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The effect of 8 weeks beta-alanine supplementation and resistance training on maximal-intensity exercise performance adaptations in young males

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Abstract

Purpose: The aim of this study was to examine the effects of 8 weeks beta-alanine (BA) supplementation with resistance training on some components of physical fitness and body composition in young males.

Material: Twenty healthy young men volunteered to participate for the study and divided into two groups and performed 8-week resistance training while supplementing with either BA or placebo (4.8 g per day). The subjects were evaluated for 1 repetition maximum (1RM) bench press and leg press, vertical jump (VJ), anaerobic power (RAST) prior to and after training intervention. In addition, body composition variables such as percent body fat, and BMI were assessed per and post training period.

Results: Both the groups showed significant increases in 1RM bench press and leg press, VJ, and anaerobic power (RAST), and also the BA supplementation group showed greater gains compared with the placebo. In addition, percent body fat decreased significantly in BA and placebo groups, while no statistically significant changes were seen in BMI for the BA supplementation group and placebo group.

Conclusions: The results indicated that resistance training improved physical performance and BA supplementation induced greater gains and therefore it could be recommend to coaches and athletes who use this supplementation to greater gains in physical fitness variables.

Keywords: recovery, strength training, body composition, performance, alanine.

Introduction

β-alanine (BA) has been used as a nutritional supplement for enhancing recovery, and increasing power and aerobic performance [1]. It appears that supplementations with BA could results in reducing muscle fatigue and increasing in muscle buffering capacity [2-4]. Studies assessing the effects of BA in physically active individuals have mainly focused on verifying changes such as physical and neuromuscular performances [5, 6, 7]. BA supplementation has been shown to increase muscle carnosine levels, which can act as a buffer to reduce the acidity in the active muscles during high-intensity exercise [8-10].

In the studies by Hill et al. [5] and Harris et al. [11], they demonstrated that one month of BA supplementation increased intramuscular levels of carnosine by approximately 60%. It has been suggested that carnosine serves as a buffer and helps maintain skeletal muscle acid-base homeostasis when a large quantity of H+ produced during high-intensity exercise [2, 12]. Harris et al. [11] demonstrated improvements in performance during a 4-minute maximal cycle ergometry test in men after supplementing with BA for 5 weeks. The authors concluded that the improvements may have been caused by an enhanced H+ buffering capacity as a result of increased muscle carnosine levels after BA supplementation. In theory, increasing skeletal muscle carnosine concentrations via BA supplementation will work to delay fatigue by decreasing intramuscular lactate accumulation, and buffering H during exercises [4]. However, no previous studies have examined the effects of long term BA supplementation during resistance training on maximal-intensity exercise performance tests in young males.

Although very few findings suggest that BA supplementation during training may enhances adaptive changes, the available scientific literature on BA supplementation in humans is still preliminary in nature and should be considered with reservation [13-15]. Also, the data about the influence of BA supplementation, particularly with resistance training, in younger males are still scarce in the literature regarding the effect of BA supplementation on these variables.

Therefore, the aim of the present study was to assess the effect of BA supplementation on body composition, muscular strength and, performance adaptations after 8 weeks resistance training in younger males. We hypothesized that BA supplementation will lead to greater adaptive responses than placebo groups in adaptive responses in maxima-intensity exercise performance tests and body composition.

Materials and Methods

Participants

The subjects were 20 healthy men who were familiar with resistance exercise and training volunteered to participate in this study. Subjects were randomly assigned to one of two training groups: BA plus resistance training group (BA; N = 10, age = 17.7 ± 1.0 y, height = 176.1 ± 6.1 cm, and body mass = 78.4 ± 1.3 kg) and (b) placebo...
plus resistance training group (PL; N = 10, age = 17.1 ± 0.6 y, height = 175.2 ± 4.3 cm, and body mass = 76.3 ± 2.2 kg). The subjects did not have medical or orthopedic problems that compromised their participation in this study. Each parent subject was informed of the risks and benefits of the study and subsequently signed an informed consent form in accordance with the guidelines of the university’s Institutional Review Board.

**Procedure**

This study was designed to examine the effects of resistance training plus BA or PL supplementation on body composition and performance adaptations. Subjects in both groups were instructed on proper technique of training one week prior to initiation of study. The subjects subsequently underwent 8 weeks of training and were tested a week pre-and a week post-training for the variables.

The participant underwent 4 days of testing, namely 2 pre- (48 h apart between testing sessions) and 2 post-test day (48 h apart between testing sessions), respectively. A week before the initiation of training, each subject was familiarized with the training programs, and the demographic data were gathered and anthropometric measurements taken. The subjects were tested at the exact same time of day (2 to 4 P.M, post-test day) and same day of the week as the pre-test day to minimize the effect of circadian variations in the test results. All subjects had to continue with the normal daily life activity and dietary intake.

**Measurements**

Anthropometric measurements were done in light clothes before and after the training period. Height and weight were measured by an automatic height–weight scale, to the nearest 0.1 cm and 0.1 kg, respectively. BMI was calculated by dividing weight (kg) by the square of the height (m2). To estimate the amount of subcutaneous fat in the body, skinfold thickness was measured (Lafayette Caliper, model 01128, USA) at three sites (Chest, Abdomen and Quadriceps) in the right of body. Each measurement was performed in triplicate and the average was taken for analysis. All the measurements were made with the subject in standing position and body fat percent were estimated in accordance with Jackson and Pollack [16]. LBM was determined by subtracting the fat mass from weight.

The RAST test was used to measure subjects’ anaerobic performance ability, maximum power. Subjects run 35-m intervals, six times, with 10 s of rest between each interval. Power was calculated as previously suggested [17].

In the vertical jump test (VJT), subjects performed three trials with 30-sec of rest in between each jump. The following procedure was used for each subject during data collection. Subjects stood directly under the Vertec, fully extending an arm to touch the highest vane possible while remaining flat-footed to establish standing reach height, which was recorded. Subjects were instructed to perform the highest jump vane possible. The difference between standing reach height and each vertical jump height was calculated and the highest jump was used in the data analysis [10].

A bilateral leg press test was selected to provide data on maximal strength through the full range of motion of the muscles involved. Maximal strength of the lower extremity muscles was assessed using concentric 1RM leg press action. Bilateral leg press tests were completed using standard leg press equipment, with the subjects assuming a sitting position and the weight sliding obliquely at 45°. On command, the subjects performed a concentric leg extension (as fast as possible) starting from the flexed position to reach the full extension against the resistance determined by the weight. Warm-up consisted of a set of 10 repetitions at loads of 40-60% of the perceived maximum [18].

For the bench press, each participant lowered the bar until contact with the chest was achieved and subsequently lifted the bar back to the fully extended elbow position. Any trials failing to meet the standardized technique criteria were discarded. A warm-up consisting of 5-10 repetitions with approximately 40-60% of perceived maximum was performed. The rest period between the actions was always 2 minutes. Subjects were allowed to perform maximum 8 repetitions during bench press and leg press, and were used equation of Brzycki [19]:

\[
\text{estimated } 1RM = \frac{\text{weight (kg)}}{1.0278 - (\text{repetitions} \times 0.0278)}
\]

for determining of 1RM.

**Training program**

The resistance training programs included three days weekly (on Saturday, Monday and Wednesday) for 8 weeks. Each training session lasted 85-min, including 10-min warm-up (e.g., jogging, stretching and ballistic exercises), 70-min training, and 5-min cool-down (e.g., jogging and stretching exercises). The resistance training program stressed all major muscle groups and included the following exercises (or variations of) in each session: leg press, knee extension, knee flexion, lat pull-down, bench press, shoulder press, cable biceps curl and triceps push down 3 sets of 12 to 8 repetitions with 70 to 80 % of 1RM. Exercise volume and intensity progressed during the training program according to previous recommendations [18]. Two and three minutes of rest intervals were assigned between sets and exercises, respectively.

**Supplementation**

The BA supplementation consisted of 4.8 g (6 × 0.8 g each 2 h) of BA in the tablet form (GNC, USA) in each daily meal. Likewise, the subjects in PL group ingested 4.8 g of polydextrose [14].

**Statistical Analysis**

All data are presented as mean ± SD. The distribution of each variable was examined using the Shapiro-Wilk test. A two-way analysis of variance with repeated measures (2 [group] x 2 [time]) was used to determine significant differences between groups. A criterion α level of P ≤ 0.05 was used to determine statistical significance. All statistical analyses were performed through the use of a statistical software package (SPSS®, Version 16.0, SPSS, Chicago, IL).

**Results**

The results of this study are presented in Table 1.
There were significant improvements in the percent body fat, RAST test, VJT, 1RM bench press and 1RM leg press after 8 weeks resistance training for both the BA and PL groups (P < 0.05). In addition, the BA group indicated greater changes than PL group in RAST test, VJT, 1RM leg press and bench press after training intervention (P < 0.05).

**Discussion**

The present study investigated the effect of 8 weeks BA supplementation on body composition, muscular strength and power performance after resistance training. The results have shown that BA supplementation induced significant change in maximal-intensity exercise performance variables, including power performance and strength gains after 8 weeks resistance training and the changes in strength, and power were greater for the BA group compared to PL group. These results are in contrast with previous studies which found positive effects of BA supplementation for performance adaptations.

In body composition variables such as BMI and body fat, both the groups showed decrements in body fat, while the changes in BMI was not statistically significant for both the groups. Recent data suggests that BA supplementation does not improve superiorly fatty acid oxidation following resistance training. In line with our finding, Hill et al. [5] reported that 4 to 6.4 g per day BA supplementation did not induce greater fat oxidation than placebo groups after training.

Power is one of the most critical attributes underlying success in sport [20]. This variable is intimately related and allows athletes to be successful in their respective sport. In this study, both the groups showed meaningful gains in VJ and RAST test after 8 weeks training, while the BA group indicated more changes than PL group in power performance. In line with the present study, Kern et al. [10], suggest that changes in power following BA supplementation are optimized within the training

### Table 1. Changes in anthropometric and performance variables in response to 8 weeks training intervention (mean ± SD).

<table>
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<th>BA (n = 10)</th>
<th>PL (n = 10)</th>
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<tr>
<td>Body fat (%)</td>
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<td></td>
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<tr>
<td>Pre</td>
<td>13.8±3.2</td>
<td>14.5±5.7</td>
<td>G=0.88</td>
</tr>
<tr>
<td>Post</td>
<td>12.3±4.5*</td>
<td>12.2±5.0*</td>
<td>T=0.03, G×T=0.91</td>
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<tr>
<td>BMI (kg/m²)</td>
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<td></td>
<td></td>
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<tr>
<td>Pre</td>
<td>25.2±1.9</td>
<td>26.1±3.3</td>
<td>G=0.55</td>
</tr>
<tr>
<td>Post</td>
<td>25.7±1.5</td>
<td>26.4±3.2</td>
<td>T=0.51, G×T=0.76</td>
</tr>
<tr>
<td>RAST (w)</td>
<td></td>
<td></td>
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<tr>
<td>Pre</td>
<td>560±30.3</td>
<td>568.1±25.5</td>
<td>G=0.23</td>
</tr>
<tr>
<td>Post</td>
<td>581.1±17.1*, **</td>
<td>577 ±23.3*</td>
<td>T=0.001, G×T=0.03</td>
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<tr>
<td>VJT (cm)</td>
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<tr>
<td>Pre</td>
<td>36.4±2.9</td>
<td>37.1±2.2</td>
<td>G=0.12</td>
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<tr>
<td>Post</td>
<td>45.7±3.6*, **</td>
<td>41±2.2*</td>
<td>T=0.02, G×T=0.02</td>
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<tr>
<td>1RM leg press (kg)</td>
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<tr>
<td>Pre</td>
<td>180.7±39.1</td>
<td>177.1±45.8</td>
<td>G=0.23</td>
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<tr>
<td>Post</td>
<td>195.9±27.8*, **</td>
<td>191.8±37.2*</td>
<td>T=0.03, G×T=0.03</td>
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<tr>
<td>1RM bench press (kg)</td>
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<tr>
<td>Pre</td>
<td>56.8±17.4</td>
<td>54.2±10.5</td>
<td>G=0.16</td>
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<tr>
<td>Post</td>
<td>65.1±18.2*, **</td>
<td>61.2±12.7*</td>
<td>T=0.04, G×T=0.048</td>
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</table>

*: denotes significant differences between baseline and post-training values (p ≤ 0.05); **: denotes significant differences between the BA and PL supplementation groups at post-training (p ≤ 0.05). G = group, T = time.
program. Moreover, other researchers found positive effects of BA supplementations for the power gains after training [1, 6, 9, 14]. The greater adaptive responses in power performance after BA supplementations could be due to increased fatigue-resistance during repetitions in each training sets, allowing greater training intensity and muscle workout during the latter part of resistance training sessions, decreasing H and blunting lactate production and maintain pH for better muscle contractile ability during resistance exercise [2, 8] and thus increasing chances for greater RAST and VJT-related performance adaptations, such as neuromuscular related explosive improvements; however, it only could be speculations and more studies are necessary.

Regarding to strength performance, the results of our study indicated that BA supplementation induced greater changes in 1RM leg press and bench press which is in line with previous findings that BA supplementation resulted in a significant greater strength gain after training [9, 12]. Luis et al. [15] reported that 4.6 g BA supplementation for one month induced greater gains in strength performance after resistance training. Typically, changes in strength are largely due to neurological adaptations early in practice (i.e., changes in motor unit recruitment, asynchronous to synchronous contractions, etc.) [18], while increases in lean muscle mass, which increases the capacity of the body to produce force, accounts for a greater percentage of strength gain later on. Currently, the ability of BA to increase strength has been attributed to the changes in muscle contractile ability and also buffering capacity during resistance training [21]. In fact, the ability of BA supplementation to enhance strength is generally thought to be related to an elevated muscle carnosine content [3].

As muscle carnosine stores increase fatigue rates during exercise are thought to decrease, providing the athlete with a higher quality workout [4]. It does appear that the addition of BA to resistance training regime provides an additive benefit in reducing fatigue rates during training sessions. Previous research has demonstrated that BA is involved with the synthesis of muscle carnosine, and that oral ingestion of BA may elevate muscle carnosine levels [11]. Carnosine, a histidine-containing dipeptide, is known to contribute to acid-base buffering in skeletal muscle [8]. Increasing muscle carnosine and also buffering capacity of muscles during training sessions from a nutritional supplement, such as BA, would likely provide a strength performance via increasing subject ability to with stand and maintain higher intensity workouts resulting in improved strength performance [6, 21].

Conclusions

In summary, the results of this eight-week study demonstrated the efficacy of BA supplementation on strength and power performance. The use of these supplements appears to provide greater changes compared with placebo supplementation. It could be concluded that eight weeks of BA supplementations induced meaningful increases in power and strength performance in young males.

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Conflict of interest

The authors declare no conflict of interest.

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The effects of preparation period exercises on the hematological parameters of the taekwondo athletes

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Authors’ Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection.

Abstract

Purpose: This study aimed at examining the effects of preparation period exercises, which were applied for eight weeks to elite level taekwondo athletes, on the hematological parameters.

Material: Totally 21 athletes with international degrees from the university taekwondo team participated in this study, 12 of whom were female (Mean age: 20.3 – Mean exercise age: 8.8) and 9 of whom were male athletes (Mean age: 20.3 – Mean exercise age: 9.5). The participants attended an 8-week exercise program for 5 days a week, which included basic motoric features and technical and tactical development. 4 cc blood samples were taken from the right antecubital vein before and after the preparation period exercises. On the blood samples, WBC, GRAN, GRAN %, LYM, LYM %, MID and MID % values were examined among thrombocyte sub-groups; RBC, HGB, HCT, MCV, MCH, MCHC and RDWC values were examined among the erythrocyte sub-groups, and PLT, MPV, PCT and PDW values were examined among thrombocyte sub-groups.

Results: At the end of the study, we determined that there was a statistically significant increase in the MCHC values of both the male and the female taekwondo athletes. Moreover, it was determined that there were statistically significant decreases in the HCT, MCV, MCH, MPV and PCT values of the female taekwondo athletes, and in the MCHC, RDWC and PCT values of the male taekwondo athletes.

Conclusions: As a conclusion, we can state that the 8-week exercises applied during the preparation period affected the hematological parameters of the male and female taekwondo athletes to an extent, however, this effect was limited and it did not cause an important change.

Keywords: Taekwondo, training, university students, leucocyte, erythrocyte, thrombocyte.

Introduction

The data revealed by the studies conducted on athletes, both enables a better understanding of the sport and the sport physiology and it helps interpret the changes occurring in the bodies of people, who are actively doing sports [1]. The effect of exercise on hematological parameters has been a research field for a long time. In many studies, the interrelation of factors determining the performance and physical / physiological characteristics of athletes of the elite level has been established [2-5].

It was reported that the acute exercise has an important effect on the rheological characteristics of the blood [6] and that there was an increase in the erythrocyte hardness and in the plasma viscosity after the acute exercise, while there was a decrease in the sedimentation speed [7]. It is known that both acute and chronic exercises cause various hematological changes in human body. It was determined that the exercise-based hematological changes depended on the type, intensity, and duration of the exercise. Additionally, various factors such as education level, gender, age, environmental conditions, and the nutrition of the subjects have an important role, as well [8].

In the accessible literature findings, we observed differences concerning the effects of exercise on hematological parameters. There are studies reporting that, in the athletes, who attend both acute [9] and chronic intense exercises [2], the hemoglobin [10] and hematocrit values decrease and this case is called as the athlete anemia [9]. Additionally, there are also research studies stating that, when the values before and after the acute sub-maximal exercise are compared, the acute sub-maximal exercise significantly increases erythrocyte, leukocyte [11], and thrombocyte count, hematocrit and hemoglobin levels [12]; and the researchers determined that these increases depended on plasma losses caused by this exercise [13]. Moreover, it is reported that a short-term exercise until fatigue increases the leukocyte count and this situation cannot be explained by the hemoconcentration mechanism alone. Therefore, the researchers stated that it can be related with metabolic changes such as ischemia developed during the exercise and increased muscle activity. In addition, they claimed that it can cause larger capillary swelling and leukocyte adhesion incidence in the venules [14].

With reference to the possible changes in the hematological parameters based on the type, intensity, and duration of the exercise, we thought that it is important to determine the possible effects of preparation-period exercises on the hematological parameters of elite level taekwondo athletes, which led us to conduct his project. Therefore, the purpose of this study is to examine the effects of preparation-period exercises, which were applied for 8 weeks to elite level taekwondo athletes, on the hematological parameters.
Materials and Methods

Participants.

The subjects of this research were chosen among the volunteer athletes. We conducted the research on 21 elite level taekwondo athletes (9 males and 12 females) from the Selçuk University Taekwondo Team, who regularly continued exercises and participated in tournaments. Additionally, in order to compose the elite level athlete group, we determined inclusion criteria. According to these criteria, the athletes to be included in the study must have a 5-year exercise background, must be participated in national and international level competitions, and must have continued exercises for 4 days and over in a week. Moreover, based on the inclusion criteria the participants must be between 17-25 years old, they must have willingness to participate in the study, and additionally no smoking, no use of notorious or mood enhancing supplements, physical and mental health, and no diseases to be detected in the specimens’ medical history. Exclusion criteria were first, non-compliance with the training protocol, and second, inability to collect the information sought by the researchers. All the volunteers participating in the research signed the informed consent (volunteer) form and filled personal information form.

Research Design.

The research method was semi-experimental. It was conducted in accordance with the Declaration of Helsinki, and the protocol was approved by the Necmettin Erbakan University, Meram Medical Faculty, Ethics Committee of non-Pharmaceuticals and non-Medical Device Researches with the decision dated 27/04/2018 and numbered 2018/67.

Before starting the research, we made interviews with the authorities, trainers, and athletes of the team, who were planned to be included into the study as the research group (Selçuk University Taekwondo Team). The athletes participated in an 8-week preparation period exercise before the Interuniversity Taekwondo Turkey Championship that was organized by the Turkey University Sports Federation. All of the measurements and tests of the taekwondo athletes composing the experiment group were carried out in Konya Selçuk University Sports Hall. The preparation period exercises were conducted during June and July of 2018. The physical feature measurements of the athletes were conducted one day before the exercise period began. We organized another meeting with the athletes just before the test, and gave information about the objective and importance of the study. Necessary equipment and test mechanisms for the test and measurements were prepared in the sports hall that hosted the test. Tests were conducted and measurements were taken one day before and after the preparation period exercise. We informed the athletes that they should not take medicine and alcohol the day before and in the same day of blood sample taking activity. While taking the blood sample, the athlete was positioned in a sitting posture on a chair. 4 cc blood samples were taken from the right antecubital vein into the hemogram tubes with K3 Edta by the specialist nurse. After the blood samples were transferred to the laboratory under proper storage conditions without being centrifuged, they were analyzed in the Cell-Dyn 1800 (Abbott Diagnostics, Abbott Park, IL, USA) hemogram device. Among the hematological parameters;

- WBC, GRAN, GRAN %, LYM, LYM %, MID and MID % values from the leukocyte sub-groups were analyzed,
- RBC, HGB, HCT, MCV, MCH, MCHC and RDWC values from the erythrocyte sub-groups were analyzed,
- 3- PLT, MPV, PCT and PDW values from the thrombocyte sub-groups were analyzed.

The exercises of the taekwondo athletes during the preparation period were conducted according to the content described below. Besides the warm-up and cooling exercises in each unit of exercise period, the athletes conducted;

- Single and combined technical practices on the glove (with all the techniques used in the competitions),
- Paired tactical practices on the safeguard,
- Exercise competition (the athletes participated in the competition with the “pull system” method) (sparring),

The practices were conducted in the unit exercise period, and the duration of the exercise was limited to 90 minutes. The level of the competition was revised based on the exercise principles and according to the adaptation status of the athletes.

Statistical Analysis.

SPSS 24.0 (IBM Corp., Armonk, NY, USA) program was used in the analysis of the data obtained in the study, and minimum, maximum, arithmetic mean, and standard deviation values were determined. Since the number of the participants in the research was lower than 30, the differences between the tests applied before and after the exercise were determined via “Wilcoxon Signed Rank Test”. Significance level was admitted as p<0.05.

Results

Table 2 shows the age, height, body weight and BMI average values of athletes participating in the study.

The Wilcoxon Signed Rank Test analysis was applied here to determine whether there was significant difference between the pre-test and post-test mean values of the male taekwondo athletes. When Table 3 was examined, according to the mentioned test, it was determined that there were statistically significant differences in the MCV (z= -2,675), MCHC (z= -2,549), MPV (z= -2,092) and PCT (z= -2,075) parameters (p< 0.05). However, there was statistically no significant difference (p> 0.05) for the other parameters.

The Wilcoxon Signed Rank Test analysis was applied here to determine whether there was significant difference between the pre-test and post-test mean values of the female taekwondo athletes. When Table 4 was examined, according to the mentioned test, it was determined that there were statistically significant differences in the HCT (z= -2,943), MCV (z= -2,981), MCH (z= -2,119), MCHC
However, there was statistically no significant difference ($p > 0.05$) for the other parameters.

**Discussion**

In this study, the effects of preparation period exercises, which were applied for eight weeks to elite level taekwondo athletes, on the hematological parameters were examined.

When we examined the leukocyte and sub-parameters of the female taekwondo athletes, we determined increases in WBC, GRAN, GRAN % and LYM parameters compared to those taken before the preparation period. Additionally, we determined decreases in the other parameters, however, they were statistically not significant. As per the males, we detected decreases in GRAN % and LYM % parameters, and increases in all other parameters, however, they were statistically not significant, either. In a similar study conducted on taekwondo athletes, it was stated that a 4-week camp period exercise increased the WBC values of the athletes; however, it was statistically not significant [15]. In two different studies conducted on football athletes examining the effect of acute exercise and 10-day game program on

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Male (n=9)</th>
<th>Female (n=12)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Min</td>
<td>Max</td>
</tr>
<tr>
<td>Age (year)</td>
<td>19.00</td>
<td>23.00</td>
</tr>
<tr>
<td>Exercise age (year)</td>
<td>7.00</td>
<td>14.00</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>176.00</td>
<td>188.00</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>63.00</td>
<td>82.00</td>
</tr>
<tr>
<td>BMI (kg/m2)</td>
<td>20.09</td>
<td>23.20</td>
</tr>
</tbody>
</table>

($z$ = -2.984), MPV ($z$ = -3.062) and PCT ($z$ = -2.283) parameters ($p < 0.05$). However, there was statistically no significant difference ($p > 0.05$) for the other parameters.
## Table 3. Average values of hematological parameters of male taekwondo athletes and the results of Wilcoxon Signed Rank test. (* \( p < 0.05 \))

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Pre-test (n= 9)</th>
<th>Post-test (n= 9)</th>
<th>z</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Leukocyte sub-groups</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WBC (10^3/μL)</td>
<td>Min</td>
<td>Max</td>
<td>Mean ± Sd</td>
<td>Min</td>
</tr>
<tr>
<td>GRAN (10^3/μL)</td>
<td>2.30</td>
<td>6.20</td>
<td>3.44±1.13</td>
<td>2.00</td>
</tr>
<tr>
<td>GRAN (%)</td>
<td>42.70</td>
<td>64.30</td>
<td>54.74±6.06</td>
<td>25.30</td>
</tr>
<tr>
<td>LYM (10^3/μL)</td>
<td>1.80</td>
<td>2.60</td>
<td>2.10±0.31</td>
<td>1.40</td>
</tr>
<tr>
<td>LYM (%)</td>
<td>25.90</td>
<td>47.50</td>
<td>34.55±6.32</td>
<td>23.40</td>
</tr>
<tr>
<td>MID (10^3/μL)</td>
<td>0.50</td>
<td>0.90</td>
<td>0.65±0.13</td>
<td>0.50</td>
</tr>
<tr>
<td>MID (%)</td>
<td>9.20</td>
<td>13.00</td>
<td>10.70±1.09</td>
<td>6.60</td>
</tr>
<tr>
<td><strong>Erythrocyte sub-groups</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RBC (10^6/μL)</td>
<td>4.82</td>
<td>6.16</td>
<td>5.26±0.45</td>
<td>4.91</td>
</tr>
<tr>
<td>HGB (g/dL)</td>
<td>11.40</td>
<td>16.60</td>
<td>15.07±1.54</td>
<td>10.60</td>
</tr>
<tr>
<td>HCT (%)</td>
<td>35.70</td>
<td>51.00</td>
<td>45.88±4.39</td>
<td>33.40</td>
</tr>
<tr>
<td>MCV (fL)</td>
<td>62.20</td>
<td>98.00</td>
<td>87.68±10.99</td>
<td>58.40</td>
</tr>
<tr>
<td>MCH (pg)</td>
<td>19.90</td>
<td>32.60</td>
<td>28.82±3.78</td>
<td>18.50</td>
</tr>
<tr>
<td>MCHC (g/dL)</td>
<td>31.90</td>
<td>33.40</td>
<td>32.83±0.52</td>
<td>31.70</td>
</tr>
<tr>
<td>RDWC (%)</td>
<td>12.90</td>
<td>19.30</td>
<td>14.25±1.94</td>
<td>12.80</td>
</tr>
<tr>
<td><strong>Thrombocyte sub-groups</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PLT (10^3/μL)</td>
<td>196.00</td>
<td>321.00</td>
<td>254.22±43.64</td>
<td>179.00</td>
</tr>
<tr>
<td>MPV (fL)</td>
<td>8.10</td>
<td>11.70</td>
<td>10.21±1.01</td>
<td>8.00</td>
</tr>
<tr>
<td>PCT (%)</td>
<td>0.21</td>
<td>0.33</td>
<td>0.25±0.03</td>
<td>0.15</td>
</tr>
<tr>
<td>PDW (%)</td>
<td>15.80</td>
<td>17.10</td>
<td>16.46±0.47</td>
<td>15.70</td>
</tr>
</tbody>
</table>

## Table 4. Mean values of hematological parameters of female taekwondo athletes and the results of Wilcoxon Signed Rank Test. (* \( p < 0.05 \))

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Pre-test (n= 12)</th>
<th>Post-test (n= 12)</th>
<th>z</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Leukocyte sub-groups</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WBC (10^3/μL)</td>
<td>4.00</td>
<td>9.90</td>
<td>7.06±1.90</td>
<td>5.70</td>
</tr>
<tr>
<td>GRAN (10^3/μL)</td>
<td>1.80</td>
<td>7.20</td>
<td>4.65±1.83</td>
<td>3.10</td>
</tr>
<tr>
<td>GRAN (%)</td>
<td>45.30</td>
<td>86.10</td>
<td>63.78±11.56</td>
<td>51.90</td>
</tr>
<tr>
<td>LYM (10^3/μL)</td>
<td>0.70</td>
<td>2.60</td>
<td>1.76±0.45</td>
<td>1.20</td>
</tr>
<tr>
<td>LYM (%)</td>
<td>9.10</td>
<td>41.60</td>
<td>26.73±9.65</td>
<td>17.60</td>
</tr>
<tr>
<td>MID (10^3/μL)</td>
<td>0.40</td>
<td>1.10</td>
<td>0.66±0.21</td>
<td>0.50</td>
</tr>
<tr>
<td>MID (%)</td>
<td>4.80</td>
<td>13.10</td>
<td>9.48±2.58</td>
<td>6.50</td>
</tr>
<tr>
<td><strong>Erythrocyte sub-groups</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RBC (10^6/μL)</td>
<td>4.04</td>
<td>5.07</td>
<td>4.52±0.27</td>
<td>4.23</td>
</tr>
<tr>
<td>HGB (g/dL)</td>
<td>11.80</td>
<td>14.50</td>
<td>13.10±0.69</td>
<td>11.70</td>
</tr>
<tr>
<td>HCT (%)</td>
<td>35.70</td>
<td>44.50</td>
<td>39.70±2.12</td>
<td>34.60</td>
</tr>
<tr>
<td>MCV (fL)</td>
<td>78.90</td>
<td>99.00</td>
<td>87.90±5.80</td>
<td>75.00</td>
</tr>
<tr>
<td>MCH (pg)</td>
<td>26.00</td>
<td>31.70</td>
<td>28.99±1.87</td>
<td>25.30</td>
</tr>
<tr>
<td>MCHC (g/dL)</td>
<td>32.00</td>
<td>33.90</td>
<td>33.00±0.60</td>
<td>33.10</td>
</tr>
<tr>
<td>RDWC (%)</td>
<td>12.80</td>
<td>20.40</td>
<td>14.51±2.07</td>
<td>12.50</td>
</tr>
<tr>
<td><strong>Thrombocyte sub-groups</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PLT (10^3/μL)</td>
<td>152.00</td>
<td>343.00</td>
<td>244.41±54.40</td>
<td>179.00</td>
</tr>
<tr>
<td>MPV (fL)</td>
<td>9.20</td>
<td>13.30</td>
<td>11.29±1.04</td>
<td>8.60</td>
</tr>
<tr>
<td>PCT (%)</td>
<td>0.16</td>
<td>0.39</td>
<td>0.27±0.06</td>
<td>0.16</td>
</tr>
<tr>
<td>PDW (%)</td>
<td>15.30</td>
<td>17.50</td>
<td>16.36±0.65</td>
<td>15.20</td>
</tr>
</tbody>
</table>
the hematological parameters, it was reported that there were decreases in the leukocyte values, however, they were statistically not significant [11, 16]. In another study conducted on female basketball athletes aiming to determine the relations between the blood parameters and some performance values from upper extremity, WBC values were reported as $6.85 \times 10^3/\mu L$ [17]. In a different study conducted on basketball athletes, it was reported that a 12-day intense competition period caused an increase in the WBC parameter, however, it was statistically not significant [3]. It can be stated that previous studies support the findings of this study. However, opposing to the findings of this study, there are studies which state [12, 18] that exercises conducted on sedentary individuals and in different sport branches caused decreases in the leukocyte level. In addition to these, there are also studies reporting that it caused statistically significant increases [6, 19, 20]. These post-exercise increases at the leukocyte levels are reported to be originated from de-margination, which, after the increasing blood stream with exercise, is defined as joining of the leukocytes that stick to the walls of the veins to the blood stream [21, 22]. Moreover, it is known that high intensity exercises create a heavy stress over the organism, and as a reaction to that, the count of the leukocytes could significantly increase together with some hormonal changes. Accordingly, as Patlar (2010) reported, particularly with the increasing pressure after the strength exercises, the cortisol level increases, this brings an increase in the level of the leukocyte, as well [23]. However, that the differences in the leukocyte and sub-group parameter values were not statistically significant in this research study might be an indicator of the adaptation of the athletes against pressure in the organism caused by the exercise.

When we examined the erythrocyte and sub-parameters, compared to the values taken before preparation period, we observed statistically significant differences. These differences were concerning the HCT, MCV, MCH and MCHC parameters of the female taekwondo athletes, and concerning the MCV and MCHC parameters of the male taekwondo athletes. However, we determined that the values for the other sub-parameters taken before and after the preparation period were statistically non-significant. In a research study conducted on national and international level 13 male 800 m runners, comparing the summer and winter competition periods, it was determined that there were decreases for the RBC values and also statistically significant decreases for the HCT values [2]. It was reported that short term intensive basketball competition caused a statistically significant decrease for the HCT parameters of the athletes, while causing a statistically non-significant decrease for RBC and HGB parameters [3]. Moreover, in another study conducted on long distance runners (n=31), it was stated that there were statistically significant decreases for the RBC and HGB values compared to the pre-competition values [24]. In another study conducted on the maximal strength development of elite level female weightlifting athletes, it was reported that there were decreases for erythrocyte and sub-parameters [4]. Although the accessible literature findings support the findings of this study, İbiş et al. (2010) reported that there were significant increases for the HBG and HCT values after an anaerobic exercise [21]. On the other hand, Mashiko et al. (2004) stated that a 20-day camp period applied to the rugby athletes did not cause any statistically significant difference for HCT values [25]. In another study conducted on taekwondo athletes, there were statistically significant increases for the RBC values, and non-significant increases for HGB and HCT values [15]. Although it was reported that these increases depended on the plasma losses caused by the exercise, we evaluated that the motive behind the decrease in the erythrocyte values might be the intravenous hemolysis caused by the trauma due to the intense exercises in this study.

When we examined the thrombocyte and its sub-parameters, compared to the values obtained before the preparation period, we observed that there were decreases in all parameters of both male and female taekwondo athletes, except for the PLT value of the female taekwondo athletes. As far as the accessible literature findings, although there are many research studies [12, 15, 16, 21, 24, 26-28] reporting that both acute and chronic exercises cause increases in the values of thrombocyte and its sub-parameters, there are also studies [2, 3, 18] reporting that they cause a decrease. Increases obtained in the PLT levels are attributed to both exercise-contingent hemoconcentration and sympathetic nervous system activation, which is caused by stress-creating factors and the organism under pressure. We evaluate that, although statistically not significant, the increase in the PLT level in this study is caused by fresh thrombocyte secretion from either spleen, bone marrow, or other reservoirs. It is thought that the effects of exercise on the count of thrombocyte is questionable, therefore, a more in-depth research study is needed.

Conclusions
It can be accepted as a strength of the study that the research group of this study is comprised of male and female athletes with participation experiences in national or international level competitions. Additionally, some findings were obtained as a result of the exercises conducted during the preparation period with the full participation. However, in order for the results to be more significant, we evaluated that further studies should be conducted with a higher number of participants and with different load intensities. In this study, which was conducted on elite level taekwondo athletes, leukocyte, erythrocyte, thrombocyte, and their sub-parameters, totally 18 parameters were examined. There were statistically significant differences for 6 parameters of the female taekwondo athletes and for 4 parameters of the male taekwondo athletes. Although we observed increases and decreases in the other parameters, we determined that these differences were statistically not significant.

As a result, we can state that the preparation period exercises, which were conducted for 8 weeks, caused
increases or decreases in the hematological parameters of male and female taekwondo athletes. However, this effect was limited and it did not cause a significant change. We attribute it to that the athletes in the research group are elite level competitor athletes and that they developed an adaptation ability to the stress caused by the chronic exercise.

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Conflicts of interest

The authors declare no conflict of interest.

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Acute effects of pre-workout supplement on aerobic and anaerobic performance in basketball players

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Authors’ Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection.

Abstract

Purpose: In recent years, the use of ergogenic aid has become widespread in order to improve performance among the athletes and to achieve success more easily. Pre-workout nutritional supplements that attract the attention of many athletes as a legal ergogenic aid are used by both aerobic and anaerobic branch athletes. The aim of this study is to examine the acute effect of the pre-workout supplement on aerobic and anaerobic performance in basketball players.

Material: Twenty male college basketball players who have played regularly at least for 5 years participated in the study voluntarily (mean ± SD 22.00 ± 1.70 years, height 1.83 ± 0.07 cm, weight 85.15 ± 10.78 kg, BMI 25.32 ± 3.10). Double-blind placebo-controlled, cross-over method was used for the collection of data. The players were divided into two groups as placebo (PL, n=10) and pre-workout (PRW, n=10). Placebo and pre-workout groups were replaced 48 hours after the initial measurements and the same tests were repeated. The pre-workout group was given 17 gr (Bigjoy Predator) in 200 mg of additive-free juice 1 hour before the test, only 200 mg of additive free juice was given to the placebo group. Countermovement Jump (CMJ) and Running-Based Anaerobic Sprint Test (RAST) were used to measure the anaerobic performance of the athletes, and Yoyo Intermittent Recovery Test 1 (Yo-Yo IR1) was used to measure aerobic capacities.

Results: A significant difference was found concerning the Countermovement Jump (CMJ) test results (p= 0.004), Relative peak power (p=0.001) and Relative average power (p=0.012) values obtained from RAST test data. There was no significant difference in fatigue index (p = 0.79) and VO2 max (p = 0.492) values.

Conclusions: While pre-workout supplementation has an acute effect on anaerobic power data, it has been observed that there is no acute effect on the data obtained from fatigue index and aerobic endurance test.

Keywords: basketball, aerobic performance, anaerobic performance, pre-workout, acute effect.

Introduction

As for the recent years, use of ergogenic aid has gained wide currency among the athletes with the aim of increasing the performance and attaining success in an easier manner [1-3]. Ergogenic aids, which contribute to the increase of training and match performance and are not considered as doping, are nutritional supplements [4]. In this sense, one of these ergogenic aids is pre-workouts which increase the performance, training adaptation, energy-production/use of athletes as well as support the recovery [2, 5].

Pre-workout nutritional supplements which attract the attention of many athletes by virtue of its being a legal ergogenic aid are used by aerobic and anaerobic branch athletes due to their potential ergogenic effects [6]. Producers of multi-ingredient pre-workouts generally claim that their products enhance the performance of athletes and reduce the fatigue sensation during the exercise. These products characteristically include a combination of many ingredients (30+) and generally contain stimulants (e.g. caffeine), energy-producing factors (e.g. creatine), agents which act as hydrogen ion buffers (e.g. beta alanine), protein recovery nutrients (e.g. amino acids), antioxidants as well as nitric oxide precursors (e.g. arginine) [7].

When the literature concerning this aspect is examined, it is observed that there are studies with respect to the effect of pre-workout nutritional supplement on athlete’s aerobic and anaerobic performances [5, 8 – 11]. To illustrate, Martinez et al. [9] investigated the acute effects of caffeine-containing pre-workout nutritional supplement on anaerobic power for men who work out recreationally, and reported that these supplements lead to significant improvements in the values of anaerobic peak power and mean power. In a similar study, Jagim et al. [10] examined the effects of multi-ingredient pre-workout ingestion on strength performance, lower body power and anaerobic capacity in resistance trained college-aged men, and concluded that this supplement improved the mean power in anaerobic running capacity test. Furthermore, Smith et al. [8] examined the effect of using pre-workout, which contains caffeine, creatine and amino acid, together with high-intensity exercises on the aerobic and anaerobic performance in moderately-trained men and reported that there were improvements with regard to VO2 max values of the participants. Cameron et al. [5] found that as a result of their studies which examine the acute effect of multi-ingredient pre-workout supplement on resting energy expenditure and exercise performance of recreationally active women, pre-workout supplement improves diastolic blood pressure, resting metabolism,
upper body muscular strength and anaerobic capacity.

Furthermore, the integration of nutritional supplements into research by means of realistic exercise training protocols will allow for sportive practical uses. Particularly, intermittent running trainings, which are practicable for team sports based on repeated bouts of short sprints such as football, basketball, hockey and soccer as well as practicable for team sports based on active recovery periods, are sensitive to additional nutritional supplements which are designed to delay fatigue resulting from considerably extensive training [8].

Although there are studies examining the acute [5, 10, 12] and chronic [8, 9] effects of the use of pre-workout nutritional supplements, it is observed that these studies are mostly performed on individuals who perform sports individually and in a recreative manner. Furthermore, it is observed that there is a limited number of studies which examines the effect of these supplements on performance in team sports which include intermittent running and is bound up with aerobic and anaerobic systems. Accordingly, the purpose of this study is to investigate the acute effect of pre-workout nutritional supplementation on aerobic and anaerobic performance in basketball players.

Material and methods

Participants
20 athletes from Sakarya University Basketball Team, who have at least 5 years of athletic background and have not taken any nutritional supplement in the last 6 months, participated in this study (mean ± SD 22, 00±1, 70 yrs; height 1, 83±0, 07 cm; weight 85, 15±10, 78 kg; BMI 25, 32±3, 10).

Furthermore, they were informed about the objective and significance of the study as well as the benefits and risk of the nutritional supplement to be consumed; moreover, their voluntary participation was ensured. For this study, ethical approval (numbered 16214662/050.01.04/70) was received from Sakarya University Department of Medical Research Ethical Committee.

Research Design
In this study, double-blind placebo-controlled crossover method was used. Aerobic and anaerobic tests were performed on the participants on 4 separate measurement dates which had 48 hours interval among each other. As for the 1st measurement day, CMJ and RAST tests were performed on the placebo and pre-workout groups. As to 2nd measurement day, the same tests were repeated by replacing placebo and pre-workout groups. Concerning 3rd day, Yo-Yo IRL1 test was performed. With regard to 4th day, Yo-Yo IRL1 test was repeated by replacing placebo and pre-workout groups (Figure 1). A dietary control was performed on the athletes 3 hours prior before the measurements, and they were demanded not to consume caffeine during this study. Additionally, pre-workout and placebo products were given to athletes by independent nutrition expert one hour before the tests. The athletes were demanded to maintain their current training program during the study. Besides, the athletes were also instructed to refrain from doing any compelling physical activity other than their own training. Before the tests, the athletes were informed about the test protocols and a demonstration regarding these tests was performed. Moreover, athletes completed a 10-minute standard warm-up procedure consisting of low intensity running, dynamic stretching of the lower body and vertical jump exercises before each test.

Measurements and Tests
Body weights of the athletes were measured by “Tanita Segmental Body Composition Monitor InnerScan BC-545N – Japan”; on the other hand, height measurements (Seca 213 Germany) were measured with 1 mm precision portable stadiometer. Furthermore, their body-mass indexes were calculated with the formula Bodyweight / height^2 (m). In CMJ test, leg lengths of the athletes were measured and standardized in accordance with CMJ test. Besides, CMJ and RAST were used to measure anaerobic performance of the athletes; additionally, Yo-Yo IRL1 test was used to measure aerobic performance. The mentioned measurements were performed within 4 days at 48-hour intervals and they were realized during the same training hours at Sakarya University Faculty of Sports Sciences Indoor Sports Facility. The same dietary control was performed on the athletes 3 hours before the measurements.

Running-Based Anaerobic Sprint (RAST) Test
The Running-Based Anaerobic Sprint Test (RAST), which was developed by Draper and Whyte at the University of Wolverhampton in the United Kingdom in 1997, is a test protocol designed to measure anaerobic power and capacity [13]. The test includes 6 sprints over a distance of 35 meters with an active resting time of 10 seconds for each sprint. In this sense, after the participants were informed about the test, a specific 10-minutes warm-up protocol was performed. Moreover, photocell (SE-100 Chronometer) was used during the tests. Within the scope of the RAST test; relative peak power, relative average power as well as fatigue index data were collected in an indirect way.

Countermovement Jump Test
Jump performance (explosive power) has a significant role in the branches in which aerobic or/and anaerobic energy systems are used [14]. In this study, My Jump 2 application (app), which was accessed via the iPhone Apple Store, was used to measure the vertical jump performance (ICC = 0.97-0.99) [14]. The My Jump 2 app has been developed to calculate the jump height from flight time using the high-speed video recording feature via iPhone 6S [15]. Each participant was allowed to jump for three times and their best scores were recorded.

Yo-Yo Intermittent Recovery Test I
The Yo-Yo IRL1 test consists of 2 * 20-meter shuttle runs that are repeated with incremental speed increases controlled by commands from a laptop audio file between the start, rotation and termination lines. Each interval between the shuttle runs includes an active recovery time of 10 seconds in which the athletes walk or jog in a 2 * 5-meter area. If the athletes fail to reach the finish line for two times, the test is terminated and the total distance
covered by the athlete is recorded as a test result. In this framework, the total duration of the test was 6-20 minutes [16, 17]. VO2max was measured indirectly from the Yo-Yo test.

Supplement Consumption
In this study, double-blind placebo-controlled crossover was used. Moreover, the pre-workout group was given 17 gram of BigJoy Predator (Forest Fruity, 510 gr) by mixing it with 250 ml of organic fruit juice which has the same aroma with pre-workout product. As for the placebo group, they only received 250 ml of unmixed fruit juice with the same aroma as the pre-workout. The contents of the pre-workout product used in the study are shown in Figure 2.

Dietary control
Participants were selected from healthy athletes who had not received any ergogenic dietary supplement for 6 months before the measurements. Participants were demanded not to take alcohol, caffeine, or any other drugs within 48 hours prior to the measurements. Moreover, participants were asked not to change their dietary habits during the study period. However, the foods to be consumed on the measurement days were determined. Furthermore, all participants consumed the same food 3 hours before each measurement. Meal contents were prepared in accordance with the principle of a balanced diet, which includes various energy sources and macronutrients [18]. The contents of each meal - totally four meals- which were consumed before measurement were similar.
Descriptive statistics (mean and standard deviation) of all data were calculated. Besides, normality test of the obtained data was analyzed by the Shapiro-Wilk test. Wilcoxon Signed Rank test was used to analyze the data that were not distributed normally. Significance was determined as $p < 0.05$. SPSS software was used in analyzing the data.

**Results**

The age average of basketball players participating in the research was determined as $22.00 \pm 1.70$; additionally, the mean height was $1.83 \pm 0.07$, the mean body weight was $85.15 \pm 10.78$, the body mass index average was $25.32 \pm 3.10$. 

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**Table 1.** Descriptive Statistics of participants

<table>
<thead>
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<th>Indicators</th>
<th>N</th>
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<th>Maximum</th>
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<th>Std. Dev.</th>
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<td>10.78</td>
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<td>31.02</td>
<td>25.32</td>
<td>3.10</td>
</tr>
<tr>
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<td>93.00</td>
<td>117.00</td>
<td>104.75</td>
<td>5.48</td>
</tr>
</tbody>
</table>

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**Statistical Analysis**

Descriptive statistics (mean and standard deviation) of all data were calculated. Besides, normality test of the obtained data was analyzed by the Shapiro-Wilk test. Wilcoxon Signed Rank test was used to analyze the data that were not distributed normally. Significance was determined as $p < 0.05$. SPSS software was used in analyzing the data.
In examining the difference among the athletic performance variables of basketball players, while there was a difference among the values of CMJ, Relative Peak Power and Relative Average Power, it was observed that there was no difference between the values of fatigue and VO2max (p<0.05).

**Discussion**

The aim of this study is to examine the effect of pre-workout use on aerobic and anaerobic performance for basketball players. According to the results of this study, it was observed that pre-workout supplement consumption had a positive effect on the test results which measured anaerobic performance of the basketball players but had no positive effect on aerobic performance. When relevant studies in this subject are examined, it is observed that these studies support the anaerobic performance results of this study. For instance; Cameron et al. [5] used CMJ testing to measure anaerobic performance in their study with respect to the acute effect of a multi-ingredient pre-workout supplement on exercise in recreationally active females. As a result, they reported that the multi-ingredient pre-workout supplement had a positive effect on anaerobic performance. As for another similar study, Kreamer et al. [19] investigated the effect of multi-ingredient nutritional supplementation on exercise performance and hormonal responses concerning 9 healthy males; and reported that multi-ingredient nutritional supplementation improved vertical jump test results which is an indicator of anaerobic performance. In contrast to these studies, Dawes et al. [20] found no significant difference with regard to anaerobic power in their studies which examine the effect of pre-workout energy drink on physical performance of 41 healthy males. However, it was determined that there was difference between the values of relative average power and relative peak power which were obtained by means of RAST Test. Besides, the reason why anaerobic power results found by Dawes and his colleagues diverge from the results of this study and other cited studies is thought to be resulted from the sample group that has less training background. Furthermore, Gonzales et al. [6] studied the effects of pre-workout supplement on multi-joint endurance exercise regarding eight athletes with a mean 5-year endurance training history. Consequently, they concluded that pre-workout supplementation significantly increased mean and peak power values. Similarly, within the scope of their studies which examines the effect of multi-ingredient pre-workout on strength performance, lower body strength and anaerobic capacity of college-aged individuals with endurance training background, Jagim et al. [10] found that mean power values which are calculated indirectly from the maximum force test of athletes using pre-workout were high.

It is observed that different results have been obtained in the studies which examine the chronic effects of the use of pre-workout derivative supplement on aerobic (VO2max)
and anaerobic performances of athletes. For example, Urbina et al. [21] found no significant difference with respect to the effect of 6-week pre-workout nutritional supplementation and post-training protein ingestion on the VO\(_{2}\text{max}\) values of individuals who do crossfit. On the other hand, Smith et al. [8] examined the effect of the use of high-intensity interval training together with pre-workout containing caffeine, creatine and amino acid for 3 weeks on aerobic and anaerobic performance of moderately-trained males and concluded that there was improvement with regard to VO\(_{2}\text{max}\) in their research. Additionally, In consequence of their studies which examine the effect of the combination of pre-workout nutritional supplements and 3-week high-intensity interval training on critical speed, anaerobic running capacity, training volume and body composition with regard to men and women (25 well-trained recreational athletes), Smith et al. [22] showed that VO\(_{2}\text{max}\) increased with the rate of %10.5. It is evaluated that the scope and intensity of the applied training programs can be influential with respect to the fact that study results dealing with the chronic effects of pre-workout differ.

**Conclusion**

The acute effects of pre-workout supplement on anaerobic and aerobic performance of basketball players were examined in this study. It was determined that CMJ test and RAST test values which are anaerobic capacity indicators of the athletes using pre-workout supplement were higher. However, there were no differences between the fatigue index obtained from RAST test and VO\(_{2}\text{max}\) values which were indirectly obtained from the aerobic capacity test.

**Conflict of interest**

The authors declare no conflict of interest.

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Association between hydration status, hydration knowledge and fluid consumption during training among soccer players

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Abstract

Purpose: The purpose of this study was to determine the correlation between hydration status, knowledge of hydration and the amount of fluid intake consumption during training among the soccer players.

Material: Pre-training hydration status was measured by urine colour chart and Urine Specific Gravity (USG). A questionnaire on hydration knowledge was answered by the participants on the last day of training session. Pearson Correlation test was used to analyse the correlation between hydration status, knowledge of hydration and total amount of fluid intake among the participants.

Results: The results showed that the participants were dehydrated during the three days of training. Sixty four percent of the participants had a satisfactory knowledge of hydration. However, the results indicated that the sweat loss was higher than fluid intake during the training. Pearson test revealed there were positive correlation between USG and urine colour (r=0.809, p<0.001) as well as urine colour and fluid intake (r = .424, p<0.05).

Conclusions: In conclusion, the findings indicate the needs to increase awareness of pre training hydration status among the participants.

Keywords: thirst, fluid balance, fluid intake, personal trainers, knowledge.

Introduction

Human body system needs fluid balance mechanism to ensure that all body system function well. When athletes train under the hot weather, the body’s homeostatic balance can be disrupted [1]. Furthermore, during muscle contraction, the heat produced from the metabolism of the body which must be removed from the body to prevent hyperthermia. Besides, during training, body water could be lost through perspiration which leads to dehydration. According to Coyle [2], the effect of dehydration on the physiological functions and exercise performance is higher when the athletes were training under warm weather compared to cold weather.

If the level of dehydration increases, body temperature, heart rate and stroke volume will increase and jeopardize the sports performance. Therefore, it is very important for an athlete to ensure the fluid intake before, during and after exercise are sufficient. In fact, individuals who are active in sports require adequate energy and fluid intake to maintain normal hydration, electrolyte balance and variety of food choices that provide balanced nutrients for optimal performance [3]. Sawka et al. [4] stated that when dehydration occurs during training under warm weather, pressure on the physiology of the body increases and requires more effort to do the exercises. They also noted that the higher the level of dehydration, the performance of aerobic exercise will also be disrupted. Duffield, McCall, Coutts and Peiffer [5] conducted the study on hydration, sweat and thermoregulatory responses among professional football players training in the heat found that the average rate of sweat loss during training under was between 0.7 - 1.5 Lh⁻¹ with weight loss between 1-5%. This study supports the previous findings by Kilding, et al. [6] and Shirreffs et al. [7] in which they stated that the rate of sweat loss during exercise under hot weather was between 1.0-2.0 Lh⁻¹ with weight loss between 1-3%. Therefore, adequate fluid intake before and during training should be emphasized among athletes to maintain body fluid balance and sports performance. Furthermore, it is also to ensure that the athletes are not exposed to heat injury and health problems, especially heat illness. Apart from that, a study conducted by Ritz and Berrut [8] showed that minimal dehydration also disrupts some important aspects of cognitive function such as memory short ratio, sensitivity and concentration.

Despite the importance of proper hydration on sports performance, many athletes started their training [9, 10, 11] or competition [12, 13] in hypohydrated state. This situation may be due to ignorance or lack of knowledge on the aspect of hydration. Normah [14] showed that the athletes in selected sport school in Perak had good score on hydration knowledge, yet they were dehydrated prior to the training session, suggesting they probably ignored the importance of proper hydration status for optimal training. Decher et al. [15] also showed that there was no correlation observed between hydration status and hydration knowledge among children who attended summer camp, and they speculated that other factors may contribute to the hypohydrated state among the children. Indeed, Nichols, Jonnalagadda, Rosenbloom, and Trinkaus [16] concluded that even though the athletes had knowledge on hydration, but they may not apply the knowledge to improve their hydration status. The application of hydration knowledge includes the sufficient fluid consumption before, during and after training as well as monitoring their hydration status using physiological and psychological signs.

Therefore, the purpose of this study was to examine
the prevalence of dehydration among soccer players in Universiti Pendidikan Sultan Idris, Perak (UPSI) during three consecutive days of training. Besides, this study also sought to determine the relationship between hydration status, knowledge of hydration and fluid intake during training among these players. We hypothesized that there will be no significant correlation between hydration status and knowledge with fluid intake among the players. The study is crucial to increase knowledge and awareness of hydration status among UPSI soccer players, athletes, coaches, team managers and individuals who perform physical activity, especially in hot and dry environments such as in Malaysia.

**Materials and Methods**

**Participants**

A total of 25 male soccer players aged 22.3 ± 1.1 years, height 1.7 ± 0.1 m, body mass 63.3 ± 8.9 kg and BMI 22.2 ± 2.5 kg/m² volunteered to participate in this study. All participants were received verbal and written information about the study and consent form were obtained from them. The participants were also asked to complete the Health Screen Questionnaire prior to the trial. The participants were free from chronic diseases and did not have injuries within 6 months prior to the study. The study protocol was designed in accordance with the Helsinki Declaration and approved by the Faculty of Sports Science and Coaching Research Committee.

**Procedure**

The data collection were conducted during three consecutive days of training. Pre training and post training body weight was measured using digital weighing scale (Omron HN-283, Kyoto, Japan) accurate to 100g. Pre training and post training urine sample was also collected using a labelled urine collection container. The participants had also been instructed to collect any urine passed during training into the container given. Urine specific gravity (USG) and urine colour of the participants during three days of training were analysed. Pre training and post training urine sample was also collected using a labelled urine collection container. The participants had also been instructed to collect any urine passed during training into the container given. Urine specific gravity (USG) and urine colour were analysed.

The mean value of USG on Day 1 was 1.025 ± 0.007 and Day 2 was 1.019 ± 0.010. Likewise, urine colour on both Day 1 and day 3 reported the same value which was 4 ± 1. Day 3 was 1.022 ± 0.009. Likewise, urine colour on both Day 1 and day 3 reported the same value which was 4 ± 1. The mean value of USG on Day 1 was 1.025 ± 0.007 and Day 2 was 1.019 ± 0.010. Likewise, urine colour on both Day 1 and day 3 reported the same value which was 4 ± 1.

Table 1 shows the mean value of pre-training USG and urine colour of the participants during three days of training. The findings showed that the participants started their training in hypohydrated state on Day 1 and Day 3. The mean value of USG on Day 1 was 1.025 ± 0.007 and Day 3 was 1.022 ± 0.009. Likewise, urine colour on both Day 1 and day 3 reported the same value which was 4 ± 1.

Table 2 illustrates the level of hydration knowledge based on scores of 17 items. The results shows that 48% of the participants had good hydration knowledge and 16% scored satisfactorily. In contrast, only 36% of the participants had poor to very poor knowledge in hydration. None of the participants scored very well for hydration. None of the participants scored very well for hydration knowledge. None of the participants scored very well for hydration knowledge. None of the participants scored very well for hydration knowledge.

**Statistical analysis**

All data were analysed using Statistical Program for Social Sciences (SPSS) version 17.0 (Windows, SPSS, Inc., Chicago, IL). Kolmogorov-Smirnov test was utilized to check the normality of the data. Descriptive analysis was performed on the demographic data, hydration status (USG and urine colour), scores of hydration knowledge and volume of fluid intakes throughout 3 days of training. The findings were reported in mean, standard deviation (SD), frequency (N) and percentage (%). Total score of hydration knowledge questionnaire had been categorized as Excellent (98% - 100%), Very Good (81.95%-97.59%), Good (66.30% - 81.94), weak (66.29% - 50.65%) and very weak (50.64% and below).

Pearson Correlation Test was used to determine the relationship between hydration status, scores of hydration knowledge and volume of fluid consumption among the participants. The significant level was set at P<.05.

**Results**

Table 1 shows the mean value of pre-training USG and urine colour of the participants during three days of training. The findings showed that the participants started their training in hypohydrated state on Day 1 and Day 3. The mean value of USG on Day 1 was 1.025 ± 0.007 and Day 3 was 1.022 ± 0.009. Likewise, urine colour on both Day 1 and day 3 reported the same value which was 4 ± 1.

Table 2 illustrates the level of hydration knowledge based on scores of 17 items. The results shows that 48% of the participants had good hydration knowledge and 16% scored satisfactorily. In contrast, only 36% of the participants had poor to very poor knowledge in hydration. None of the participants scored very well for the questionnaire.

Data of fluid intake and sweat loss volume were used to calculate the fluid balance during the training. Table 3 shows the mean of the total fluid consumption, the amount of sweat loss and the difference between consumption of fluids and sweat loss during the 3-day training. The mean fluid intake were 1271.3 ± 248.5 ml, 1173.3 ± 337.5 ml, 1173.3 ± 337.5 ml of consumed water was recorded before and after training using digital precision balance (Salter 1017, England) accurate to 1g. After training session on the third day of the study, the participants were asked to answer a set of modified Hydration Knowledge Questionnaire [16]. The result of Cronbach alpha showed the internal reliability value of 0.74, suggesting that the modified questionnaire had high reliability. The questionnaire consists of two sections. Section A enquires about the participant demography and section B consists of 17 closed-ended questions about the hydration knowledge.

<table>
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<tr>
<th>Variable</th>
<th>Day 1(n=25)</th>
<th>Day 2(n=25)</th>
<th>Day 3(n=25)</th>
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</thead>
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<tr>
<td>USG</td>
<td>1.025 ± 0.007</td>
<td>1.019 ± 0.010</td>
<td>1.022 ± 0.009</td>
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<tr>
<td>Urine Colour</td>
<td>4 ± 1</td>
<td>3 ± 1</td>
<td>4 ± 1</td>
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</table>

**Table 1. USG and urine colour during the three-day training (mean ± SD)**
2019
01

ml and 1241.3 ± 232.3 ml for Day 1, Day 2 and Day 3, respectively. Whereas, the mean sweat loss on the first, second and third days were 1759.3 ± 418.5 ml, 1573.3 ± 378.5 and 1877.3 ± 450.6 ml. Thus, the difference between consumption of fluids and sweat loss during three days of training were -488.0 ± 364.4 ml, -400.0 ± 285.8 ml and -636.0 ± 396.2 ml. The results showed that the participants were in negative fluid balance because the drink consumption were less than the sweat loss during the three days of training.

Table 4 shows the correlation between hydration status, score of hydration knowledge and the amount of fluid consumption during training in UPSI Soccer Player. There was positive correlation observed between the USG and the urine colour \(r=0.809, p<0.001\). Meanwhile, there was correlation between USG and hydration knowledge score \(r=-0.099, p=0.639\) and the amount of fluid intake \(r=0.213, p=0.308\). In addition, urine colour and scores of hydration knowledge had weak correlation and \(r=0.206, p=0.324\). While the correlation between urine colour and the amount of fluid intake was significantly positive correlation \(r=0.424, p=0.035\). Hydration knowledge did not correlate well with the amount of fluid intake \(r=0.031, p=0.883\).

**Discussion**

The results indicated that the participants were dehydrated before training, especially on the first and third day of training. They experienced varying level of dehydration ranges from minimal to serious dehydration. Our results was in agreement with many previous studies [10, 11, 17] which found that the football players from different continents usually commenced their training in hypohydrated state.

Various factors may contribute to dehydration among the participants before training. The athletes may not consume suitable and adequate fluid intake during the early morning or several hours before training [18]. Sufficient amount of fluid intake may help the body to be in a normal state of hydration throughout the day. Accordingly, lack of knowledge on maintaining hydration status may also affect the hydration status of the players before training. Bland et al. [18] who studied the pre-training hydration status in athletes of National Collegiate Athletic Association (NCAA) suggested that the athletes should be given proper education on hydration strategy and should be encouraged to practice hydration schedule to ensure optimal hydration and well beings. In addition, the intensity and frequency of training exercises on a daily basis is also one of the factors that may cause the dehydration among the participants. Excessive training load may dehydrate the body, even after training. If the hydration status does not return to normal state, dehydration will be experienced by the athletes before training the following day. Furthermore, dietary intake and medications may also affect the day-to-day hydration

---

**Table 2.** Level of hydration knowledge of the participants (frequency and percentage)

<table>
<thead>
<tr>
<th>Hydration knowledge</th>
<th>Frequency (n=25)</th>
<th>Percentage (n=25)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Good</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Good</td>
<td>12</td>
<td>48</td>
</tr>
<tr>
<td>Satisfactory</td>
<td>4</td>
<td>16</td>
</tr>
<tr>
<td>Poor</td>
<td>7</td>
<td>28</td>
</tr>
<tr>
<td>Very Poor</td>
<td>2</td>
<td>8</td>
</tr>
</tbody>
</table>

**Table 3.** Fluid balance during three consecutive days of training (mean ± SD)

<table>
<thead>
<tr>
<th>Variables</th>
<th>Day 1 (n=25)</th>
<th>Day 2 (n=25)</th>
<th>Day 3 (n=25)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total of fluid consumption (ml)</td>
<td>1271.3 ± 248.5</td>
<td>1173.3 ± 337.5</td>
<td>1241.3 ± 232.3</td>
</tr>
<tr>
<td>Amount of sweat loss (ml)</td>
<td>1759.3 ± 418.5</td>
<td>1573.3 ± 378.5</td>
<td>1877.3 ± 450.6</td>
</tr>
<tr>
<td>Difference between fluid consumption and sweat loss (ml)</td>
<td>-488.0 ± 364.4</td>
<td>-400.0 ± 285.8</td>
<td>-636.0 ± 396.2</td>
</tr>
</tbody>
</table>

**Table 4.** Correlation between hydration status, knowledge of hydration and fluid consumption during training in UPSI soccer players (n=25)

<table>
<thead>
<tr>
<th>Variables</th>
<th>USG</th>
<th>Urine colour</th>
<th>Hydration Knowledge</th>
<th>Fluid consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>USG</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Urine colour</td>
<td>(r=0.809**)</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Hydration knowledge</td>
<td>(r=-0.099)</td>
<td>(r=-0.099)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Fluid consumption</td>
<td>(r=0.213)</td>
<td>(r=0.424*)</td>
<td>(r=0.031)</td>
<td>-</td>
</tr>
</tbody>
</table>

**Correlation is significant at P<0.01;  *Correlation is significant at P<0.05**
status of the athletes [19, 20, 21]. Therefore, early detection of hydration status is very important to maintain performance during training. According to Maughan and Shirreffs [19], in order to avoid deficiency of fluid and salt in the body, the athletes are encouraged to keep themselves euhydrated before training. This is because when hypohydration occurs, the physiological changes will occur and may expose the athletes to heat illnesses including heat stroke [4, 22, 23, 24].

The second major findings of the present study was that hydration knowledge among the participants are yet to reach excellent level or completely acquired very well on their body hydration. Table 2 illustrates that more than 50% of the participants had a good and satisfactory knowledge in hydration, but most of the participants experienced dehydration particularly on the third day of the training. Supposedly, if the participants have sufficient knowledge about hydration, they should be alert on their hydration status, especially before training. This statement was further supported by Nichols et al., [16], who suggested that lack of knowledge among athletes makes them unaware in maintaining their normal hydration status. But this view does not apply to the participants in our study. Thus, it indicates that despite having a good knowledge in hydration, but they might not apply the knowledge to keep them hydrated especially before commencing the training session. Our result was similar to the study conducted by Decher and colleagues [15] on hydration status, knowledge, and behaviour in youths at summer camp in the US. They reported that the participants of the camp could identify their hydration status, but they failed to translate hydration knowledge to an effective hydration strategy. This was proved by the results of USG and urine osmolality (Uosm) of the participants, which ranges from minimal to significant dehydration during the four-day camp.

Furthermore, based on the feedback of the individual item in the questionnaire, most of the participants answered correctly on questions of general hydration. For example, the following item categorized as general hydration knowledge “It is important for individuals who are active in sports drinking water during training and competition” was answered correctly by all participants. However, many of them did not answer correctly on the questions related to the guidelines of fluid intake of National Athletic Trainers Association (NATA) and the American College of Sports Medicine (ACSM) position stands before, during and after training or competition. Position stands from both ACSM [4] and NATA [23] provide guidelines on fluid and electrolyte needs and replacement as well as the impact of the imbalance on exercise performance. To illustrate, 52% of the participants gave the wrong answer regarding the statement “individuals who are active in sports should drink sports drinks in two hours after training” which was recommended by ACSM and NATA to ensure optimal exercise performance. The results of our study was in agreement with other studies [25, 26, 27]. These study revealed the athletes have little understanding of the positive effects of sports drinks to maintain proper hydration and exercise performance especially in intermittent and endurance events. Therefore, they suggested that the athletes should be educated regarding the beneficial role of carbohydrate and electrolytes in sports drinks to help regain energy and maintain normal hydration status. Accordingly, the researchers recommended that knowledge about consuming proper sports drinks should also be given to the coaches and athletic trainers because they are partly responsible for the athletes’ performance.

To conclude, a total of 64% of the participants in our study possess a good hydration knowledge, especially in terms of replacement of body fluids. However, they are confused about a specific drink to be taken before, during and after training or competition. They also perplexed in identifying the correct signs for dehydration. Therefore, it is crucial for the coaches and team managers to provide correct and relevant information regarding hydration to the athletes to ensure proper hydration status during training and competition. The findings of the present study showed that the participants consumed water to replace fluids loss during training. However, the amount of fluid intake were less than the fluid loss through sweat during three consecutive days of training (Table 3). Our results support the previous studies of the fluid balance among soccer players during training and competition [13, 17, 28, 29, 30]. These studies concluded that the athletes rarely consume beverage on par with the amount of sweat loss even though the beverages were readily available, leading to hypohydration during training and competition.

The findings from our study suggests that the participants need not merely to drink fluid during training and competition, but more importantly, they should consume adequate amount of fluids to replace sweat loss to maintain proper hydration. Furthermore, [16] recommended that the coaches and team managers should increase the availability of drinking stations, provide bottled drinks and monitor the weight changes before and after training in order to promote sufficient fluid consumption among athletes. Total fluid requirement varies among athletes. Fluid replacement protocols recommended by ACSM and NATA can only be used as a general guideline for the athletes to consume fluids correctly. The actual amount of drinks need to be replaced during training and competition depends on the individual sweat loss. The athletes who consume fluids which is not based on individuality are prone to incidence of dehydration because the amount of sweat loss during training is different for each athlete [29].

Results of Pearson product-moment test showed that only USG and urine colour (r=.809, p<0.001) and urine colour and the amount of fluids intake (r=.424, p<0.035) had significantly positive correlations. A strong correlation observed between USG and urine colour to indicate hydration status in our study was similar to the study done by [31]. The results of the study showed that there was a strong relationship between urine osmolality (r=.80) and USG (r =.82) with urine colour. Therefore, the use of USG and urine colour in the present study is adequate
to estimate hydration status of the participants prior to training. Indeed, USG is more accurate and practical than other expensive methods to measure hydration status [32, 33]. Furthermore, through the observation of urine colour, the athletes can easily determine when they should hydrate themselves during exercise. Even though the urine colour does not provide the same accuracy and precision compared to USG and urine osmolality, but urine colour is practical for field research setting and athletes who do not require high accuracy for estimating hydration status [20].

Another significant correlation was detected between urine colour and fluid consumption, but the value did not reach strong correlation. The result violates our speculation whereby when the fluid intake increases, the urine colour supposedly become lighter which indicates euhydration. However, in our study fluid consumption was not sufficient to replace sweat loss as showed in Table 5, which might explain the high incidence of pre training dehydration for three consecutive days despite voluntarily taking fluid during training sessions. When the participants trained in a state of dehydration, it is difficult for their body to maintain normal hydration level because of their resting time and the provision of adequate water during training in the field. This statement was in agreement with [34] whereby they found that if the athletes are dehydrated prior to training, they experienced various difficulties to hydrate themselves during training.

Our study also indicated that there were no strong correlation between both hydration indices (USG and urine colour) with hydration knowledge. Most of the participants were experienced high incidence of dehydration ranges from minimal to serious level despite scored well in hydration knowledge test. The correlation result implies that having knowledge does not necessarily translate into good hydration strategy among the participants. Our results support the findings [35] which revealed that no relationship exists between knowledge and practices on hydration and fluid replacement among endurance athletes in National University of Malaysia. However, a study by [16] on knowledge, attitude and behaviour regarding hydration in collegiate athletes in the US showed otherwise. The study found a significant and positive correlation between the scores of knowledge, attitude and behaviour among the participants. Although the correlation was low, it shows that when hydration knowledge and attitudes score increased, score on behaviours also increased. Thus it is important for the coaches and managerial team not only to educate the athletes on hydration, but also highlight the need to create a positive attitude and behaviour so that the athletes can apply the knowledge to strategize the fluid replacement for optimal sports performance.

**Conclusion**

The obvious findings emerged from this study is that a large numbers of UPSI soccer players are dehydrated before training. The athletes should monitor and be responsible for handling and preventing dehydration before training. The athletes should not depend on their coach or team manager to remind about their hydration practices. Experts have provided recommendations regarding the importance for the athletes to identify rehydration strategies on their own [19]. The recommendation includes encouraging the players to measure their body weight before and after training sessions in different climatic conditions, as well as intensity and duration of exercise to estimate their sweat loss. Weight loss exceeds 1-2% of body weight indicates that the athletes do not consume enough fluids and they should drink accordingly. Therefore, the athletes should know the right amount of fluid that is adequate to replace excessive sweat loss during training to prevent dehydration on the subsequent days of training.

The athletes also need to improve on the knowledge about dehydration so that they can be more responsive to the sign of dehydration before training. The players will have a risk of dehydration if their urine production is less than daily observation. This means that, if urine production is less and the colour becomes darker, the athletes should increase the fluid intake until their urine production increases and the urine colour changes to pale yellow. The athletes should be encouraged to think and observe why and when they should consume more fluid attributed to the loss of sweat and urine production. Coaches and managerial team are the backbone of the success of a team or an athlete. However, the strategy to get the best performance for training or competition will not complete if they ignored the nutrition especially on hydration strategy. Therefore, it is suggested that the coaches or team manager provide a record of the data collection and constructive suggestions on the improvement of hydration practices for the players.

In conclusion, the athletes, coaches and managerial team should do a routine monitoring of hydration status before the athletes start their training. Besides, having knowledge without proper hydration practices may not prevent the athletes from risks of dehydration and performance deterioration. Therefore, investigations into the interventions to improve fluid replacement practices among exercising individuals is warranted.

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**Conflict of interest**

The authors declare no conflict of interest.
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Effects of caloric restriction on anthropometrical and specific performance in highly-trained university judo athletes

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A - Study Design; B - Data Collection; C - Statistical Analysis; D - Data Interpretation; E - Manuscript Preparation

Abstract

Purpose: The purpose of this study was to determine the ultimate body mass, performance, and nutritional characteristics of the Algerian judo junior athletes, and also analysing the impact of nutritional intakes on stabilising body weight according to special performance of judo athletes.

Material: Twenty-one male university athletes (aged: 21.45 ± 1.32; height: 1.81 ± 0.45 m; and body mass: 73.9 ± 4.1 kg) participated in this study during a period of stabilising body weight loss before and after 15 days of caloric restriction. Athletes were submitted to anthropometrical measurements and performed the Special Judo Fitness Test. Values for nutrient intakes were obtained from a 15-day food record kept during a training camp period of body weight maintenance and after a 15-day caloric restriction.

Results: Caloric restriction resulted in significant decreases in body mass (73.73 ± 2.1 kg) and performance. However, Special Judo Fitness Test index increased significantly (14.00 ± 1.75) during caloric restriction in comparison to stabilising body weight loss.

Conclusions: Exercise and caloric restriction lead to determine the ultimate body weight and physical performance. The present study provides baseline nutritional data that can be used in the prescription of individual training programs for university judo athletes.

Keywords: weight loss, nutritional, physical performance, judo.

Introduction

Nutrition and Dietary is recommended as an important part of sport performance for young athletes [1]. Nutrition is increasingly recognized as a key component of optimal sporting performance, with both the science and practice of sports nutrition developing rapidly [2]. Sports nutrition enhances athletic performance by decreasing fatigue and the risk of disease and injury; it also enables athletes to optimize training and recover faster [3]. To optimize performance, young athletes need to learn what, when and how to eat and drink before, during and after activity [1]. Hector and Phillips [4] noted that high quality body weight loss is of importance to elite athletes in order to maintain their muscle (engine) and shed unwanted body fat mass, potentially improving athletic performance.

Judo is an intermittent combative sport requiring technical, tactical, and psychological skill that creates great muscle-strength and -power demands on both the upper and lower body [5]. Judo competitions are divided into weight classes [6]. However, most athletes reduce their body weight in a few days before competition in order to obtain a competitive advantage over lighter opponents [7,8], and no study investigated a weight loss higher than 5% of athlete’s body mass [9]. To achieve fast weight restriction, athletes use a number of aggressive nutritional strategies so many of them place themselves at a high health-injury risk [4]. Judo, as a combat sport, involves open and complex skills [10,11], presenting irregular intervals of effort and pause, and characterized as an intermittent activity [5,12,13]. However, few athletes maintain their daily body weight within the limits of their class before competition [14].

Weight loss is one of the most commonly used strategies by athletes in combat sports to gain a winning edge in their targeted weight classes [15]. The loss of large amounts of body mass in a short time is extremely harmful to the body; it can reduce muscle strength [16] also demonstrate that the exercise-induced hyperthermia and dehydration in the present experiments had only minor effects on the neuromuscular performance. In addition, reductions in renal blood fluid and the volume of liquid filtered by the kidneys [17,18]. Additionally, these physiological alterations can decrease anaerobic capacity, an important determinant of overall performance in judo [19]. A questionnaire was designed to evaluate rapid weight loss patterns of competitive judo players and to assess its validity and reliability [20]. In conclusion, the questionnaire showed good validity and reliability and could be used accurately to assess weight loss patterns of judo players. Suzuki et al [21] concluded that weight reduction, consisting of both intense exercise and energy restriction, might possibly cause both an increase in oxidative burst activity and decrease in neutrophil phagocytic activity in judo athletes females. Additionally, studies investigating the effects of weight loss on performance used at laboratory-based techniques [9], which may not reflect the demands of real judo combat heart rate [22,23]. Therefore, a judo-specific performance test (Special Judo Fitness Test, SJFT), which is more representative of judo movements than laboratory tests, has been proposed as a valid and reliable measure of performance in judo athletes [24,25].

Hypothesis: This study set out to test the hypothesis that body mass, performance, and nutritional characteristics of...
nutritional intakes could stabilise Weight loss according to special performance of judo athletes.

**Purpose:** of this study was to determine the ultimate body mass, performance, and nutritional characteristics of the Algerian judo junior athletes, and also analysing the impact of nutritional intakes on stabilising Weight loss according to special performance of judo athletes.

**Materials and Methods**

**Participants**

Twenty-one healthy male university judo competitors took part in this study (mean (±SD); aged: 21.5 ± 0.7 years; height: 1.81 ± 0.45 m; and body mass: 75.0 ± 2.8 kg) participated in the study after receiving a comprehensive explanation of the procedure. This study protocol was in accordance with the Helsinki Declaration for human experimentation [28] and was approved by the scientific institute of sports ethics committee. The participants were also selected based on their mean period of practising judo was 9.2 ± 2.1 years. They competed in categories between -66 kg and -73 kg. Based on the results of a self-reported questionnaire, no subject had been treated with any experienced acute illness from infection during the first three months. Subjects reported no sleep disorder and did not consume any alcoholic beverages and none of them was taking any medication. All judokas participated in official judo competitions during this year and trained for 20-22 hours per week.

**Study Design**

During the week before the experimentation, participants came to the training GYM several times to become fully familiarized with the procedure and tests involved so as to minimize learning effects during the experimentation. Athletes participated in two experimental test sessions. The first was a baseline condition in which athletes were taking a normal diet (baseline). The second was a condition of caloric restriction for 15 days; participants reduced their energy intake by 4.5 MJ/day (CR). At the end of each phase athletes performed the SJFT at the same time of day (10 a.m.). All experimental study were scheduled during a period with no official competitions.

At the end of each phase body mass, percent body fat, fat mass, fat-free mass, and body water were recorded using bioelectrical impedance scale to the nearest 0.1 kg (Tanita, Tokyo, Japan) calibrated in accordance with the manufacturer’s guidelines by one trained technician. The body mass index was then calculated according to [29]. Following this, duplicate measurements were taken with participants standing and wearing only briefs, as recommended by the guidelines. The average of these two measurements was used for the final analysis. Moreover, the heart rate was monitored using Automatic Blood Pressure [30]. During the experimental period, participants were required to maintain their habitual physical activity and to avoid exhausting physical efforts 24h before each test time.

**Assessment of Dietary Intake**

Nutritional assessment was carried out every 7 days to assess the energy intake of the subjects (i.e., fat, protein, and carbohydrate). Each athlete received recommendations needed to properly complete the food diaries. The athletes completed a self-administered validated Rapid Weight loss Questionnaire [13]. Thus, they detailed the food and beverages consumed during the 3 days prior to sampling. We asked athletes to maintain their normal diet during the study period (control period). Values for nutrient intakes were obtained from a food diary for a holding period of body mass and dietary restriction after 15 days. The plan was to carry out dietary restriction according to the report from [31]. The Weight loss methods used by athletes in this study appear to be generally used [32]. The records were analyzed by a nutritionist using a computerized nutrition system, the NUTRISOFT-BILNUT [Vers. 2.01, Paris, France] [33].

**Special Judo Fitness Test (SJFT)**

This test was proposed by Sterkowicz (1995). Briefly, three athletes of similar body mass are needed to perform the Special Judo Fitness Test: 1 participant (tori) is evaluated, and 2 other individuals receive throws (ukes). The tori begins the test in a position between the 2 ukes who are standing 6 m away from each other. On a signal, the tori runs to one of the ukes and employs a throwing technique called ippon-seoi-nage. The tori then immediately runs to the other uke and completes another throw. The athlete must complete as many throws as possible within the test time.

The Special Judo Fitness Test is composed of 3 periods (15 s, 30 s, and 30 s) separated by 10 s recovery intervals. Performance is determined by the total number of throws completed during each of the 3 periods. Heart rate is measured immediately after and 1 minute after the test and the following index is calculated as follows:

\[
\text{Index} = \text{final HR (bpm)} + \text{HR 1 min after the end of the test (bpm)/total number of throws,}
\]

where Final HR is the heart rate measured immediately after the test, HR 1 min is the heart rate measured 1 min after the test, and throws represent the total number of throws executed during the three sets.

**Statistical Analyses**

The Levene test was used to check the homocedasticity, and the Shapiro-Wilk test was used to test the normality of data, and given these assumptions were confirmed parametric statistics were used. Data are reported as mean ± SD, and 95% confidence intervals (95%CI) of the difference. Energy intake, anthropometric parameters, performance of SJFT, and heart rate were tested by a paired Student’s t-test. The level of statistical significance was set at 5%. Cohen’s d was calculated as post caloric restriction mean minus baseline mean divided by baseline standard deviation and classified according to Rhea (2004) for highly trained athletes (trivial < 0.25; small = 0.25 to 0.50; moderate = > 0.50 to 1.0; large = > 1.0).
Results

There was a significant effect of caloric restriction on body mass ($t_{20} = 4.21, p < 0.001, 95\%\text{CI difference} = 0.6$ to 1.8, $d = 0.43$ [small]), body mass index ($t_{20} = 4.25, p < 0.001, 95\%\text{CI difference} = 0.51$ to 1.50, $d = 0.41$ [small]), body water ($t_{20} = 8.61, p < 0.001, 95\%\text{CI difference} = 2.2$ to 3.6, $d = 1.00$ [moderate]), fat free mass ($t_{20} = 4.78, p < 0.001, 95\%\text{CI difference} = 0.6$ to 1.4, $d = 0.31$ [small]), energy intake ($t_{20} = 16.35, p < 0.001, 95\%\text{CI difference} = 1223$ to 1580, $d = 5.32$ [large]), carbohydrate intake ($t_{20} = 14.67, p < 0.001, 95\%\text{CI difference} = 138$ to 184, $d = 4.12$ [large]), protein intake ($t_{20} = 22.75, p < 0.001, 95\%\text{CI difference} = 57$ to 69, $d = 5.70$ [large]), and fat intake ($t_{20} = 55.12, p < 0.001, 95\%\text{CI difference} = 136$ to 146, $d = 14.00$ [large]), with a decrease during caloric restriction compared to baseline. However, no change between periods was detected for body fat ($t_{20} = 0.95, p = 0.352, 95\%\text{CI difference} = -0.4$ to 1.0, $d = 0.13$ [trivial]).

The caloric restriction resulted in significant decrease in the number of throws during A ($t_{20} = 4.18, p < 0.001, 95\%\text{CI difference} = 0.4$ to 1.1, $d = 0.80$ [moderate]) and total ($t_{20} = 3.05, p = 0.001, 95\%\text{CI difference} = 0.5$ to 2.9, $d = 0.37$ [small]) compared to the baseline, with a decrease during caloric restriction compared to baseline. However, no change between periods was detected for body fat ($t_{20} = 0.95, p = 0.352, 95\%\text{CI difference} = -0.4$ to 1.0, $d = 0.13$ [trivial]).

Discussion

Our main aim in this study was to address the almost total lack of research evidence on stabilising weight loss of judo athletes. We have done so by directly observing and reporting on the daily work of Twenty-one healthy male judo competitors, with special attention to their high judo training, caloric restriction whereby these assessments made themselves knowledgeable for all practical purposes, as dictated by their specific performance.

The main findings of the present study were that a 15-day caloric restriction program decreased judo athletes’ body mass, body water, body mass index, free fat mass and judo-specific performance, specifically decreasing the number of throws during set A and total during the Special Judo Fitness Test, while increasing heart rate (after and 1-min after this test) and the index in this test (which indicates worse performance). The study [22] assess effectiveness of training’s construction and of micro-cycle in total and detect in due time the trend to development.

Table 1: Anthropometric parameters and daily nutrient consumption at baseline and caloric restriction periods (values are mean and standard deviation; $n = 21$).

<table>
<thead>
<tr>
<th>Anthropometric parameters</th>
<th>Baseline</th>
<th>Caloric restriction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Body mass (kg)</td>
<td>75.0 ± 2.8</td>
<td>73.73 ± 2.1*</td>
</tr>
<tr>
<td>Body water (kg)</td>
<td>42.7 ± 2.9</td>
<td>39.8 ± 3.6*</td>
</tr>
<tr>
<td>Body mass index (kg/m²)</td>
<td>27.8 ± 2.4</td>
<td>26.8 ± 3.1*</td>
</tr>
<tr>
<td>Body fat (kg)</td>
<td>9.1 ± 2.2</td>
<td>8.8 ± 2.5</td>
</tr>
<tr>
<td>Free fat mass (kg)</td>
<td>66.8 ± 3.2</td>
<td>65.8 ± 3.6*</td>
</tr>
<tr>
<td>Energy intake (kcal/day)</td>
<td>3675 ± 263</td>
<td>2274 ± 216*</td>
</tr>
<tr>
<td>Carbohydrates (g/day)</td>
<td>425 ± 39</td>
<td>264 ± 25*</td>
</tr>
<tr>
<td>Protein (g/day)</td>
<td>150 ± 11</td>
<td>87 ± 7*</td>
</tr>
<tr>
<td>Fat (g/day)</td>
<td>233 ± 10</td>
<td>92 ± 6*</td>
</tr>
</tbody>
</table>

* Significant difference from baseline ($p < 0.001$).

Table 2: Performance and heart rate responses during the Special Judo Fitness Test in judo athletes during normal diet (baseline) and after caloric restriction (values are mean and standard deviation; $n = 21$).

<table>
<thead>
<tr>
<th>SJFT test parts</th>
<th>Baseline</th>
<th>Caloric Restriction</th>
</tr>
</thead>
<tbody>
<tr>
<td>A (rep)</td>
<td>5 ± 1</td>
<td>4 ± 1**</td>
</tr>
<tr>
<td>B (rep)</td>
<td>12 ± 2</td>
<td>12 ± 1</td>
</tr>
<tr>
<td>C (rep)</td>
<td>11 ± 2</td>
<td>10 ± 2</td>
</tr>
<tr>
<td>Total throws (rep)</td>
<td>28 ± 5</td>
<td>26 ± 3**</td>
</tr>
<tr>
<td>Final heart rate (bpm)</td>
<td>178 ± 6</td>
<td>189 ± 8**</td>
</tr>
<tr>
<td>Heart rate1min after (bpm)</td>
<td>163 ± 8</td>
<td>170 ± 8**</td>
</tr>
<tr>
<td>Special Judo Fitness Test index</td>
<td>12.72 ± 2.60</td>
<td>14.00 ± 1.75**</td>
</tr>
</tbody>
</table>

A = first set of the Special Judo Fitness Test (15s); B and C = second and third, respectively, sets of the Special Judo Fitness Test (30s each); ** Significant different from baseline ($p < 0.01$); ** significant different from baseline ($p < 0.001$).
of over-loading and failure of adaptation. As planned the caloric restriction program reduced total energy intake by 38%, resulting in decreased carbohydrate (38%), protein (42%) and fat (41%) intakes. However, this diet did not change body fat.

Despite the fact that athletes reduced only 1.7% of their body mass, which is in the range recommend for gradual Weight loss, performance was negatively affected. This is in contrast to the observation that up to 5% rapid Weight loss did not affect judo-related performance [18]. Our findings are also different from those reported by [34] when comparing wrestlers and judo athletes submitted to gradual (5.0 ± 0.4% Weight loss in three weeks) or rapid Weight loss (6.0 ± 0.6% in 2.4 days). These authors reported no change in 30-m sprint and 1-min Wingate performances, suggesting that the athletes analysed coped well with both types of diets.

The ultimate goal is to identify a healthy body Weight that the athlete can maintain for most of the year, while minimizing the amount of Weight that needs to be lost for competition. We hypothesized that the Weight loss would result in more detrimental effects on both caloric restriction and judo performance test. [16] investigate the effect of liquid losses occurring in training sessions during the competition period on some biochemical values of the male Judokas competing in the U18 category. The results of the performance tests support the fact that the duration of the intervention was important for changes in performance test. [33] Study results are equivocal when it comes to performance. Some studies report unchanged or improved performance in certain tests after Weight loss in athletes, despite loss of IBM [34]. There are several risks related to rapid Weight loss and Weight cycling, such as depressed immune activity [35–37], [38] indicate that supplying HMB promotes advantageous changes in body composition and stimulates an increase in aerobic and anaerobic capacity in combat sports athletes.

In this study, the caloric intake during the caloric restriction period leads to a significant decrease in body Weight (2.2 ± 0.23%), which was in accordance with other athletes in combat sports [39]. The loss of body Weight represented an average of 2.6 kg in absolute (Table 1). In this context, Artioli et al. [20] observed a reduction in body Weight after a 5-day Weight loss period when compared to control values. Likewise, Mendes et al. [40] showed 5% reduction in body Weight after a 5-day Weight loss period. The most frequent methods used by judo players were increased exercise, restricted food ingestion, training in heated rooms, gradual dieting, and fluid restriction [7]. In accordance with several reports our results showed that rapid Weight loss affects negatively performance in judo athletes [41]. We herein argue that rapid Weight loss clearly meets all three criteria and, therefore, should be banned from the sport [42]. Considering that these health-threatening methods are more commonly used by lower level athletes, specific education programs should be directed to them [43]. In a recent review, Fagerberg [44] discussed the negative consequences of restricting calories too severely, [45] this review summarises guidelines for athletes and coaches for manipulating BM and optimising post weigh in recovery period, also to achieve better health and performance outcomes across the different Olympic combat sports. The ultimate goal is to identify a healthy body Weight that the athlete can maintain for most of the year, while minimizing the amount of Weight that needs to be lost for competition.

Although other studies analysed the effects of body Weight reduction on performance among combat sport athletes [14,42,43], it is worth noting that the present study was designed to determine the appropriate Weight. The Weight of an athlete can maintain without dieting is typically higher than their competition Weight [46]. The results of our study allowed us to conclude that stabilising Weight loss was not a good strategy to optimise judo athletes performance. Finally, more research is needed concerning the long-term effects of stabilising Weight loss on physical and cognitive performance of judo athletes as recommended by [9], especially those investigating female judo athletes. also An individualized and well-planned gradual and safe Weight loss program under the supervision of a team of coaching staff, athletic trainers, sports nutritionists, and sports physicians is recommended. In addition, the sport dietitian can help make daily meal plans, address nutrition and sport supplements and health issues, and make sure the athletes is fuelled for their sport. This will improve their ability to design individualized and realistic Weight-management programs. This study was limited by the reduced sample size of the population studied and the participants’ characteristics as Olympic athletes, as well as the duration of the study (2weeks).

Another Two main limitations can be identified in our study: the absence of a control group submitted to a judo training and the lack of control concerning athletes’ nutritional intake before the study. The use of control group in training camp is difficult, because athletes are submitted according to their performance result process. Additionally, some authors consider that there would be “ethical problems with restricting a particular treatment to elite athletes” [47], athletes were not using any supplementation and were oriented to keep the nutritional training diet throughout the study.

Acknowledgments

The authors would like to thank the athletes who participated in the study for their time and patience. We also want to thank the Algerian national coach and his staff and also Emerson Franchini for valuable contributions and careful proofreading. Thank you for your inspiration and for being a great friend and colleague.

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Conflict of interest

The authors declare no conflict of interest.
References


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An examination of Turkish physical education teachers’ interpersonal self-efficacy beliefs

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Abstract

Purpose: This study was conducted for two purposes. The first purpose was to examine the psychometric properties of the Teacher Interpersonal Self-Efficacy Scale (TISES) for Turkish Physical Education (PE) teachers and the second was to analyze teachers’ interpersonal self-efficacy beliefs according to some demographic variables.

Material: The study was conducted on 360 Turkish PE teachers. Confirmatory factor analysis was applied in order to verify the factor structure of the scale. Pearson’s product-moment coefficients were used in order to assess the correlations between the factors. For determining the reliability of the scale Cronbach Alpha coefficient was calculated. Multivariate analysis of variance was used to determine differences between the scores acquired from the scale and some independent variables.

Results: The results confirm the 3-factor internal structure of the TISES. The results of the correlation analysis between the TISES subscales indicated significant and positive relationships. We also found acceptable values of the alpha coefficient, which confirms the TISES as a reliable instrument. Overall, all physical education teachers had positive self-efficacy beliefs on high levels. Whereas by gender significant difference was not found in self-efficacy beliefs, significant difference were found between teachers depending on years of experience and grade levels they taught.

Conclusions: The reexamination of the scale led to a new scale structure comprised of three factors with sixteen items. The TISES is a relatively short questionnaire that allows researchers to measure interpersonal self-efficacy beliefs of PE teachers. The experienced teachers and the teachers who were employed at the high schools had higher self-efficacy belief levels.

Keywords: teacher efficacy, classroom management, scale development, validity, reliability.

Introduction

A key component of a teacher’s beliefs and knowledge is self-efficacy [1] since a teacher’s self-perception is one of the essential factors determining his/her competence in the profession. Perceived teacher efficacy has been defined as “the extent to which the teacher believes he or she has the capacity to affect student performance” [2, p. 137] or as “teachers’ belief or conviction that they can influence how well students learn, even those (students) who may be difficult or unmotivated” [3]. In other words, a teacher’s efficacy belief is a part of the active role-playing process in which he/she arrives at “a judgment of his/her capabilities to bring about desired outcomes of student engagement and learning, even among those students who may be difficult or unmotivated” [4].

The importance of self-efficacy for teachers has been the subject of serious academic research that has approached the issue from many different aspects. According to Brouwers and Tomic [5], for example, teachers who believed that they are competent to teach their students were considered to have strong self-efficacy beliefs in teaching, whereas teachers who doubted their ability in this respect were considered to have weak self-efficacy beliefs in teaching. It can be argued that teachers who have high teacher self-efficacy beliefs are more capable of using instructional strategies effectively, more capable of ensuring student participation and more successful in classroom management skills [6, 7]) and they use direct teaching less [8]. Teachers with high teacher self-efficacy make more efforts to overcome the problems they face, and they can maintain these efforts longer [9, 10]. Studies also demonstrate that differences exist between teachers with high and low self-efficacy beliefs in issues such as using new techniques and giving feedback to students with learning disabilities [4, 11]. Teacher self-efficacy belief (TSEB) also enables the teacher to be open to new ideas and to develop positive teaching attitudes [12, 13], and to take more responsibility in teaching [14].

Another argument is that perceived teaching self-sufficiency is positively associated with teachers’ job satisfaction [6, 15]. This was thoroughly presented in the study of Tschannen-Moran and Hoy [16], which showed that the satisfaction derived from classroom performance, is positively correlated with teaching self-efficacy belief. Klassen et al. also found a high correlation, in the study they carried out in five different countries, between teachers’ job satisfaction levels and teaching self-efficacy beliefs. Exploring the relationship between TSEB and job satisfaction may have implications for teachers’ job performance, and by extension, the academic achievement of students [17].

Other dimensions of self-efficacy extend beyond satisfaction, performance and academic achievement issues. Teacher self-efficacy is also positively related to perceptions of parental (e.g. home tutoring) involvement
these demands of the profession, a physical education teacher has to carry required mental, physical, social and emotional capacity adequate for professional competence. Taking all these points in regard, it is necessary to use efficacy scales specifically adapted to physical education teachers if a sound contribution to the research literature in this field is to be made. Therefore, the first purpose of this study was to examine the psychometric properties of Teacher Interpersonal Self-Efficacy Scale that was developed by Brouwers and Tomic [5] and adapted to Turkish by Çapri and Kan [33] for physical education teachers. The second purpose was to analyze teachers’ interpersonal self-efficacy beliefs according to gender, years of experience and grade levels they taught.

Material and methods
This study utilized the survey method that is used most commonly in descriptive research models [34, 35]. In the survey method, samples consist of large groups, and each member of the group is asked about their opinions in order to find out their attitudes on a case, fact or a situation. Researchers try to describe the facts or situations as they are and in their respected conditions [36].

Participants:
This study included 360 voluntary participants from different regions of Turkey who worked as physical education teachers in the education institutions (public schools organized under the National Department of Education) at the time of data collection. The sample consisted of 80 female and 280 male teachers whose ages ranged between 23 and 55 and whose years of experience ranged between 1 and 34. The average age and year of experience of the participants were 35.29 years (SD = 6.65) and 10.67 years (SD = 6.81) respectively.

Procedure:
In this study, the Turkish adaptation of Teacher Interpersonal Self-Efficacy Scale (TISES) developed by Çapri and Kan [33] was used as the data collection instrument. The TISES developed by Brouwers and Tomic [5] that was developed to determine teachers’ interpersonal self-efficacy belief levels consisted of 24 items and 3 subscales. The distribution of items in Brouwers and Tomic’s subscales were listed as follows: perceived self-efficacy belief in classroom management (CM-14 items), perceived self-efficacy in eliciting support from colleagues subscale (ESFC-5 items), and perceived self-efficacy in eliciting support from principals subscale (ESFP-5 items). The Turkish version of the scale consists of 18 items and 3 subscales. The subscales carry the same titles as the original in the Turkish version but first subscale consists of 8 items instead of 14 original items of the TISES. The subscales were listed as follows: CM (e.g., I can manage my class very well), ESFC (e.g., I can always find colleagues with whom I can talk about problems at work), and ESFP (e.g., I am confident that if necessary I can ask principals for advice). All items were measured and sorted using a five-point Likert scale (1=completely disagree, 2=disagree, 3=undecided, 4=agree, 5=completely agree).

The data used in the study were collected online. The
hyperlínk of the website that included the questionnaire was sent to the participants and websites of various social media platforms formed by physical education teachers via electronic mail with detailed information on the purpose of the study and the directions to fill out the questionnaire.

**Statistical Analysis:**

Before the data analysis, all of the questionnaire forms were checked and a number of them were omitted from the analysis as they were incorrectly filled out. The sample size was adequate for factor analysis as the sample size used in this study was above 300 [37, 38]. We calculated the descriptive statistics (mean, standard deviation, range, skewness and kurtosis) of the variables of the study with the intention of verifying if our data fell within the normalcy of the statistics that allows us to carry out the confirmatory factor analysis (CFA) or not. Kline [39] indicates that value of 3 for skewness and 10 for kurtosis is acceptable. We used the statistic program SPSS 20 for these calculations. CFA was employed to examine the construct validity using the maximum likelihood for confirmatory factor analysis.

Confirmatory factor analysis (CFA) was conducted to test the factorial validity of the TISES. Before performing the CFA, we assessed the suitability of the data for factor analysis. Table 1 contains the means, standard deviations, skewness, kurtosis, and ranges for the total TISES and the three subscales. The skewness and kurtosis values showed that the data was distributed within the area of normalcy for confirmatory factor analysis.

The results of the CFA indicated that all fit indices except from the NFI reached acceptable levels as follows: \( \chi^2/df=2.48 \), GFI=0.91, NFI=0.88, CFI=0.93, IFI=0.93, TLI=0.91, RMR=0.03, SRMR=0.05, RMSEA=0.06. To define the contribution of each of the items with their respective factors, we also analyzed the standardized regression loadings and squared multiple correlations. In Table 2, all items, except for two items, demonstrated acceptable standardized regression loadings and squared multiple correlations. The item with the highest regression loadings (0.82) is number 18 (I can get through to most difficult students) which is related to the CM factor. The items with the lowest regression loadings are number 6 (There are very few students that I cannot handle) related to the CM factor and number 2 (When necessary, I am able to bring up problems with principals) related to the ESFP factor. These items did not fit the structure of the scale. Therefore, these items were omitted from the scale and item number was reduced to 16. The results of the CFA of the 16 remaining items demonstrated an acceptable fit of the hypothetical factor model of the TISES (\( \chi^2/df=2.44 \), GFI=0.92, NFI=0.91, CFI=0.95, IFI=0.95, TLI=0.93, RMR=0.03, SRMR=0.05, RMSEA=0.06) with a three-factor structure.

After the CFA, our results confirmed the first factor (CM) as consisting of seven items whereas second (ESFC) and third (ESFP) factors yielded five and four items, respectively. Factor loading values of the items that belonged to the first factor ranged between 0.61 and 0.82. Same values differed between 0.55 and 0.75 for the items in the second factor, and between 0.68 and 0.78 for those

### Table 1. Descriptive statistics for the TISES

<table>
<thead>
<tr>
<th>Factor</th>
<th>M</th>
<th>SD</th>
<th>Skewness</th>
<th>Kurtosis</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classroom Management (CM)</td>
<td>4.22</td>
<td>0.50</td>
<td>-0.83</td>
<td>2.69</td>
<td>1.50-5.00</td>
</tr>
<tr>
<td>Eliciting Support from Colleagues (ESFC)</td>
<td>4.46</td>
<td>0.49</td>
<td>-0.99</td>
<td>1.24</td>
<td>2.20-5.00</td>
</tr>
<tr>
<td>Eliciting Support from Principals (ESFP)</td>
<td>4.20</td>
<td>0.65</td>
<td>-1.07</td>
<td>1.71</td>
<td>1.20-5.00</td>
</tr>
<tr>
<td>Total</td>
<td>4.28</td>
<td>0.44</td>
<td>-0.69</td>
<td>0.80</td>
<td>2.61-5.00</td>
</tr>
</tbody>
</table>
in the third factor. The latent variable of the CM factor explained between 0.38 and 0.67 of the variance, whereas the latent variable of the ESFC factor explained between 0.30 and 0.56 of the variance and the latent variable of the ESFP factor explained between 0.47 and 0.61 of the variance.

The correlations between each of the factors and Cronbach Alpha reliability coefficients for the subscales and total scale are depicted in Table 3. The correlation coefficients ranged between 0.49 and 0.89. Cronbach Alpha values were calculated as 0.88, 0.78, 0.83 and 0.90 for the subscales and total scale respectively.

Overall, all physical education teachers had positive self-efficacy beliefs on high levels as shown in Table 4 (M=4.30, SD=0.48). When the three components of the TISES were examined, the values were 4.25 (SD=0.53) for CM factor, 4.46 (SD=0.49) for ESFC factor and 4.20 (SD=0.70) for ESFP factor respectively (Table 4).

A multi-variate analysis of variance (MANOVA) was conducted to examine the effects of gender, years of experience and grade levels on teacher interpersonal self-efficacy beliefs. Table 4 shows the means and standard deviations for the subscales and the total scale by gender, years of experience and grade levels. Results from the MANOVA indicated that there was no significant main effect of gender [Wilks’ Lambda=0.97, F(3, 356)=0.51, p=0.675] for any of the subscales. There was a significant main effect of years of experience [Wilks’ Lambda =0.97, F(3, 356)=4.27, p=0.006, η²=0.035]. In tests between subject effects by years of experience, results showed a significant difference in the Classroom Management (CM) factor [F(1, 358)=9.20, p=0.003, η²=0.025]. The experienced teachers had higher self-efficacy scores (M=4.35, SD=0.51). Whereas by grade levels a significant main effect was not found [Wilks’ Lambda =0.97, F(3, 356)=4.27, p=0.006, η²=0.035]. In tests between subject effects by years of experience, results showed a significant difference in the Classroom Management (CM) factor [F(1, 358)=5.95, p=0.015, η²=0.016]. The teachers who were employed at the high schools had higher self-efficacy scores (M=4.33, SD=0.46) than the teachers who were employed at the middle schools (M=4.19, SD=0.58).

### Table 2. Statistical characteristic of items used in the CFA for the TISES

<table>
<thead>
<tr>
<th>Factor</th>
<th>Item Number</th>
<th>Item</th>
<th>M</th>
<th>SD</th>
<th>SRW</th>
<th>SMC</th>
</tr>
</thead>
<tbody>
<tr>
<td>CM</td>
<td>1</td>
<td>I can keep defiant students involved in my lessons.</td>
<td>4.23</td>
<td>0.68</td>
<td>0.61</td>
<td>0.38</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>I am able to respond adequately to defiant students.</td>
<td>4.29</td>
<td>0.70</td>
<td>0.71</td>
<td>0.51</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>I can manage my class very well.</td>
<td>4.41</td>
<td>0.62</td>
<td>0.62</td>
<td>0.38</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>There are very few students that I cannot handle.</td>
<td>3.96</td>
<td>1.26</td>
<td>0.03</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>I can keep a few problem students from ruining an entire class.</td>
<td>4.28</td>
<td>0.69</td>
<td>0.71</td>
<td>0.51</td>
</tr>
<tr>
<td></td>
<td>14</td>
<td>If students stop working, I can put them back on track.</td>
<td>4.29</td>
<td>0.67</td>
<td>0.75</td>
<td>0.56</td>
</tr>
<tr>
<td></td>
<td>16</td>
<td>If a student disrupts the lesson, I am able to redirect him quickly.</td>
<td>4.18</td>
<td>0.71</td>
<td>0.78</td>
<td>0.61</td>
</tr>
<tr>
<td></td>
<td>18</td>
<td>I can get through to most difficult students.</td>
<td>4.08</td>
<td>0.81</td>
<td>0.82</td>
<td>0.67</td>
</tr>
<tr>
<td>ESFC</td>
<td>4</td>
<td>I am able to approach my colleagues if I want to talk about problems at work.</td>
<td>4.48</td>
<td>0.69</td>
<td>0.59</td>
<td>0.35</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>When it is necessary, I am able to ask a colleague for assistance.</td>
<td>4.58</td>
<td>0.56</td>
<td>0.67</td>
<td>0.45</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>I can always find colleagues with whom I can talk about problems at work.</td>
<td>4.31</td>
<td>0.81</td>
<td>0.55</td>
<td>0.30</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>If I feel confronted by a problem with which my colleagues can help me, I am able to approach them about this.</td>
<td>4.46</td>
<td>0.65</td>
<td>0.75</td>
<td>0.56</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>I am confident that, if necessary, I can ask my colleagues for advice.</td>
<td>4.46</td>
<td>0.63</td>
<td>0.75</td>
<td>0.56</td>
</tr>
<tr>
<td>ESFP</td>
<td>2</td>
<td>When necessary, I am able to bring up problems with principals.</td>
<td>4.18</td>
<td>0.93</td>
<td>0.37</td>
<td>0.14</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>I am confident that if necessary I can ask principals for advice.</td>
<td>4.27</td>
<td>0.83</td>
<td>0.68</td>
<td>0.47</td>
</tr>
<tr>
<td></td>
<td>11</td>
<td>When it is necessary, I am able to get principals to support me.</td>
<td>4.18</td>
<td>0.87</td>
<td>0.73</td>
<td>0.53</td>
</tr>
<tr>
<td></td>
<td>13</td>
<td>I am able to approach principals if I want to talk about problems at work.</td>
<td>4.25</td>
<td>0.87</td>
<td>0.76</td>
<td>0.58</td>
</tr>
<tr>
<td></td>
<td>17</td>
<td>I am confident that, if necessary, I can get principals to help me.</td>
<td>4.11</td>
<td>0.90</td>
<td>0.78</td>
<td>0.61</td>
</tr>
</tbody>
</table>

Note: M = mean; SD = standard deviation; SRW = standardized regression weight; SMC = squared multiple correlation.
Discussion
This study was conducted to adapt the TISES, which was originally developed in order to measure interpersonal self-efficacy belief levels of the teachers, to PE teachers and analyze the PE teachers’ interpersonal self-efficacy beliefs according to gender, years of experience and grade levels they taught. To ascertain the factor structure of this scale, CFA was administered. The results of the CFA for 16 items showed relative improvement in some fit indices that had low values in 18 items such as NFI (0.88). Factor loadings of the items that belonged to the subfactors, ranged between 0.55 and 0.82. Same values differed between 0.59 and 0.81 in Çapri and Kan’s (2006) [33] study, and between 0.36 and 0.96 in Garcia-Ros, Fuentes and Fernandez’s [47] study and between 0.52 and 0.90 in Moura and Costa’s [48] study and between 0.45 and 0.90 in Brouwers and Tomic’s [5] study. The results of the correlation analysis showed that the subscales were moderately related to each other, and all were highly correlated with the total TISES score. In our study, the correlation coefficients among the subfactors were calculated between 0.49 and 0.65. These values are in parallel with the results of Çapri and Kan’s [33] and Garcia-Ros, Fuentes and Fernandez’s [47] and Moura and Costa’s [48] studies that arrived at correlation values between 0.45-0.54 and 0.50-0.56 and 0.49-0.54 respectively. In Brouwers and Tomic’s [5] study, the correlations coefficients were calculated between 0.32 and 0.57. The analyses that were made to determine the reliability level of the scale indicated that the scale had a high reliability level. Cronbach Alpha values for the subscales were calculated between 0.78 and 0.83 in this study. These values ranged between 0.89 and 0.91 in Çapri and Kan’s [33] study, and between 0.92 and 0.94 in Garcia-Ros, Fuentes and Fernandez’s [47] study and between 0.91 and 0.93 in Moura and Costa’s [48] study. Brouwers and Tomic [5] reported that the reliability coefficients for the TISES subscales were above 0.90 in their study.

Overall, descriptive statistics showed that the PE teachers’ scores from total TISES and its subscales were on fairly high levels. In other words, the participants had positive interpersonal self-efficacy beliefs. These findings were consistent with the results of some studies which were made in Turkey [49, 50]. In contrast with these results, it was reported that the teachers had moderately self-efficacy beliefs in some studies which were made abroad [5, 51]. However, the reason for this disparity may be related to culture. The results of some studies in the literature revealed that the culture, where the teachers lived in, affected their teacher self-efficacy beliefs [52, 53].

In regards to the influence of gender on self-efficacy levels, our study found that there was no significant difference between the self-efficacy levels of male and female PE teachers. Similar findings were reported in some studies which were conducted on teachers and pre-service teachers [54, 55]. Mouton et al also found no significant difference by gender in their study, which was conducted on 119 PE teachers in order to determine the relationship between emotional intelligence and self-efficacy [56].

The results of our study revealed that the experienced PE teachers had higher self-efficacy belief levels. The results supported the findings of other studies [57, 58]. Mouton et al, however, found no significant relationships between ages, years of physical education teaching and self-efficacy beliefs of the teachers [56]. The reason for this difference may be related to sample characteristics. Whereas the mean age and years of teaching experience

<table>
<thead>
<tr>
<th>Table 3. Correlations among the TISES revised</th>
</tr>
</thead>
<tbody>
<tr>
<td>Factor</td>
</tr>
<tr>
<td>Classroom Management (CM)</td>
</tr>
<tr>
<td>Eliciting Support from Colleagues (ESFC)</td>
</tr>
<tr>
<td>Eliciting Support from Principals (ESFP)</td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
</table>

*p<0.01

<table>
<thead>
<tr>
<th>Table 4. Descriptive statistics for the TISES revised</th>
</tr>
</thead>
<tbody>
<tr>
<td>Factor</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>CM</td>
</tr>
<tr>
<td>ESFC</td>
</tr>
<tr>
<td>ESFP</td>
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<tr>
<td>Total</td>
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</table>

(CM=Classroom Management; ESFC=Eliciting Support from Colleagues; ESFP=Eliciting Support from Principals)
of the participants in this study were 35.29 and 10.67 respectively, the same values in Mouton et al.'s [56] study were 42.1 and 18.2. The literature confirms that self-efficacy belief increases by time and experience [9]. Bandura [23, 59] expressed the view that the formation of a person’s self-efficacy belief could only be realized with that person going through the direct life experiences, which constituted one of the most important informative sources of Bandura’s related theory. Moreover, Bandura [10] argued that experiences were one of the most important factors that affected the self-efficacy beliefs and that the positive experiences contributed to the development of self-efficacy belief.

According to the findings of our study, on the classroom management subdimension the TISES scores of the participants pointed to significant difference based on the grade levels the PE teachers taught at. In other sub-dimensions, however, although the mean scores of the teachers taught at the high school level are high, it did not point to a significant difference. In respect to the classroom management subdimension, the PE teachers who were employed at the high schools had higher self-efficacy scores than the PE teachers who were employed at the middle schools. The studies that subjected the effect of this variable on self-efficacy are pretty limited in the literature. Among these studies, the study conducted by Akkoyunlu and Kurbanoglu [60] and Özgün [61] obtained similar findings that our study arrived at. In an effort to interpret the above mentioned phenomenon, the effect of ages and experience levels of the middle school and high school PE teacher on self-efficacy were analysed. We found that the average year of experience for the high school PE teachers was 12.27, whereas the same score was 9.30 for the middle school PE teachers. Based on these findings and in tandem with the results about experience mentioned above, it can be stated that such a result might be affected by years spent on teaching.

**Conclusions**

In this study, the validity and reliability of the Teacher Interpersonal Self-Efficacy Scale was tested for PE teachers. The reexamination of the scale led to a new scale structure comprised of three factors with sixteen items. The results obtained after validity and reliability analyses confirmed that the restructured scale can be applied on the PE teachers. The distribution of items in the subscales were listed as follows: perceived self-efficacy belief in classroom management (CM-7 items), perceived self-efficacy in eliciting support from colleagues subscale (ESFC-5 items), and perceived self-efficacy in eliciting support from principals subscale (ESFP-4 items). The scale includes a brief questionnaire that is easy to apply and evaluate. Overall, all PE teachers had positive self-efficacy beliefs on high levels. Whereas a significant difference was not found in self-efficacy beliefs by gender, significant differences were found between teachers depending on their experience and grade levels they taught. The experienced teachers had higher self-efficacy belief levels. Additionally, the teachers who were employed at the high schools had higher self-efficacy beliefs than the teachers who were employed at the middle schools. While this study had its limitations in terms of its sample characteristics and target sample, this can be overcome with the administration of the scale on different and larger samples. Future studies that will use different and larger samples can further contribute to the validity and reliability of the scale. Further studies should also include qualitative tools such as interviews, which may help provide further understanding about the issue.

**Conflicts of Interest**
The authors declare no conflict of interest.

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Training structure of powerlifters with regard to biological rhythms and operational functional condition

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Authors’ Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection.

Abstract

Purpose: to develop and experimentally confirm the structure of training cycles, training load and sports results with regard to the biological rhythms and functional condition of powerlifters.

Material: the study involved qualified powerlifters (n = 40). The diagnostic procedure was performed on the Omega hardware complex. Ostberg questionnaire was applied to determine the athlete's chronotype. According to the results of the questionnaire, athletes were divided into morning, evening and mixed chronotypes. In the experimental group (N1, n = 20), intensive training was conducted at the peak of the biological rhythm. Medium and low-intensity training was performed in the phase of reducing the biorhythms activity. Standard training was performed in the control group (N2, n = 20), without regard to chronotypes.

Results: it was determined that the application of non-standard means of athletes training at the peak of the biological rhythms activity and in the rising phase of the biogram significantly influences on the increase in maximum strength results. Non-standard means include Crossfit training and a reverse pyramid (the maximum weight is applied at the beginning of the training, in the subsequent approaches the weight reduces, the number of repetitions increases). It is determined the significant differences between groups in the control exercises: hanging pull-up/chin up, parallel bar dips, hanging on the crossbar.

Conclusions: the training of qualified powerlifters should be based on their chronotype. The main mean of the training process optimizing of athletes should be a biogram, reflecting the physical, emotional and intellectual biological rhythm.

Keywords: chronotype, planning, cycle, training, competition.

Introduction

The dynamic development of powerlifting draws the attention of scientists to the development of the qualified athletes training content and the methodological bases of training cycles structure [1, 2]. In recent years, there is a sufficient number of scientific works devoted to powerlifters training at the primary level. It is determined the optimal combinations of means, methods, and parameters of power and speed-power training load. It was revealed the effect of power training on the athletes’ health [3, 4]. The researchers confirm that athletes’ training should be based on individual training programs. This allows you to increase the level of their special power fitness and effectiveness of performances in competitions [5, 6].

The effective variants of training load structure were revealed in works of Kholopov and Rybalsky. Load in the weekly and monthly cycles allow optimizing the athletes’ training [7, 8]. It was developed and put into practice the methodical recommendations of pre-competitive weight regulation by powerlifters. Recommendations are based on identifying the optimal way of weight reduction and its effect on athletic performance [9]. Recovery processes in power triathlon are revealed in the studies of Khitrov, Stetsenko, Artyushenko [10, 11]. The research by Dalsky confirmed the effective application of the powerlifter’ functional index. The operational control and training load correcting are made on the index base [12].

However, these works do not consider the issue of training structure based on a biogram. There are not enough scientific works in powerlifting based on the daily, weekly, monthly activity of biological rhythms. Not enough hardware methods to control the functional status of athletes [13]. Increasing requirements for the implementation of maximum strength abilities, the level of reliability of training of athletes led to the search for new ways of sports training [14]. Depending on the athlete’s biological rhythm, the voltage level of the body’s systems is changing. The voltage of functional systems is essential for achieving high results of powerlifters [15, 16]. Differences between the maximum and minimum sports results during the day are 10–25%. Therefore, training sessions in the morning and evening hours are justified, depending on the biological rhythm. Such an approach can be a reserve for improving the athletic performance of qualified athletes in the annual training cycle. Shaposhnikova, Taymazov found that 52.3% of sports injuries were received on critical days of biorhythms. And in the positive phase of biorhythms, athletes achieve better results than in the negative phase [17, 18]. Therefore, studies on the management of the training process based on the activity of biological rhythms, planning training time depending on the chronotype are relevant.

The purpose of the study: to develop and experimentally justify the construction of training cycles, training load, and athletic performance, taking into account the biological rhythms and functional state of qualified powerlifters.
Material and methods

The participants. The experimental group (N1, n = 20) consisted of powerlifters 18-25 years old with the following qualifications: 7 – candidates for master of sports, 4 – masters of sports, 9 – I category; the control group had almost identical qualifications (N2, n = 20).

Design of the study. The experiment was conducted on the basis of the Tchaikovsky State Institute of Physical Culture (Tchaikovsky, Russia). The N1 group trained 4 times per week, 2.5 hours long. Group N2 trained 3 times per week: 2 times per week 3 hours long and 1 time 2 hours long.

Improving the training process of qualified powerlifters was to distribute them according to the biological rhythm. To solve this problem, athletes have passed diagnostics on the Omega hardware complex (1st stage). It was detected hours of biological activity during the day, week, month. The control included indicators of the level of adaptive abilities, psycho-emotional state, fitness level, energy supply, the tension of regulatory systems. The express technique “Omega” characterized the integral indicator of the functional state and sports form of each of the athletes.

The technique has defined the “zones” of the functional state: “Red” - overstrain, overwork, the significant decrease in the functional state. The “green” zone is an optimal functional state, a high level of adaptation and fitness. The “yellow” zone is a borderline state, a decrease in reserves of the functional state, a violation of adaptive capabilities. The Omega complex took into account: the internal and external components of biological rhythms; adaptation processes after high-intensity training sessions; recovery time.

The next step in determining the chronotype was Ostberg questionnaire (stage 2) [19]. According to the results of the questionnaire, athletes were divided into morning, evening and mixed chronotypes. The questionnaire can be attributed to the subjective and objective means of determining biological rhythms. In conclusion, the questionnaire was applied in the form of interviewing (stage 3). It was conducted to determine the subjective components of the psychophysical condition, adaptation to physical loads, and general condition during and after training. The individual biogram (14-30 days) for every athlete is distributed over periods of 4-8 days.

The structure of training effects was chosen depending on the phase of biological rhythms activity (Fig. 1). The recovering training load was applied in minimal biorhythm activity (phase 1, means from -80, -100, to -80 points – the lowest point of the graph). During this period, the recommended physical load was 40-60% of the maximum weight. The support training was performed in the ascending activity (phase 2, from -80, -50, to 50 points – the average ascending part of the graph). The loads 60-75% of the maximum weight are realized in these days. The intensive training was conducted with a maximum load of 75-105% and higher at the peak of biorhythm activity (phase 3, from 50 to 100 and again 50 points – the top point of the graph). The training process included 50-75% of the maximum load in descending activity (phase 4, from 50, 0 points and up to -80 points – the average descending part of the graph). Biogram reflects the physical, emotional, intellectual biological rhythm of the athlete (Fig. 1). The plans of training loads were developed for every phase of biorhythms activity.

Statistical analysis

Statistical data processing was carried out by the method of variation statistics with the calculation of the arithmetic mean value, standard deviation, and verification of the results of the study for the significance of differences at the 5% significance level [20]. Student’s t-criterion was applied in the evaluation of significant differences. Mathematical processing was carried out applying the Excel 2010 tabular processor and the StatPlus2009 program.

Fig. 1. Individual biorhythm graph for 30 days (point)
Results
In the experiment were obtained data concerning the types of training load for qualified powerlifters (limiting, supporting, recovering), their combination in the structure of the occupation and training cycles. The experiment included non-standard means of training: Crossfit training and the inverse pyramid (the maximum weight is applied at the beginning of the training, in subsequent approaches the weight reduces, the number of repetitions increases).

The construction of the training process considering the biological rhythms and functional status has significantly improved the athletic performance. In the N1 group, the results are higher compared to the N2 group. The squats were 197.9 kg (group N1) versus 184.7 kg (group N2). The bench press was 147 kg (group N1) versus 129 kg (group N2). The dynamics of the deadlift reached 187 kg (group N1) and 489.6 kg (group N2) (Table 1). It is proved the effectiveness of training influences on the basis of special physical fitness of athletes in the control exercises: hanging pull-up/chin up, parallel bar dips, hanging on the crossbar.

The effectiveness of experimental training of powerlifters is proved by the optimal functional condition of athletes of the N1 group, in comparison to the N2 group. The total value of the functional condition (“Omega” method) is: 85.7% (group N1), 71.9% (group N2) (maximum 100%). Adaptation to physical loads is: 84.3% (group N1) and 71.4% (group N2). The level of energy supply is 81.9% (group N1) and 71.6% (group N2). The level of fitness is 93% (group N1), 80.2% (group N2). The psycho-emotional condition is: 80.8% (group N1), 71.0% (group N2) (maximum 100%). The level of adaptation and reserve capabilities of the cardiovascular and respiratory systems is 7.3 c.u. (group N1), 10.1 c.u. (group N2). Vital capacity of the lungs does not have significant differences in results. The initial and final values are practically the same and are 4000-4300 ml. (group N1), 4100-4200 ml. (group N2).

Blood pressure does not have significant differences. The revealed values of systolic and diastolic pressure at rest correspond to the parameters of the norm. Conducted training are not contributed to the increase in blood pressure.

Discussion
The objectification of the training process management of qualified powerlifters remains relevant. It requires the development of integral criteria, models for evaluating the physical, functional and psychological components. It is also necessary to consider biological rhythms, the development of the most rational options for training load structure. Attention should be paid to the fact that a significant part of the research is devoted to determining the optimal volumes and intensity of training load.

Rybalsky developed a classification of the volume and intensity of training load. The classification gives an objective evaluation of the magnitude and direction of training effects. In the micro cycles of the basic stage of preparation, the volume of exercises should be squats – 45%; bench press – 35%; deadlift – 20%. The volume of the exercises should be 14-20% – high intensity; 41-44% – medium intensity; 39-42% – low intensity [8]. In our study, the volume and intensity of training influences are determined by the phase of activity of biological rhythms during the month; daily activity; operational functional

<table>
<thead>
<tr>
<th>Exercises</th>
<th>Group</th>
<th>2015 (X± σ)</th>
<th>2016 (X± σ)</th>
<th>2017 (X± σ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Barbell Squat (kg)</td>
<td>N1</td>
<td>167±19.5</td>
<td>183.5±15.7</td>
<td>197.9±16.5*</td>
</tr>
<tr>
<td></td>
<td>N2</td>
<td>170.9±10.5</td>
<td>176.7±16.3</td>
<td>184.7±9.2*</td>
</tr>
<tr>
<td>2. Bench Press With Barbell (kg)</td>
<td>N1</td>
<td>111.7±10.5</td>
<td>125.3±8.7</td>
<td>147.1±20.4**</td>
</tr>
<tr>
<td></td>
<td>N2</td>
<td>109.3±9.1</td>
<td>119.5±6.3</td>
<td>129.7±8.7*</td>
</tr>
<tr>
<td>3. Barbell Deadlift (kg)</td>
<td>N1</td>
<td>163.7±14.1</td>
<td>182.5±13.3*</td>
<td>187.2±9.6**</td>
</tr>
<tr>
<td></td>
<td>N2</td>
<td>165.2±12.4</td>
<td>170.6±11.5</td>
<td>175.2±10.4</td>
</tr>
<tr>
<td>4. The sum of three control exercises (kg)</td>
<td>N1</td>
<td>443±21.9</td>
<td>491.3±18.6</td>
<td>532.2±23.7**</td>
</tr>
<tr>
<td></td>
<td>N2</td>
<td>445.4±24.9</td>
<td>466.8±12</td>
<td>489.6±20.7*</td>
</tr>
<tr>
<td>5. Handgrip Strength Test (right), kg</td>
<td>N1</td>
<td>44.8±5.3</td>
<td>46.6±5.3</td>
<td>46.9±4.7</td>
</tr>
<tr>
<td></td>
<td>N2</td>
<td>46.3±5.8</td>
<td>46.6±5.2</td>
<td>48.8±5.1</td>
</tr>
<tr>
<td>6. Handgrip Strength Test (left), kg</td>
<td>N1</td>
<td>42.1±5.6</td>
<td>43.6±5.7</td>
<td>44.2±5.4</td>
</tr>
<tr>
<td></td>
<td>N2</td>
<td>45.7±5.6</td>
<td>45.6±5.5</td>
<td>46.8±5.2</td>
</tr>
<tr>
<td>7. Pull-Up / Chin Up Test (upper crossbar), quantity of times</td>
<td>N1</td>
<td>16.5±4.8</td>
<td>18.9±5.1</td>
<td>27.6±3.9**</td>
</tr>
<tr>
<td></td>
<td>N2</td>
<td>15.9±4.4</td>
<td>16.3±3.9</td>
<td>20.1±3.5*</td>
</tr>
<tr>
<td>8. Parallel bar dips (quantity of times)</td>
<td>N1</td>
<td>18±5.3</td>
<td>37.8±8.7**</td>
<td>38.3±5.5**</td>
</tr>
<tr>
<td></td>
<td>N2</td>
<td>22.7±7.8</td>
<td>24.6±7.8*</td>
<td>25.6±6.2*</td>
</tr>
<tr>
<td>9. Bent Arm Hang Test (two hands), sec</td>
<td>N1</td>
<td>38.5±10.9</td>
<td>45.5±13.4</td>
<td>46.1±12.8</td>
</tr>
<tr>
<td></td>
<td>N2</td>
<td>38.2±10.7</td>
<td>39.7±10.6</td>
<td>41.1±9.7</td>
</tr>
</tbody>
</table>

Note: X – arithmetic mean, σ – standard deviation; EG – experimental group, CG – control group; * – significance of differences (p <0.05), ** – intergroup significance of differences (p <0.05).
condition.

The structure of the training means of qualified powerlifters includes special strength training (74.4% of the time a year); general physical training (18.7%); pedagogical means of recovery (3.7%). The intensity dynamics by the number of barbell lifts is in the range of 70-112% of the individual maximum [21]. In our study, the intensity of the barbell lifts is in the range of 40-105% of the individual maximum. It depends on the phases of biorhythms.

Experimental application of static power stresses in the study allowed an increase in the initial strength indices of the arms (by 35.4%), leg muscles (by 33.4%), back muscles (by 36.7%) [22]. Vorozheikin identified the rank structure of the factors that determine the high level of power fitness of powerlifters. They include: individual strength abilities (19.7%); high level of motivation to achieve a good result in competitions – 17.8%; high degree of concentration (15.5%); good moral-volitional fitness (14.3%); correspondence of the volume and intensity of the load to individual peculiarities (10.7%); accuracy of performance depending on anatomical and morphological features (9.5%); high relative load during the training process (7.2%); the ability to quickly recover in the process of strength training (5.3%) [6].

Analysis of other studies has shown that the emotional rhythm lasts 28 days. It is associated with changes in mood, the reactivity of the body. The intellectual rhythm lasts 33 days. It is associated with mental performance. Many athletes are dominated by weekly and two-week biorhythms. Biorhythms are determined by the indices of the minute respiratory volume, heart rate, temperature and body mass, energy metabolism [23]. Our study showed that considering the biorhythms of athletes it is possible: to develop maximum strength capabilities; expect intense training at the peak of the biological rhythm. The medium and low-intensity load should be applied in the biogram reduction phase. Therefore, the structure of the training load for 14-30 days (biogram) is justified.

The results of our research allow us to evaluate objectively the planning of preparation cycles; evaluate training load and sports results. It is necessary to consider the biological rhythms and operational functional status of athletes (the method of “Omega”). The results of our study are in good agreement with the data of other authors [15, 24]. Training athletes considering the phases of biorhythms (4 phases for 4-7 days) demonstrates a significant increase in athletic indicators. The study allows to characterize the possibilities of practical application of the system of tools and methods for individualizing the training process of athletes.

Conclusions

The training of qualified powerlifters should include 4 training per week, 2.5 hours long. Training should be conducted: in the morning (8.00-10.00, for the morning type of activity of biological rhythms); in the evening (18.00-20.00, for the evening type of activity of biological rhythms). Training (morning or evening) should be conducted for a mixed type of activity. The main means of athletes training process optimizing should be a biogram for 14 and 30 days. Biogram reflects the physical, emotional, intellectual biological rhythm of the individual. To increase the maximum strength results of athletes, it is recommended to apply non-standard means of training. Non-standard means include Crossfit workouts and a reverse pyramid. These means must be applied at the peak of the activity of biological rhythms and in the ascending phase of the biogram.

Conflict of interest

The authors declare that there is no conflict of interest.

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Criterion score of the physical and psychophysiological condition of students in the context of determining their individual adaptability to physical loads

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Authors’ Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection.

Abstract
Purpose: to suggest and to evaluate the criterion score of the physical and psychophysiological condition of students. The basis of the score is the individual-directed pedagogical control at physical education.

Material: the study involved students (n = 75, age - 17-19 years). The physical condition was determined by applying anthropometry and motor skills testing. The psychophysiological condition was studied according to objective parameters of psychomotor qualities and functional capabilities of the cardio-respiratory system.

Results: It was realized the criterion score of the individual degree of students’ adaptability to physical loads. It was determined the most significant interrelation between the indicators of motor qualities and psychomotor parameters of students. It was revealed the approaches of realization the complex individual-directed pedagogical control in the physical education of students.

Conclusions: criteria of physical and psychophysiological capabilities of students are recommended for determining their adaptability to physical loads.

Keywords: criterion score, adaptability, physical education, psychomotor system, students.

Introduction
The definition of adaptive abilities of the individual considering his age, gender, and psychophysiological peculiarities is the actual and perspective direction of pedagogical science. The abovementioned is crucial for the organization of physical education and sports classes according to the modern requirements [1, 2]. It is expedient to reveal the neurophysiological and psychophysiological mechanisms of adapting the organism to various factors of the external environment [3]. The development of this scientific direction was carried out in the context of determining the adaptation of the individual to physical loads of different orientations [4]. According to various data, the condition of health of young people has significantly deteriorated in recent years [5-7]. It is noted that among students there is a small proportion of practically healthy persons [8-10]. The introduction of health diagnostic methods according to objective parameters of physical and psychophysiological condition was confirmed in the studies of various authors [11-13]. Il’in [11] emphasizes the continuity of the physical and psycho-physiological component in the organization of human loads. Nikandrov [6], Degtiarenko et al. [7] suggest the application of psychomotor tests as a priority for evaluation of the adaptability of the individual.

A lot of authors emphasize the feasibility study of the interdependence of the functional condition and the volume of motor loads of students [14-16]. It is proposed to determine the functional level of students on the performance of cardiovascular and respiratory systems. The criteria for adaptation are arterial pressure, heart rate at rest, the vital capacity of the lungs (VCL) and Stanger test [17, 18]. In the process of physical education, there should be performed the complex coordination abilities testing [19]. It is determined the importance of studying power, speed qualities and flexibility in the pedagogical control of the physical education process of students [20, 21]. Sergiienko defines the need to consider the somatotype of students during physical education modeling [22]. It is determined the peculiarities of the development problem individualization in the framework of the psychophysiological paradigm’s implementation. It is revealed the high level of correlation between the perceptive-cognitive indicators and psychomotor functions of a person [23]. The necessity of psychomotor qualities research for determining the level of a person’s physical development is confirmed in the study of Tarovyket al. [24]. The development of quantitative and qualitative scales to determine the psychophysiological rating of respondents is revealed in the study of Korobejnikov et al. [25]. The comprehensive evaluation of physical fitness and psychophysical status of students of the special medical group is presented in the study of Blavt [16]. It is proved that the intensification of the test process ensures the effectiveness of the implementation of the diagnostic control function of physical education [27-29].

Everyone is able to adapt to constant changes in the...
natural and social environment. This requires continuous improvement of personal adaptation resources [4, 21]. It is important to consider the main theoretical and methodological provisions of the medical and pedagogical control of physical education. It is necessary to define the interdisciplinary sense of such a concept as “adaptation”. The phenomenological sense of the adaptation process should be considered in the system “man – environment”. It is important to determine the degree of adaptability of the individual to a particular type of loads. The result of such loads is the success or failure of various tasks. For example, the effectiveness of mastering certain types of physical exercises [30]. It is necessary to emphasize the necessity of experts’ compliance in the interpretation of the terminological definition “adaptation” and “adaptability of the individual”. It is necessary to adhere to the terminology discipline in defining and interpreting the abovementioned concepts. The terms “adaptability or disadaptability” are used in the context of evaluating the effectiveness of different activities. It will be legitimate to use these concepts in determining the success or failure of physical exercise [3, 13].

The actual problem is the implementation of an individual approach to the educational process organization. This principle should be based on the objective evaluation of the adaptability degree of students to mental and physical loads.

Hypothesis. The study of individual characteristics of the physical and psychophysiological condition of students should be conducted on the basis of objective criteria. It provides an opportunity to determine their adaptability to physical loads. Such an approach will allow the implementation of individual pedagogical control in physical education.

The purpose of the work is to offer and test a criterion evaluation of the physical and psychophysiological condition of students. The basis of evaluation is the individual-directed pedagogical control of physical education.

Material and methods
Participants. The students participated in complex research (n = 75, age – 17-19 years). The mandatory condition for participation in the study was a medical examination and the absence of contraindications to physical education. All students give written consent for participation in the research.

Design of the research. The research was conducted during 2017-2018. Complex researches of diagnostic-prognostic direction were performed according to the developed author’s program [1]. The program included an individualized evaluation of the physical and psychophysiological condition of students according to objective parameters [11, 12]. The developed and implemented program included the following stages:

I. General data (age, gender, medical background).
II. Physical condition (anthropometry and motor quality).
III. Psychophysiological condition (psychomotor quality).
IV. Functional abilities (the potential of the cardiorespiratory system).

Analysis of anthropometric data and motor qualities indicators of student allowed to determine the peculiarities of each student’s physical condition [22, 31, 32]. The following indicators were determined: body length (cm); body weight (kg); chest circumference at rest (cm); dynamometry strength (kg). Individualized evaluation of students’ motor skills was performed applying the following tests: 100 m run (s); 4x9 m shuttle run (s); push-ups (times); sit-ups in sitting position in 1 min (times); standing jump from the spot (cm); forward inclination of body from sitting position (cm) [21, 33, 34]. It was applied the following criteria for evaluating the students’ physical condition: body mass index (BMI); Power index (PI); Index Pynie (IP) [35]; speed of running; Coordination; Power endurance; speed power; Flexibility [22, 30, 36]. In our opinion, these criteria should be considered acceptable for the application in professional loads of physical education teachers. Such criteria are informative, accessible, safe and valid.

The psychophysiological studies were performed to determine the individual peculiarities of the psychomotor system and functional abilities of the body. They allowed to study the condition of perceptive-cognitive function and student psychomotor system. It was determined the parameters of sensorimotor components of motor loads and the students’ cardiorespiratory system potential (CRS). Individualized evaluation of students’ psychophysiological condition is calculated by the computer program (NS-Psychotest) [37]. We have chosen 5 directions: “Visual sensorimotor reactions” (simple and complex), “Reaction to moving object”, “Tap test”, “Kohs Block Design Test” [37, 38]. Testing of individual features of the cardiovascular and respiratory systems allowed to determine their functional capabilities. It was determined the heart rate, timed inspiratory capacity and timed expiratory capacity [35]. Individual peculiarities of the psychomotor system and functional abilities of students were determined according to the following criteria: duration of the latent period of choice reaction; level of sensorimotor excitation; level of sensorimotor accuracy; the speed of a dominant hand; coefficient of functional asymmetry; Loads of thinking; potential of CRS.

Determination of students’ adaptability to physical loads was performed at the following stages:
1. Diagnostic – physical and psychophysiological condition testing.
2. Selection of criteria – according to anthropometric data, motor qualities, the psychomotor system condition and functional abilities [1, 22].
3. Development of a quantitative and qualitative scale – based on the average values of the selected criteria (for transformation the obtained results into the score) [19, 39, 40].
4. Calculation of total points – according to the results of each test.
5. Integrative evaluation of adaptability – according to the appropriate degree (high; significant; insignificant; disadaptation) [41].

6. Analytical interpretation of the distribution of students by the degree of adaptability to physical loads

The results of the testing were given the following score: 1 – failing, 2 – unsatisfactory, 3 – satisfactory, 4 – good, 5 – excellent. The next stage was to implement the interpretation of the total score to determine the students’ adaptability degree to physical loads. Criterion-point evaluation of students’ adaptability to physical loads was the following: high – 80-61 points; significant – 60-41 points; insignificant degree – 40-21 points; disadaptation – 20 points and less [38]. The proposed criterion evaluation allowed to determine the students’ adaptability degree to physical loads and to divide the examined contingent into the appropriate groups.

Statistical analysis: SPSS20 and Excel programs were applied. The following indicators were calculated for each variable: average mean, standard deviation, mean error, the coefficient of variation. The level of correlations between the selected adaptation criteria was determined by correlation analysis.

Results

The results of the conducted research allowed to offer an individualized criterion evaluation of the physical and psychophysiological condition. The average means of the selected criteria of the physical and students’ psychophysiological condition evaluation are presented in Table 1.

The percentage division of students into the degree of adaptability to physical loads (n = 75) is presented in Figure 1.

The “high” degree of adaptability to physical loads was found in 11.2% of students. “Sufficient” adaptability is determined in 26.6% of students. The most widespread evaluation of the studied contingent was “insignificant” adaptability to physical loads. It was detected in 33 students (44.1%). Disadaptation to physical loads is determined in 14 students. More than 18% of students were characterized as unable to perform the educational loads in physical education. Only 38% of students can engage in physical education without risk to health (“adapted”). The obtained data became the basis for the correction of educational programs for the students’ physical education belonging to the group “unadapted”.

The carried out correlation analysis allowed to determine the most significant correlations between the indicators of motor qualities and the parameters of the psychomotor system. It is determined the significant correlation are between the duration of the latent period of choice reaction and coordination (r = 0.412); duration of the latent period of choice reaction and speed of running (r = 0.393, p <0.01); potential of the cardiorespiratory system and power endurance (r = 0.427, p <0.01).

Discussion

We consider the psychophysical abilities of a person in performing motor actions as his individualized characteristics. The motor actions qualities reflect the unity of neurophysiological and psychological mechanisms of a person’s motor loads [11, 12]. Parameters of simple motor actions are well measurable [23, 37]. The evaluation of the functional capacity of the cardiovascular and respiratory systems is successfully applied in the field of physical education and sports [35, 42]. In the course of scientific developments, it is expedient to adhere to the provisions of the theory of evaluations [39]. The logic of our research coincided with this provision and included the following stages: the development of scales which help to transform the test results into points; the transformation of the received data into points; calculation of the total points. We performed the development of the evaluation scale on the basis of the application of square deviations, which is confirmed the position of other researchers [19, 26]. Our approach to the criteria evaluation of the obtained data extends the possibility of interpreting the motor skills testing results of students.

The results of our research confirm that the parameters

| Table 1. Average means of the selected criteria for evaluation of the physical and psychophysiological condition of students (n = 75) |
|-----------------|-----------------|-----------------|-----------------|-----------------|
| **Criterion**   | **X** | **m** | **Criterion** | **X** | **m** |
| Body mass index (c.u.) | 22.81 | 0.57 | Duration of the latent period of choice reaction (ms) | 447.54 | 5.14 |
| Power index (%) | 130.17 | 2.32 | Level of sensomotor excitation (ms) | 8.63 | 1.42 |
| Index Pynie (c.u.) | 26.3 | 0.84 | Level of sensomotor accuracy (ms) | 29.23 | 1.09 |
| Speed of running (s) | 14.21 | 0.11 | Speed of a dominant hand (times) | 7.43 | 0.04 |
| Coordination (s) | 9.87 | 0.04 | Coefficient of functional asymmetry (c.u.) | 2.94 | 0.11 |
| Power endurance (times) | 37.17 | 1.61 | Loads of thinking (s) | 297.19 | 12.36 |
| Speed power (times) | 39.41 | 0.98 | Potential of CRS (c.u.) | 1.59 | 0.06 |
| Flexibility (cm) | 7.88 | 0.77 |

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of the physical and psycho-physiological condition of a person objectively characterize the individual peculiarities of students’ adaptation to physical loads [13, 38]. The abovementioned updates existing ideas about the importance of the students’ psychomotor system condition evaluation. This allows to determine the student’s adaptability to perform various types of motor activity.

It is considered that anthropometric data are an important part of the research and are aimed at determining the somatotype of a person [21, 27]. Evaluation of motor qualities must be included in the programs of physical education of students [20-22]. We consider that the complex testing of the psychophysical condition of students should be carried out three times during the study year (incoming, process-current and stage medical and pedagogical control).

It is proved that the implementation of the psycho-physiological paradigm provides an opportunity to evaluate objectively the individual peculiarities of the psychomotor system [11, 23, 24]. The authors confirmed that psychomotor quality should be determined by latent periods of the visual-motor reaction; levels of sensory-motor excitation and accuracy; the speed of the left and right hands; coefficient of functional asymmetry, the speed of action. Indicators of the cardiovascular and respiratory systems can objectively characterize the adaptive capacity of the body [35]. The application of the indicator “CRS” complete the evaluation of the student’s functional reserve.

We indicated correlations between the indicators of motor qualities and psychomotor system. This is due to the unity of mechanisms of neuro-regulation and psychophysiological support of sensorimotor components of motor activity of students [11, 23]. In general, we believe that the proposed criteria for assessing the physical and psycho-physiological condition provide an opportunity to determine the degree of adaptation of students to physical loads [38, 41, 43].

The results of our research indicate the need to introduce an individualized evaluation of students’ adaptability to physical loads. This is indicated by the number of students who received from 21 to 40 points. These students had “insignificant” degree of adaptability to physical loads.

The obtained data coincide with the results of other studies [44-46]. Thus, in studies of Khotienko, students of the first year did not have the highest level of physical fitness [46]. The author revealed a low level of 25% and a lower than average 71% of students. In our opinion, the given data are overestimated and do not correspond to the national indicators. Similar differences confirm the expediency of individual pedagogical control in the process of physical education; to consider the place of residence; to consider the type of professional loads, gender, age.

The need to consider the individual characteristics of the psychophysical condition of students to confirm the results of other studies [24, 25]. The obtained results confirm the data of studies, which apply the differentiated approach to the organization of physical education [24, 25]. We adhere to the concept that the implementation of a comprehensive, individualized pedagogical control will contribute to the improvement of the educational process in the field of physical culture and sports.

The application of mobile devices to monitor the health condition and motor activity of students will also be useful. This allows them to determine their adaptability to physical loads. Modern services provide the exchange of information about the students’ physical condition [27]. Similar methods of self-control significantly increase the motivation of students to physical education. However, it is necessary to consider the possibility of uncontrolled application of gadgets. The application of gadgets can have a negative effect on student health. Therefore, individual-directed pedagogical control will contribute to the optimization of approaches to the application of health-improving technologies.

The advantage of our study is substantiation of the expediency of the introduction of complex individual-directed pedagogical control in physical education. The implementation of the principle of in-depth individualization has a medical and social significance. The basis of this approach is to evaluate the psychomotor qualities of students. It promotes the timely detection and prevention of violations of the psychophysical status of students. The introduction of the author’s methodology for determining the students’ adaptability degree to physical loads will contribute to improving the physical education organization.
Conclusions

The proposed objective criteria of the individual characteristics evaluation of students’ physical and psychophysiological condition are acceptable for determining the degree of adaptability of the individual to physical loads. The results of the research conducted have a realistic perspective of implementation in the educational process. The legal and the most appropriate for improving the physical education organization is a comprehensive, individualized pedagogical control. Such an approach considers the peculiarities of physical development and the psycho-psychophysical condition of students.

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Conflict of interest

The author declares that there is no conflict of interest.

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