceived fatigue were higher on training days, and sleep quality was lower after training days, there were not effect of physical activity type on HR at supine, upright and ΔHR. It means that nocturnal recovery after workout days was sufficient for normalization of autonomic system activity. It is worth to stress, however, that body mass effects on orthostatic parameters. Heavier female contestants (A and B) showed higher supine-, upright HR and ΔHR, that is in agreement with reports by others, who examined obese non-exercising females [34]. Thus, it seems, that regardless habitual physical activity, females of higher body mass showed somewhat lower tolerance for orthostatic challenge. Hence, we assume, that judo drills, which include exercises at standing or lying position (ne-waza) conducted alternately may induce higher cardiac response in contestants of heavier body mass. The other factors leading to a lowered tolerance to orthostatic stress in females may be the reproductive hormones (E2 and P4) [35,36].

Sleep quality (SQ) is an important marker of current health status. It is sensitive also to different daily incentives including mental and physical challenges like training and competition. Disturbance of nocturnal sleep and daytime sleepiness often associate with chronic fatigue syndrome and impaired cognitive functions [37-39]. SQ may be estimated by various methods, but the most advanced and validated tool is the Pittsburgh Sleep Quality Index designed by Dr Buysse, but it may be determined with the use of accelerometer and examination of the brain waves. Standardized questionnaire (Pittsburgh Sleep Quality Index) is a form which is consisted from a number of items/questions that makes its time-consuming and difficult to fill for an excited contestant prior to a competition. Likewise, Spielberger questionnaire for estimation of state anxiety is hard to use in the morning of the competition day and completely methodologically inappropriate just prior to a struggle, as was reported earlier [40]. Nocturnal sleep may be shortened, disrupted and mistimed when subject went to the bed being very fatigued, emotionally excited or he/she anticipates a severe challenge next day. Moreover, sleep patterns are varied regarding time of awaking and time were subject goes to the bed. There are two main extreme chronotype, a morning type, so-called "early bird" , who wakes up almost at sunrise but is sleepy after sunset, and evening type, known also as "night owl" , who manifests the opposite pattern of daily activity. Hence, the optimal time for an intensive training session would take into consider morningness-eveningness pattern. The first daily training session conducted in the early morning reduces length of nocturnal sleep, therefore it is not beneficial for athletic performance [41]. For judo players, who habitually woke up at 07:00-08:00 am and went to the bed not later than after 11:00 pm, wake/sleep behavior during entire period was habitual. Their length of sleep and time spent in bed were even somewhat longer than those reported by other authors [42,43]. Moreover, Sargent [42] found, that on nights before training days time of sleep was shorter and sleep onset and offset times were earlier than prior to rest days. That findings seem to be opposite to our results, where after workout days SQ was poorer. Very poor SQ on night before competition is an evidence for anticipatory stress which disrupted nocturnal sleep. That phenomenon is elucidated by Lastella [44]. The same mechanism occurs before academic exams in students [45].

Conclusion

1. In female judo players morning orthostatic response examined day-by-day during a training period seems to be dependent on the body mass when training loads are similar for each judoka.
2. Morning orthostatic responses recorded throughout a training period did not depend on daily activity when training days are sufficiently separated by rest days .
3. There is good consistency between objective measures i.e. cardiac responses to exercises and perceived training activity.
4. Sleep quality is a sensitive marker of a training load and anticipatory stress

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