Introduction

Exercise stress induced by a training session may be estimated quantitatively using basic two kinds of ways, subjective self-reported feelings and objective parameters. One of the most widely used subjective indicator of somatic or psychological stress is state anxiety. Long since is known, that state anxiety [1-7] is higher in scores for more intensive and exhaustive bouts, but tended to decrease during short-lasting recovery. Another similar indicator of perceived physical fatigue induced by exercise is Rating Perceived Exertion (RPE). During long-lasting and endurance athletes like triathlon competition RPE significantly and negatively correlated (r=-0.911) with speed of run segments, and positively (r=+0.826) with overall race time. State anxiety prior to this event was higher than that at neutral condition [8]. It should be stressed, that both state anxiety and RPE reflex current feelings, but they are closely related to post effort bodily sensations. For this reasons these variables correlated significantly with some objective, physiological parameters, like heart rate and blood lactate concentration (LA) [9-14]. Interestingly, that various exertions are varied by their intensity and time duration demonstrated differentiated contribution of RPE for exercising body extremities, and for breathing effort, associated especially with experience of the sensation of shortness of breath and breathlessness. That latest symptom is expressed as chest RPE, while RPE extremities is often related to local pain and fatigue which are expressed as impairment of power output [11-14]. These symptoms are noted for instance at the end of Wingate-test and other anaerobic bouts. During an interval training overall RPE, aggregated lactate and HR values after several intensive efforts are useful tools for estimation of individual training tolerance/adaptation among exercising athletes. More comprehensive studies on biological response to a single training involve also hormonal behavior in capillary blood. However, decision-making regarding the use of hormonal tests is cost-dependent and as well as depend-
ent to type of training and periods. The vast majority hormonal studies among athletes have been focused mainly on acute changes of blood or salivary testosterone (T) and cortisol (C) induced by single efforts and training periods [15-20]. They have been undertaken widely among exercising athletes of various sport events regardless type of the physical activity [15-20]. It should be stressed, that the use of determinations of testosterone and cortisol in sports results in anabolic property of T and catabolic of C. Assuming, that metabolic actions each of those hormones are proportional to their levels in blood, we can consider T/C ratio as a quantitative indicator of equilibrium between rates of proteins anabolism and catabolism. Moreover, the value of that variable is responsible for skeletal muscle hypertrophy and strength development induced by resistance training [21-25].

Having possibility to examine taekwondo players during various training session, at the same time all these mentioned indices, this study was undertaken to examine the relationships between perceptual and physiological variables during two various training sessions performed by exercising females.

Material and methods

Fourteen senior female taekwondo players (light, mild and heavy weight categories) were enrolled to the study twice on separated days. To avoid possible interactions between these training sessions or earlier exercises performed, a day before, sessions were undergone in a randomized order, in the afternoon. One session was considered as less intensive training (LIT), and one as more intensive training (MIT). Each session included typical taekwondo drills. LIT training started from stretching exercises, next followed by separated series of different type of kicks (combo, turning, front skip turning, skipping step turning, side thrust, and roundhouse ones) performed against various taekwondo targets for kick (double kick pads, heavy chest protector, kicking bag.) Series of each type of kick were no longer that 3 min, and tempi of the kicking was self-selected (not very quick). MIT also started from stretching exercises, but instead of two various series of kicks, the athletes played one non-judged sparing fight (3 round x 2 minutes with 30s intermissions between rounds. Moreover tempi of each series was imposed, i.e. the athletes were asked to competed a similar number of kicks in a possible shorter time. Training sessions lasted approximately 1.5 h, including rest intervals for recovery.

Capillary blood was drown from earlobe prior to the training session and within 3 minutes after it for determination of serum hormones, cortisol (C), testosterone (T) and dihydroepiandrosterone sulfate (DHEA-S). Blood lactate were determined directly after the most three vigorous exercises performed during each training. Post-training perceived fatigue was expressed as general rating of perceived exertion (RPE) and estimated using visual analogue scale as follows.

The training was:

<table>
<thead>
<tr>
<th>Very, very light</th>
<th>very exhaustive</th>
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Serum levels of steroidal hormones were determined by ELISA commercial kits (DRG-GERMANY). Post-exertion blood lactate level (LA) was determined using DR LANGE kits (GERMANY). Wilcoxon’s signed rank test was used to verify significant differences (p<0.05) for each variable recorded pre- and post- efforts and between post-sessions values. The protocol of this study was approved by Ethical Commission at the Institute of Sport.

Results

Table 1 presents means and standard deviations of C during training sessions and post exercise LA and scores of RPE. Means and standard deviations of serum androgens levels (T and DHEA-S) are given in Table 2. As expected each session elicited significant rise of cortisol without changes in the androgens and exercises mild increases of LA. However, MIT characterised itself by significantly higher RPE in scores, and elicited higher acidification, and stronger responses of androgens and cortisol. There were no correlations between post-session hormones, LA and RPE taking into consider separated data from each trainings. However these significant correlations appeared for the new variables obtained from the following ratios: r (ΔCII/ΔCI and RPEII/RPEI) = 0.688, r (TI/TII and RPEI/RPEII) =0.575 and between aggregated data for LA (area under curve); r (AUC I/AUCII and RPEI/RPEII) =0.695.

<table>
<thead>
<tr>
<th>Training session</th>
<th>Cortisol (nmol/L)</th>
<th>RPE (scores)</th>
<th>Lactate (mmol/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre session</td>
<td>Post session</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(A)</td>
<td>(B)</td>
<td></td>
</tr>
<tr>
<td>Less intensive (I)</td>
<td>283±58</td>
<td>359 ±62A</td>
<td>62.2 ±3.5</td>
</tr>
<tr>
<td>More intensive (II)</td>
<td>272±56</td>
<td>474±76B</td>
<td>80.9±4.9</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Training session</th>
<th>Testosterone (nmol/L)</th>
<th>DHEA-S (μmol/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre session</td>
<td>Post session</td>
</tr>
<tr>
<td></td>
<td>(A)</td>
<td>(B)</td>
</tr>
<tr>
<td>Less intensive (I)</td>
<td>2.1±0.5</td>
<td>2.2±0.4</td>
</tr>
<tr>
<td>More Intensive (II)</td>
<td>2.2±0.4</td>
<td>2.7±0.5</td>
</tr>
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</table>

Table 1. Serum cortisol levels, blood levels following the most intensive physical actions and rating of perceived exertion (RPE) during training sessions of various intensity

Table 2. Serum testosterone (nmol/L) and dehydroepiandrosterone-sulfate (μmol/L) responses to training sessions of various intensity
Discussion

The study showed similar directions of post-sessions changes in the hormones. Those changes were near parallel each other for MIT. Moreover, the results indicate, that responses of blood indices were related to perceived training stress (RPE). Interestingly, cortisol appeared to be much more sensitive marker of training stress, compared its relative responses to each session, with those of T and DHEA-S. Especially after LIT, C increased by 27% while T and DHEA-S by 4.8 and 3.3% respectively. Long since we know, that although both hormones, C and DHEA-S originate from adrenal cells and are secreted into circulation due to stimulation by ACTH, C response to this stimulus is much stronger than DHEA-S response. The minor adrenal androgens responses to LIT compared to those after MIT is due to smaller physical stimulus and consequently expected lower dose of endogenous trophic hormone, ACTH. That possible explanation is based on the fact, that magnitude of acute adrenocortical responses to ACTH is dose-dependent [26]. There are also other factors affecting androgenic status in females. Basal T is usually lower in highly trained females than among untrained, short-term exercise elicits lower response than longer and exhaustive one and both T and DHEA-S increases after very exhaustive effort regardless training status of exercising individuals [27]. In female acute responses of T is also related to body composition. It was found that heavy resistance training session resulted in significant rise (by 25%) in T, and that response depended on subscapular to triceps ratio fatness [28]. Returning our deliberation about to role of DHEA and its derivative (sulphate) in exercise, it is worth to note, that these weak androgen, but of high levels in blood in case of DHEA-S, is known as neuroactive steroids, displaying protective action among humans exposed to prolonged stress. In female cyclists, who started heavy training (vast loads) physiological effect of exercise stress, expressed as high cortisolism seemed to be blunted due to the rise of DHEA-S. That suggestion is supported by negative correlation between somatic stress and DHEA-S/C ratio [29]. The above, and assumption, that DHEA better than T reflexes androgenic response to an effort in female athletes [30] we expected to found relationships between levels of androgens and perceived stress, however, in our experiment that dependence are lacking.

As mentioned above very minor rise of T and DHEA-S following LIT would be explained by post training plasma volume shift (ΔPV), which, however, was not detected in this study. The lack of this information is considered as methodological shortcoming. In a contrast to unchanged androgens. Compared to that significant elevation of C we may conclude, that measurements of T and DHEA-S in females after mild effort provided few information on exercise stress, and these data do not discriminate individual sensitivity to weaker stimulus. No relations among body mass and responses to the sessions in blood hormones were found. The players of light body mass demonstrated somewhat lower (non significant) LA levels following series of the kicks than individuals of heavy weight category. That was probably due to the greater mobility of the athletes of lower body mass. The reason for that was higher mobility of lighter contestants during their sparring matches and series of kicks performed somewhat faster.

So far taekwondo training was not monitored earlier with the use of hormonal measures, but hormonal study were utilized only for detections of competitive stress [31,32]. Other perceptual and physiological tools like heart rate and blood lactate were utilized for evaluation of physical strain of both a competition and training. There were recorded time-structure of the efforts, physiological and perceptual indices during taekwondo matches of various ranks (official and simulated) [33-38]. Study on typical training session were also carried out, but without hormonal tools. For instance Haddad reported the use of heart rate (HR) and RPE for evaluation tolerance of training load. The main finding of these studies are relationships between HR and RPE. Individual coefficients of correlation between these variables varied from 0.55 to 0.90 [39-41]. Some of these reported results were similar to those of the ours, the others were not. That disagreement are natural phenomenon considering various training experience, status mode of subsequent exercises and even environmental conditions like ambient temperature and humidity, especially, when the athletes exercised with headgear and chest protectors, which may lead to rise of body temperature.

Summing up, this is the first study on taekwondo training sessions with utilization hormonal observations in blood. Further similar investigations should be undertaken without omitted methodological limitations occurred in this design.

Conclusions

More intensive training session elicited stronger responses of all blood indices. The post-session changes were related to reported perceived fatigue.

References


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