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ORIGINAL RESEARCH

A comparative analysis of the effects of drop set and traditional resistance training on anaerobic power in young men

Kadir Keskin[1], Fatma Tokat[2]

[1] Faculty of Sport Sciences, Gazi University, Ankara, Türkiye. [2] Faculty of Sport Sciences, Erzincan Binali Yıldırım University, Erzincan, Türkiye.

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Abstract

Drop set is a popular time-efficient resistance training method. This study aimed to compare the impact of drop-set (DS) training versus traditional resistance training (TRT) while ensuring equalized total training volume on the Wingate Anaerobic Test. Twenty-four sports science students were assigned to either DS (n=12) or TRT (n=12) protocols according to their 1 RM values, and they trained twice a week for 6 weeks.1 RM test was only conducted at the beginning of the study, while the Wingate anaerobic power test was administered at baseline and after the intervention period. The study demonstrated a significant main effect of time for peak power ($p< 0.001$), and a between-group interaction effect was observed for peak power ($p< 0.05$). The DS group exhibited slightly higher peak power values compared to TRT ($p< 0.05$, 15% increase for DS, 13% for TRT, ES: 0,50 and 0,36 respectively), while both groups displayed significantly increased values from pre to post-testing ($p < 0.001$). Based on our findings, it can be inferred that DS training leads to slightly greater enhancements in anaerobic power when compared to TRT. Additionally, the study confirmed that a 6-week (12 sessions in total) resistance training program utilizing a load of 70% of 1 RM was sufficient to enhance anaerobic performance in young active men.

Keywords: Anaerobic power, drop set, resistance training.

Introduction

Resistance training (RT) is frequently recommended as an intervention strategy to augment muscular adaptations, including increases in muscle strength, size, and local muscular endurance. The available evidence suggests that the optimization of these adaptations necessitates the manipulation of resistance training variables (Kraemer & Ratamess, 2004; ACSM, 2009). The comprehensive investigation of variables, including intensity and volume of effort, exercise order, number of performed repetitions and sets, tempo of movement, duration of rest periods between sets and exercises, and training status, has been pursued diligently to optimize muscle adaptations (Bird et al., 2005; Ralston et al., 2018). Fundamental constituents of resistance training, namely volume, and load, directly influence the development of muscular adaptations (Schoenfeld et al., 2015; Schoenfeld et al., 2017; Schoenfeld et al., 2019). Empirical evidence suggests that modifications in training load can exert significant effects on the acute metabolic, hormonal, neural, and cardiovascular responses to training (Kraemer & Ratamess, 2004). An optimized strength increase is observed when employing a low repetition scheme involving heavy loads, ranging from 1 to 5 repetitions per set, at loads between 80% to 100% of the individual's 1RM (Schoenfeld et al., 2021). Athletes endeavor to manipulate resistance training (RT) load through

✉ K. Keskin, e-mail: kadirkeskin@gazi.edu.tr
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advanced techniques such as blood flow restriction (Loenneke et al., 2012), rest-pause method (Prestes et al., 2019), cluster sets (Haff et al., 2008; Tufano et al., 2016), and drop sets (Sødal et al., 2023), seeking an additional stimulus to overcome performance plateaus, maximize muscular strength and mitigate training monotony (Krzysztofik et al., 2019).

The implementation of drop sets is among the most prevalent time-efficient training modalities employed to promote muscle strength and hypertrophy. This technique involves executing sets to concentric muscle failure at a specific load and subsequently reducing the load immediately to initiate the subsequent set, taken to either concentric or voluntary muscle failure (Sødal et al., 2023). The execution protocol of drop sets (DS) lacks a well-defined consensus in the current literature and remains a subject of diverse interpretations within the weightlifting community. Since DS may increase time under tension, metabolite accumulation, cell swelling, and training volume, it may be a superior option for hypertrophy. Conversely, it has been hypothesized that DS may not be optimal for strength gains (Coleman et al., 2022), but there is no compelling evidence to accept this assumption. Although the use of DS as a training approach has gained widespread popularity, its effectiveness still must be established through rigorously controlled research studies. Several investigations have been conducted on this subject, yielding conflicting findings (Varovic et al., 2012; Enes et al., 2021; Fink et al., 2018; Ozaki et al., 2017; Angleri et al., 2017). To date, no study has been conducted to compare the anaerobic power outcomes between the DS method and traditional RT under conditions where the training volumes are equated. The primary objective of this study was to undertake a comparative assessment of the effects of DS and TRT methods implemented over a 6-week intervention period on anaerobic power outputs.

Methods

Subjects

Twenty-four active sports science faculty students volunteered to participate in the study. All participants had previous strength training experiences. The participants were assigned to either traditional resistance training (TRT: n=12, age: 20.00±1.12 years, weight: 73.96±5.41 kg, height: 176.42±6.71 cm, body fat: 13%, body mass index: 23.81±1.93) or drop set (DS: n=12, age: 21.00±1.04 years, weight: 81.46±5.64 kg, height: 180.00±6.35 cm, body fat: 15%, body mass index: 25.23±2.53) group according to their 1 RM values. Each participant received comprehensive information concerning the potential risks associated with the study and willingly presented written consent to engage in the study. This study was approved by the Health and Sports Ethics Committee of the Erzincan Binali Yıldırım University (date of approval: June 23, 2023) in accordance with the Declaration of Helsinki for Human Research. The participants were directed to abstain from engaging in strenuous physical activities (beyond those specified in the study program) and to adhere to their existing dietary habits throughout the duration of the study. No dietary restrictions or recommendations were demonstrated or prescribed.

Table 1
Descriptive statistics of the groups (Mean±SD.

Variables	TRT (n=12)	DS (n=12)
Age (years)	20.00±1.12	21.00±1.044
Weight (kg)	73.96±5.41	81.46±5.64
Height (cm)	176.42±6.71	180.00±6.35
BMI (kg/m^2)	23.81±1.93	25.23±2.53

Resistance Training

The study's training phase extended over a period of 6 weeks, during which participants engaged in 2 training sessions per week on non-consecutive days with a total of 12 sessions. The training regimen comprised of two machine-based exercises, namely, leg press and leg extension (Jimsa, Fitness Equipments, Eskişehir, 2000). These exercises were specifically selected to target the quadriceps muscles, particularly in the context of drop sets. A 45-degree leg press device was utilized, and participants received explicit instructions to avoid surpassing a 90-degree knee angle during the eccentric phase of the movement. Additionally, they were rigorously cautioned against lifting their heels off the machine's foot platform. The TRT group trained 4 sets of leg presses and 4 leg extensions, while the DS group trained 3 sets of leg presses and 7 sets of leg extensions. The load utilized for the TRT group corresponded to 70% of their one-repetition maximum (1 RM) with 8-12 reps and, accompanied by a resting period of 3 minutes between sets. The tempo employed for both the concentric and eccentric phases of the exercises was set at 1:2, and the exercise order followed a sequence of leg press followed by leg extension. The DS group performed 3 sets of leg press exercises at 70% of their 1 RM within a repetition range of 8-12. Subsequently, upon finishing the third set, they commenced leg extensions with a weight reduction of 20%, aiming to reach muscular failure. Upon achieving concentric failure, the load was once more decreased by 20%, and participants were instructed to continue the exercise until reaching failure again. Regarding the second exercise, namely the leg extension, the DS group completed three sets with a load equivalent to 70% of their 1 RM, adhering to a repetition range of 8-12. Then, the participants executed two consecutive drop sets until reaching failure, with a reduction of 20% in weight for each successive drop set (Figure 1, resistance training protocol). During each resistance training (RT) session, the number of repetitions and the load used for each set were meticulously recorded. The training volume was determined by multiplying the load (expressed as a percentage of 1RM) by the number of repetitions. Notably, the total training volume for the 12 sessions remained similar across all groups. Resistance training (RT) sessions were conducted under the supervision of competent and certified personal trainers to guarantee the precise execution of the exercises.

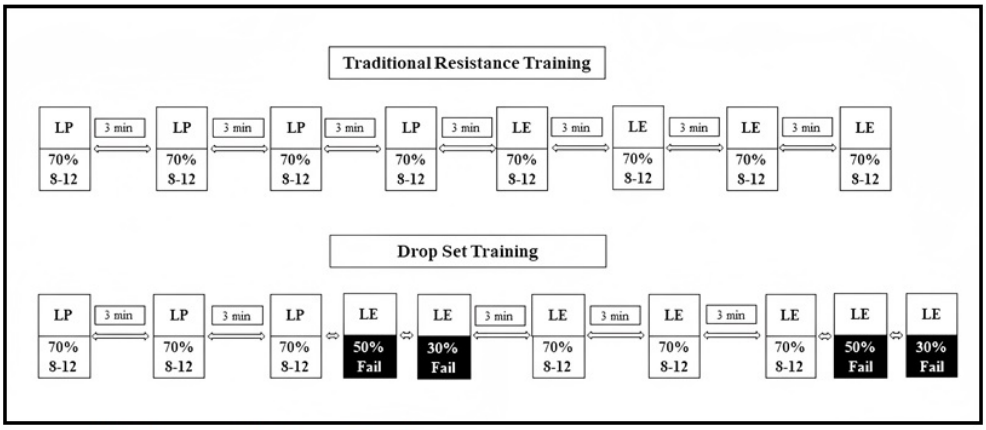

Figure 1. Resistance training protocols.

1 RM Testing

1 RM test was conducted to determine the training load for the participants. Participants underwent a warm-up comprising a 5-minute stationary bicycle ride, followed by a 1-minute rest period. Subsequently, they were familiarized with the resistance machines through 8-10 repetitions of a light load (50% of predicted 1 RM). Following a 2-minute rest, participants executed a load approximately equivalent to 80% of their estimated 1 RM throughout the complete range of motion. Subsequently, the weight was incrementally increased after each successful attempt until reaching failure. Rest intervals of 2-3 minutes were provided between each attempt and the one-repetition maximum (1RM) was achieved within 5 attempts. The order of exercises during the 1RM testing was as follows: leg press followed by leg extension. However, for the leg extension exercise, a 10-repetition maximum (10RM) test was employed to mitigate the risk of injury, as it is not advisable to conduct 1RM testing for single-joint exercises. The estimation of a 1 RM was accomplished using the Brzycki equation, which relies on a 10-repetition maximum (10RM). The equation utilized is as follows: Weight ÷ (1.0278 - (0.0278 × Number of repetitions)).

Wingate Testing

The Wingate test was performed using a friction-loaded cycle ergometer (Monark 894 E model, Sweden) connected to a microcomputer for data interfacing. The seat height and handlebars were individually adjusted to suit each subject. The Wingate test encompassed a 30-second all-out sprint against a constant resistance relative to body weight (7.5% of body weight), as proposed by Ayalon et al. (1974). Prior to testing, all participants engaged in a 10-minute warm-up session on the cycle ergometer with a resistance corresponding to 2% of their body weight. The cycling cadence was set between 70 to 80 revolutions per minute (rpm). After the warm-up, a 1-minute rest period was provided. Participants were informed that the weight basket would automatically drop when a cycling cadence of 100 rpm was achieved. When a consistent pedal rate of 60 rpm was reached, a "3-2-1-go!" countdown was announced, and participants were encouraged to pedal maximally. Subjects were verbally encouraged throughout the test to refrain from pacing and to maintain a maximal effort consistently. Upon completion of the test, the weight basket was raised, and participants continued pedaling without any additional weight for duration of 5 minutes to facilitate a cool-down period. The computer calculated and stored power output every second during the test. Data were collected through the use of software. All performance tests were conducted at least 72 hours after the last training session, and all participants were strictly instructed to abstain from engaging in intense physical activity and from consuming diuretics or stimulants such as coke, coffee, and tea for a minimum of 24 hours before the tests. Environmental variables, such as humidity and temperature, were controlled and maintained at stable levels throughout all test sessions, ensuring uniform diurnal conditions.

Statistical Analyses

Data normality was confirmed using the Shapiro-Wilk test, and variance homogeneity was assessed with Levene's test. Statistical analyses were performed using IBM SPSS Statistics software for Windows (version 22.0), and the data were presented as mean and standard deviation (SD) values. The percentage change was calculated using the equation: %change = (post-test - pre-test) / pre-test * 100. A two-way, repeated-measures ANOVA was employed to examine the interaction between time (pre and post-intervention) and condition (experimental and control). Additionally, a t-test was conducted to assess potential differences in total training volume between the two conditions. When a statistically significant difference was observed over time within or between the groups, a syntax model based on Bonferroni adjustment was utilized to determine the source of the difference. The use of paired or independent t-tests was avoided to minimize the probability of committing a type one error. Also, Eta squared (η^2) values were obtained. Effect sizes were interpreted as small, medium, and large if they corresponded to partial eta-squared values of 0.01, 0.06, and 0.14, respectively (Richardson, 2011). The statistical significance level was predetermined at $p < 0.05$.

Results

A two-way repeated measures ANOVA showed that both DS and TRT groups significantly improved Wingate anaerobic test performance (p<0.001). The DS group showed slightly improved peak power than the TRT group, but the difference was minor (p<0.040; effect size: 0.50 vs. 0.36). Both groups also increased AP with no significant difference between (p>0.05), PD was not significantly changed for TRT, but there was a significant increase in PD for the DS group, as it may be acceptable due to the high PP outputs of DS (Table and Figure 2).

Table 2
Wingate anaerobic test performance changes from pre to post test (Mean±SD).

Variables		TRT	ES	DS	ES
PP (watt)	Pre-Test	796.84±105.33	.36	886.10±132.10	.50
	Post-Test	890.73±148.89[a]		1010.19±116.57[a]	
	Mean Diff	93.83±92.64		124.09±91.40[b]	
	Change %	12%		15%	
PP (watt/kg)	Pre-Test	11±1.80	.49	10.98±1.77	.54
	Post-Test	12.31±1.48[a]		12.44±1.33[a]	
	Mean Diff	1.30±0.94		1.45±1.01	
	% Change	13%		15%	
AP (watt)	Pre-Test	561.25±59.62	.34	635.17±62.76	.25
	Post-Test	618.76±89.97[a]		681.28±62.40[a]	
	Mean Diff	57.51±74.28		46.11±38.99	
	% Change	10%		7%	
AP (watt/kg)	Pre-Test	7.72±0.85	.46	7.83±0.85	.32
	Post-Test	8.48±0.72[a]		8.39±0.78[a]	
	Mean Diff	0.75±0.73		0.55±0.43	
	% Change	10%		7%	
PD (%)	Pre-Test	60.05±8.02	.03	57.29±11.31	.18
	Post-Test	57.23±8.01		63.83±10.25[a]	
	Mean Diff	-2.82±10.12		6.54±10.44	
	% Change	-3%		15%	

PP: Peak power; AP: Average power; PD: Power drop; [a:] A significant difference within groups from pre to post test (p<0.001); [b:] A significant difference between groups for the post tests (p<0.05).

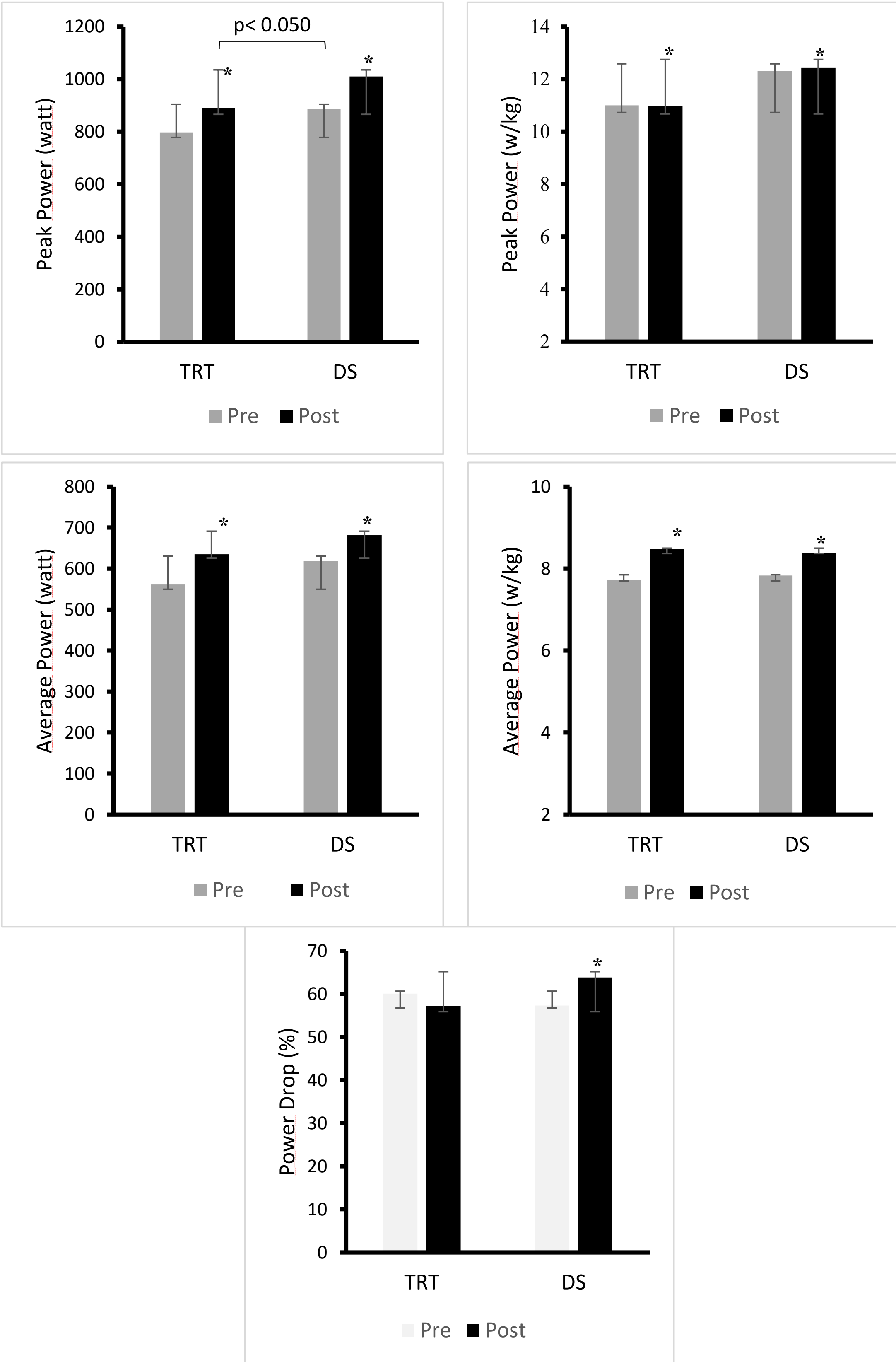

Figure 2. Wingate anaerobic test performance changes.

Discussion

The major finding of this study was that resistance training performed twice a week with a load of 70% 1 RM can significantly improve the anaerobic power of young men. The drop set method also effectively improved the anaerobic performance of young men and marginally better than TRT. These results can be partly explained by the total training volume equated between groups. The total training volume (mean) was calculated as total weight was summed in 12 training sessions and divided into 12 and was 14124.13±1540.49 for TRT and 14309.11±2353.66 for the DS group, respectively. The review by Figueiredo et al. 2018 confirmed that training volume is the most effective variable in resistance training for muscle size and health outcomes, not for strength because exercise load seems to be the predominant variable modifying muscle strength compared to other variables (Borde et al., 2015). However, it was highlighted that higher volume may result in higher strength gains when evaluating different resistance training protocols utilizing the same load (Peterson et al., 2005; Peterson et al., 2004; Rhea et al., 2003). Enes et al. (2021) examined muscle strength adaptations of different RT interventions. Consistent with our findings, DS and TRT elicited similar strength gains when the total training volume equalized. Angleri et al. (2017) compared crescent pyramid and DS systems with TRT in terms of strength and muscle hypertrophy. They found that muscle strength was similar for the groups, which may result from equated total training volume. The training load used for the interventions between groups was identical, which could be another explanation for the result. The present study's training load was also 70% of 1 RM for both groups except for the reduced drop sets. Current data support that utilizing advanced RT systems is unnecessary to optimize muscle strength gains when the total training volume is equated between conditions. Likewise, a similar fact might hold for anaerobic power, given the demonstrated positive association between anaerobic power and muscle strength and muscle morphology (Arslan, 2005; Alemdaroglu, 2012; Lee et al., 2021). It was found that strength-trained individuals exhibited notably higher average anaerobic power levels compared to their non-trained counterparts (Slade et al., 2002). The adaptations resulting from resistance training may contribute to enhanced muscular activation during anaerobic power assessments. Enhanced power output resulting from neural adaptation may be attained through several mechanisms, including heightened recruitment of motor units, improved synchronization of motor unit firing, increased synergistic activation of other muscle groups, or reduced activation of antagonistic muscle groups (Slade et al., 2002).

In contrast to our findings, Fink et al. (2018) reported an increase in triceps push-down 12RM strength of 16.1% for the DS group and 25.2% for the TRT group. However, it is important to note that these differences did not reach statistical significance (effect size: 0.88 vs. 1.34). The difference in outcomes can be attributed, at least in part, to differences in the study design employed by Fink et al. (2018) compared to our own investigation. Specifically, in their study, the DS group underwent training with 12 RM for only one set, while the TRT group engaged in 3 sets. On the other hand, our study involved a more intensive training protocol, with the DS group completing 6 sets at 70% of their 1 RM, and the TRT group performing 8 sets. These findings are consistent with earlier studies, which have indicated that improvements in muscular strength are dependent upon the magnitude of the training load (Schoenfeld et al., 2015; Ogasawara et al., 2013). Ozaki et al. (2017) investigated three resistance exercise conditions: high-load (HL), low-load (LL), and a single high-load set with additional drop sets (SDS). Significant strength gains were observed in the HL and SDS conditions, while the LL group showed no improvement in strength. These findings offer valuable insights into selecting an appropriate initial load for effective drop-set practices. Indeed, the initial load in resistance training can play a crucial role, similar to post-activation potentiation (PAP), in influencing strength gains. By selecting a high-load initial set, the phenomenon of PAP can be harnessed, resulting in enhanced muscle performance during subsequent drop sets. This strategic approach holds promise for optimizing strength adaptations and further improving resistance exercise outcomes (Petisco et al., 2019).

Conclusion

In conclusion, this study demonstrates the effectiveness of the drop sets (DS) method in enhancing anaerobic power among young men. While it exhibits similarities to traditional resistance training, the DS method shows a slight advantage. Due to its time efficiency, athletes and coaches can incorporate DS into their conditioning process for variation and potential performance gains. Existing research on the DS method predominantly focuses on hypertrophic adaptations, attributing its ability to increase metabolic and mechanical stress. However, further investigations are warranted to elucidate its impact on muscular adaptations fully. Additional studies are essential to comprehensively understand the comprehensive benefits of the DS method in resistance training programs.

Authors' Contribution

Study Design: KK, FT; Data Collection: KK, FT; Statistical Analysis: KK; Manuscript Preparation: KK, FT.

Ethical Approval

The study was approved by the Erzican Binali Yıldırım University Health and Sport Sciences Ethical Committee (2023/06) and it was carried out in accordance with the Code of Ethics of the World Medical Association also known as a declaration of Helsinki.

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The authors declare that the study received no funding.

Conflict of Interest

The authors hereby declare that there was no conflict of interest in conducting this research.

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