EFFECTS OF SPRINT AND PLYOMETRIC TRAINING ON MORPHOLOGICAL CHARACTERISTICS IN PHYSICALLY ACTIVE MEN

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Abstract:

The purpose of this study was to compare the effects of sprint and plyometric training on morphological characteristics of physically active men. One hundred and fifty one physical education students (18-24 years of age) were allocated into one of three groups: the plyometric group (PG; $n = 50$), the sprint group (SG; $n = 50$), and the control group (CG; $n = 51$). Both experimental groups participated in a training programme 3 times a week for 10 weeks. SG performed maximal sprints for distances between 10 and 50 meters, while the training programme in PG consisted of hurdle jumps and drop jumps. Anthropometric measurement was performed in the week before and the week after the experiment. There were no significant differences ($P > 0.05$) in magnitude of changes in any of the analysed anthropometric variables between the groups. However, a significant decrease ($P < 0.0167$) in the percentage of body fat (6.1%) was found in SG. We also found a significant decrease ($P < 0.0167$) in body mass (1%), fat-free mass (0.4%) and body mass index (0.9%) for the SG, but the magnitude of these changes was rather low. We conclude that the short-term explosive-type training programmes in which muscles operate in the fast stretch-shortening cycle conditions (i.e., sprinting, jumping) have a limited potential to induce morphological changes in physically active men.

Key words: *sprint running, jumping, hypertrophy, body composition*

EFFEKTE DES SPRINT- UND PLYOMETRISCHEN TRAININGS AUF DIE MORPHOLOGISCHEN CHARAKTERISTIKEN DER REGELMÄßIG SPORTTREIBENDEN STUDENTEN

Zusammenfassung:

Das Ziel dieser Studie war, die Effekte des Sprinttrainings und des plyometrischen Trainings auf die morphologischen Charakteristiken der regelmäßig sporttreibenden Studenten zu bestimmen. Einhundert einundfünfzig Studenten der Kinesiologie (im Alter 18-24 Jahre) wurden einer der drei Gruppen zugeteilt: der plyometrischen Gruppe (PG; n = 50), der Sprint- (SG; n = 50), und der Kontrollgruppe (CG; n = 51). Die beiden experimentellen Gruppen trainierten 10 Wochen, 3 Mal wöchentlich. Die SG legte die Strecken zwischen 10 und 50m in maximalen Sprintläufen zurück, während das Trainingsprogramm für die PG aus Hoch- und Fallsprüngen bestand. Die anthropometrischen Messungen wurden eine Woche vor und eine nach dem Experiment vorgenommen. Keine signifikante Unterschiede ($P > 0,05$) im Veränderungsumfang aller analysierten anthropometrischen Variablen wurden zwischen den Gruppen festgestellt. Allerdings wurde eine signifikante Abnahme ($P < 0,0167$) des prozentualen Körperfettanteils (6,1%) in der SG gefunden. Wir bemerkten auch eine signifikante Abnahme ($P < 0,0167$) in der Körpermasse (1%), der fettfreien Masse (0,4%) und im Köpermassenindex (0,9%) bei der SG, aber das Ausmaß dieser Veränderungen war ziemlich niedrig. Wir schließen daraus, dass die kurzfristige und explosive Übungen beinhaltenden Trainingsprogramme, bei denen die Muskel in den Umständen des schnellen Dehnungs-Verkürzungs-Zyklus arbeiten (z.B. Sprintläufe, plyometrische Sprünge) einen begrenzten Potential besitzen, um morphologische Veränderungen bei den regelmäßig sporttreibenden Männern beizubringen.

Schlüsselwörter: *Sprintläufe, Springen, Hypertrophie, Körperzusammensetzung*

Introduction

Muscle strength and power are important determinants of a successful performance in many individual and team sports. Consequently, during the past decades much attention both from coaches and researchers has been focused on determining the optimal training methods for the development of strength, power and competitive performance (Adams O'Shea, O'Shea, & Climstein, 1992; Little, Wilson & Ostrowski, 1996; Wilson, Newton, Murphy & Humphries, 1993). Currently, to enhance muscular power and dynamic performance athletes commonly use: 1) heavy resistance training (80-90% of one repetition maximum; 1RM), and 2) explosive-type training in a form of either resistance training (30-60% of 1RM) or plyometric training (Newton & Kraemer 1994).

Previous studies have clearly shown that both heavy-resistance training (Häkkinen, Alen, & Komi, 1985a; Kraemer et al., 2000a) and explosive-type resistance training (Häkkinen, Komi, & Alen, 1985b; Wilson, Newton, Murphy, & Humphries, 1993) can improve muscle strength, power and athletic performance. However, the exact mechanisms responsible for the improvement in muscle function and performance differ between these two training methods. In particular, it is well documented that heavy-resistance training enhances muscle function by increasing muscle size (i.e., hypertrophy), and/or by increasing the neural activation of muscle (Häkkinen, Alen, & Komi, 1985a; Jones & Rutherford, 1987; Sale, 1992). In addition, heavy-resistance training can also change body composition by increasing fat-free mass and reducing body fat percentage (Kraemer et al., 2000a). Therefore, changes in muscle function and performance induced by heavy-resistance training can partly be the result of adaptive changes in morphology. In contrast, it is generally believed that explosive-type resistance training does not produce substantial morphological changes, and that the main adaptive changes in muscle function and performance as a result of this type of training are due to an increased neural activation of muscle (Sale, 1992). However, this is not a universal finding and several studies reported also a significant increase in fat-free mass (Häkkinen, Komi, & Alen, 1985b), muscle fibre cross-sectional area (Häkkinen, Komi, & Alen, 1985b) and decrease in percentage of body fat (Häkkinen, Komi, & Alen, 1985b) as a result of explosive-type resistance training, suggesting that explosive-type training of sufficient intensity and duration can also elicit certain morphological adaptation in humans.

In addition to both heavy and explosive resistance training protocols, plyometric training can also improve muscle function and athletic performance (Bobbert, 1990; Gheri, Ricard, Kleiner, & Kirkendall, 1998), and these effects are mainly the result of various neural and mechanical changes (Adams, O'Shea, J., O'Shea, K., & Climstein, 1992; Bobbert, 1990; Sale, 1992), although few studies reported an increase in body mass (e.g., Luebbers et al., 2003; Potteiger et al., 1999) and the cross-sectional area of muscle fibers (Potteiger et al., 1999). Similar to plyometric training, sprint running also represents an explosive-type training method commonly used in athletic training. However, unlike plyometric training, in which the leg extensor muscles operate solely in stretch-shortening cycle (SSC), sprint running involves both concentric and SSC muscle function (Delecluse, 1997). Moreover, sprint running involves an activation of much greater proportion of muscles compared to plyometric training, thereby increasing the metabolic demands of such training. It is also important to stress that several cross-sectional studies showed that sprinters have greater muscle mass (Spenst, Martin, & Drinkwater, 1993) and a larger cross-sectional area of leg extensor muscles (Hakkinen & Keskinen, 1989) compared to endurance-trained athletes or controls a of similar size.

It can, therefore, be hypothesized that sprint training might lead to greater morphological changes, compared to plyometric training. Hence, the purpose of this study was to compare the effects of a 10-week sprint and plyometric training programme on the morphological characteristics in physically active, but untrained men.

Methods

Subjects

One hundred and fifty one male physical education students (18-24 years of age) volunteered to participate in this study after having had all of the risks explained to them before the investigation. The study was approved by the Ethics Committee of the Faculty of Kinesiology, University of Zagreb. None of the subjects reported any medical or orthopaedic problems that would compromise his participation and performance in the study.

Experimental design

The subjects were assigned in alphabetical order to one of three groups: the plyometric group (PG; $n = 50$), the sprint group (SG; $n = 50$), and the control group (CG; $n = 51$). The groups did not differ significantly ($P > 0.05$) in any of the analysed anthropometric measures at the beginning of the experiment. The control group was instructed to maintain their regular daily activities (i.e., academic schedule) and to avoid any additional strenuous physical activity during the study. The subjects in both experimental groups, in addition to their regular academic physical activities, completed 10 weeks of a 3-day a week exercise training programme on alternate days with a pause of one week in the middle of the training programme study (see Table 1). The training sessions in both experimental groups lasted 60 minutes, and began with a standard 15 minutes warm-up that included running for 5 minutes and was followed by calisthenics, stretching, and 5 submaximal counter movement jumps (PG) or 3 submaximal sprints of 20 meters (SG). The training programme employed by each experimental group is outlined in Table 1.

Table 1. Training programme for the plyometric- and sprint-training group.

	Plyometric group	Sprint group
Week	*Exercise × sets × reps*	*Exercise × sets × reps*
1	40cm hurdle jumps × 5 × 10	Sprint 10m × 3 × 3
2	40cm hurdle jumps × 7 × 10	Sprint 10m × 4 × 3
3	40cm hurdle jumps × 10 × 10	Sprint 20m × 3 × 3
4	60cm hurdle jumps × 5 × 10	Sprint 20m × 4 × 3
5	60cm hurdle jumps × 7 × 10	Sprint 30m × 3 × 3
6	Rest	Rest
7	60cm hurdle jumps × 10 × 10	Sprint 30m × 4 × 3
8	40cm drop jumps × 4 × 10	Sprint 40m × 3 × 3
9	40cm drop jumps × 4 × 10	Sprint 40m × 4 × 3
10	40cm drop jumps × 4 × 10	Sprint 50m × 3 × 3
11	40cm drop jumps × 4 × 10	Sprint 50m × 4 × 3

Note: rest between sets was 2-3 min.

The subjects in both experimental groups were instructed to perform exercises in each training session with maximum effort (i.e. maximal intensity). For the PG, this meant that each jump should be performed to reach maximal height with minimal ground contact time (i.e. so called "bouncing-type" jumps; see Bobbert, 1990). Specifically, both hurdle jumps and drop jumps were performed with small knee angular movements, touching the ground with the ball of the feet only (Kovacs et al., 1999), thereby stressing the calf muscles particularly. Each set of hurdle jumps consisted of ten continuous jumps over hurdles placed in front of the subject with an inter-distance of about 1 meter. Each set of drop jumps consisted of ten maximal rebounds after the drop from the 40 centimetre high box with the pause between each rebound being about 5 seconds (i.e. time needed for the subject to step on to the box again). For the SG, this meant that each sprint run should be performed with maximum acceleration and speed. The subjects were also instructed to maintain their normal dietary practices throughout the investigation. The anthropometric measurement was performed in the week before and the week after the 10-week training period. All training sessions took place at the same time of day to control the circadian variation in performance. The subjects showed 100% compliance with the exercise training programme.

Testing procedures

All the anthropometric measurements were performed by three experienced technicians according to the recommendations of the International Biological Program (Weiner & Lourie, 1969). Body mass and body height were measured by a balance beam scale and a portable stadiometer to the nearest 0.1kg and 0.5cm respectively. Body mass index (BMI) was calculated as follows: BMI = body mass / body height^2. Skinfold thickness was obtained using a Lange skinfold caliper at the calf, chest, thigh, triceps and subscapular regions. Three trials were performed and the median value was used in further analysis. The skinfolds recorded at the chest, thigh and subscapular regions were also used for the estimation of body density (Jackson & Pollock, 1978). The body fat percentage was calculated according to the method of Siri (1956). Fat-free mass (FFM) was calculated as the difference between body mass and fat mass. Thigh and calf girths were measured using an anthropometric tape. The calculation of the corrected girths (to estimate the subjects' thigh and calf muscle girths) used the principal assumptions outlined in Stewart and associates (2002). In brief, tissue boundaries were assumed to be circular and concentric. If the skin plus adipose tissue thickness is d, and the thigh and calf girth is G, then the corrected muscle girth (MG) is estimated by $MG = G - 2 \times \pi \times d$ (skinfold values are converted to cm for this calculation). If it is further assumed that the skinfold caliper reading S is twice the adipose tissue thickness, then $MG = G - \pi \times S$.

Statistical analysis

The data in each group are reported as means ± SD. All the anthropometric variables were normally distributed, as verified by the Kolmogorov-Smirnov Test ($P > 0.2$). Magnitude of changes in the three groups was compared using a one-way analysis of variance (ANOVA) on the difference (post-test minus pretest) scores. When appropriate, Tukey's *post hoc* tests were employed to locate the specific significant differences between the groups. The level of statistical significance was set at $P < 0.05$. Effects of training within each group were assessed using Dunn's multiple comparison procedure incorporating the Bonferroni correction to maintain the family-wise Type I error rate at 0.05 (Kirk, 1982). By using the Bonferroni correction, the 0.05 significance level was divided by three (three t-tests), yielding a Type I error rate of 0.0167 for each t-test. The precisions of our estimates of outcome statistics are shown as 95% confidence limits (which represent the likely range of the true value in the population from which the sample was drawn).

Results

Changes in morphological characteristics of the subjects in all groups are depicted in Table 2. There were no significant differences ($P > 0.05$) in the magnitude of changes in any of the analysed anthropometric variables between the groups. Sprint training resulted in a significant decrease ($P < 0.0167$) of body mass (1%), BMI (0.9%), FFM (0.4%), and the percentage of body fat (6.1%). No significant differences ($P > 0.0167$) in the anthropometric measures were observed in either PG or CG from pre- to post-training. However, note that the magnitude of changes in the body size measures (i.e., body mass, BMI, and FFM) found in the SG was rather small (0.4-1.0%).

Table 2. Anthropometric characteristics (Mean ± SD) for each group at pretest and post-test

Plyometric group	Pretest	Post-test	Difference	95% CI	
Body mass (kg)	77.1 ± 7.5	76.7 ± 7.4	-0.43	-0.85	-0.01
FFM (kg)	70.7 ± 6.2	70.5 ± 6.1	-0.17	-0.56	0.21
Height (cm)	181.6 ± 6.5	181.6 ± 6.5	0.04	-0.20	0.28
BMI (kg/m^2)	23.4 ± 1.9	23.2 ± 1.9	-0.15	-0.29	-0.01
Thigh muscle girth (cm)	57.8 ± 3.6	57.3 ± 4.6	-0.50	-1.08	0.08
Calf muscle girth (cm)	37.4 ± 2.2	37.6 ± 2.0	0.21	-0.09	0.51
Body fat (%)	8.2 ± 3.3	7.9 ± 3.5	-0.29	-0.58	0.00
Sprint group	Pretest	Post-test	Difference	95% CI	
Body mass (kg)	77.3 ± 8.0	76.6 ± 7.8§	-0.70	-1.12	-0.28
FFM (kg)	71.3 ± 6.9	71.0 ± 6.9§	-0.27	-0.65	-0.12
Height (cm)	180.6 ± 7.2	180.6 ± 7.3	0.00	-0.24	0.23
BMI (kg/m^2)	23.7 ± 1.8	23.5 ± 1.7§	-0.22	-0.36	-0.08
Thigh muscle girth (cm)	58.0 ± 3.5	58.0 ± 3.2	0.03	-0.55	0.60
Calf muscle girth (cm)	38.0 ± 1.9	38.0 ± 1.9	-0.05	-0.35	0.26
Body fat (%)	7.7 ± 3.0	7.3 ± 2.6§	-0.47	-0.76	-0.18
Control group	Pretest	Post-test	Difference	95% CI	
Body mass (kg)	74.0 ± 7.9	73.7 ± 7.6	-0.31	-0.72	0.11
FFM (kg)	68.8 ±6.3	68.6 ± 6.3	-0.20	-0.59	0.17
Height (cm)	181.2 ± 6.1	181.2 ± 6.2	-0.06	-0.29	0.18
BMI (kg/m^2)	22.5 ± 1.9	22.4 ± 1.7	-0.08	-0.21	0.06
Thigh muscle girth (cm)	56.2 ± 3.4	56.1 ± 3.2	-0.05	-0.63	0.52
Calf muscle girth (cm)	36.6 ± 2.3	36.7 ± 2.0	0.04	-0.26	0.34
Body fat (%)	7.9 ± 3.2	7.8 ± 3.2	-0.04	-0.33	0.25

§ Significantly different ($P < 0.0167$) compared to pretest.

Discussion and conclusions

To our knowledge, this is the first study that has compared the effects of sprint and plyometric training on human morphological characteristics. In general, the results of this study show that the 10 weeks of sprint and plyometric training have limited effects on the morphological characteristics of physically active men. In contrast to our hypothesis, no significant differences in the magnitude of changes in the anthropometric measures between groups were found. This can be explained by the short duration of the study (i.e. 10 weeks) and by the fact that our subjects belong to the population of young, healthy and physically highly active men. Therefore, a greater overall training volume and/or a longer duration of the training programme for both sprint and plyometric training are needed to induce greater changes in the morphological status of physically active men. However, changes in certain morphological characteristics, particularly in the SG, occurred (see Table 2) and deserve to be discussed.

An important finding of this study is related to the significant decrease in the percentage of body fat observed over the 10 weeks of sprint training. This finding is rather surprising considering the fact that fast SSC movements (i.e. sprinting and SSC jumping) are less metabolically demanding compared to slow movements (Ballor, Becque & Katch, 1987). Moreover, our subjects already had a very low body fat percentage at the beginning of the experiment. Specifically, the recorded skinfold values (data not shown) and the derived percentage of body fat at the pretest were comparable to the values reported for trained college wrestlers (McCardle, Katch, & Katch, 1999) and distance runners (Wilmore, 1983). The decrease of the percentage of body fat in the SG probably also resulted in a significant, albeit small decrease in body mass. Häkkinen and co-workers (1985b) also reported a significant reduction in the percentage of body fat as a result of explosive-jump training. It is also important to note that elite male sprinters, who mostly perform explosive-type activities (i.e. sprinting, jumping, bouncing, etc.), generally have very low values of the body fat percentage (McArdle et al. 1999), suggesting that long-term explosive training can elicit changes in body composition. A trend in the decrease of the percentage of body fat was also found in PG (3.5% change; $P = 0.05$). In contrast, more recent studies reported no change in body composition as a result of either plyometric training (Luebbers et al., 2003, Poettiger et al., 1999) or combined sprint/plyometric training (Kraemer, Ratamess, Volek, Mazzeti, & Gomez, 2000b).

Several possible factors may be responsible for the decrease in the percentage of body fat observed in our study. First, one could argue that the results could be an artifact of low reliability of the measurement of skinfold thickness. We believe that this was not the case in our study. Specifically, test-retest reliability coefficients for the measurement of skinfold thickness in our study ranged between 0.98 and 0.99, and the corresponding coefficients of variation ranged between 1.7% and 2.1%. More plausible explanations for the general trend of the decrease in the percentage of body fat in both experimental groups might be related to a training-induced increase in the energy expenditure of subjects, which was not accompanied by an increase in caloric energy intake. Of course, the limitation of this study was that there was no control of the dietary habits of subjects. However, since the subjects were instructed not to change their nutritional habits during the study, it is reasonable to assume that the dietary habits did not differ significantly between the groups. Our results suggest a somewhat greater reduction of body fat for the SG, compared to the PG. This finding could be explained by the greater energy expenditure for sprint running, compared to SSC jumping. Specifically, sprint running requires a strong activation of both lower- and upper-body musculature (Ward, Dintiman, & Ward, 2003). In contrast, during SSC jumps, much less activity of the upper-body is present. Moreover, sprint running activates a great proportion of leg muscles, including *m. gluteus maximus*, *m. quadriceps femoris*, *m. aductor magnus*, the hamstring and calf muscles (Delecluse, 1997; Wieneman & Tidow, 1995), while during small amplitude SSC jumps (i.e., bouncing-type forefoot SSC jumps) the calf muscles are primarily loaded (Kovacs et al., 1999). Another explanation could be the difference in the overall training volume between these two training programmes. Although it is generally difficult to compare training volumes of sprint running and jumping, we remind the reader that the training sessions in both experimental groups were of the same duration (i.e. 60 min), and that the 15-min warm-up was essentially the same for both groups. Therefore, we believe that the main reason for the reduction of body fat found in SG and, to a lesser degree, in PG, was the training-induced increase in the caloric energy expenditure, which was not accompanied by an increased caloric energy intake of the subjects. Further studies carefully controlling the dietary status of participants are needed to clarify this issue.

Previous studies demonstrated that both sprint running (Mero & Komi, 1992; Wiemann & Tidow, 1995) and SSC jumping (Kovacs et al., 1999) strongly activate the calf and thigh muscles. Still, no changes in the thigh and calf muscle girths for either PG or SG were found in this study. The lack of changes in muscle girths following the 10-week sprint or plyometric training programme may be explained by several reasons. First, the training programmes in both experimental groups used high-velocity movements intended to improve explosive muscular power, and not to cause muscles to hypertrophy. Kraemer and associates (2000b) argued that high contraction velocities are less metabolically demanding and are less conductive for increasing muscle hypertrophy. Moreover, it is a well-known fact that the eccentric phase is critically important to muscular hypertrophy (Hather, Tesch, Buchanan, & Dudley, 1991). However, during sprin-ting and plyometric jumping the leg muscles mostly operate in fast concentric (e.g. quadriceps and gluteus muscles during the starting phase of the sprint; Delecluse, 1997) and/or SSC conditions (e.g. calf muscles during maximum running speed, and during drop jumping; Delecluse, 1997). Further, SSC movements are characterized by the short duration and small joint movement amplitudes during the eccentric phase in which the whole muscle-tendon complex lengthens but the muscle fibers operate nearly isometrically (Kurokawa, Fukunaga, Nagano, & Fukashiro, 2003). Therefore, it is likely that the lack of accentuated eccentric muscle contraction in fast SSC movements may have also contributed to the lack of hypertrophy observed in the present study. Finally, if we take into account the generally accepted time course of the adaptations to strength and power training (Moritani, 1992), the duration of this study was probably too short to induce any substantial muscle hypertrophy, particularly for explosive-type training programmes (Hakkinen, Komi, & Alen, 1985b). Namely, this concept states that in strength and power training the increase in neural drive accounts for the larger proportion of the initial strength increment (i.e. during the first 6-8 weeks) and thereafter both the neural adaptation and hypertrophy take place for a further increase in strength, with hypertrophy becoming the dominant factor (Moritani, 1992). Taken together, we believe that the short-term explosive-type training in which muscles operate in fast SSC (i.e. sprinting and SSC jumping) are not well suited for muscular hypertrophy.

To summarise, 10 weeks of sprint training resulted in a significant decrease in the percentage of body fat of the subjects, while a similar trend was also observed for the plyometric training group. However, there were no differences in the magnitude of changes in any of the analysed anthropometric variables between the groups. Therefore, we conclude that the short-term explosive-type training utilizing SSC muscle function has limited effects on the morphological characteristics in physically active men. Future studies should examine the effects of long-term (12 or more weeks) SSC training on morphological characteristics while carefully controlling the dietary status of the subjects.

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EFEKTI SPRINTERSKOG I PLIOMETRIJSKOG TRENINGA NA MORFOLOŠKE KARAKTERISTIKE TJELESNO AKTIVNIH MUŠKARACA

Sažetak

Uvod

Tijekom posljednjih desetljeća znatan napor trenera i istraživača bio je usmjeren na utvrđivanje optimalnih metoda treninga namijenjenih razvoju jakosti, snage te natjecateljskih kvaliteta. Trenutno se u te svrhe najčešće koriste: 1) trening s velikim opterećenjima (75-90% od maksimalnoga), 2) trening s malim i umjerenim opterećenjima (30-60% od maksimalnoga) eksplozivnoga karaktera i 3) pliometrijski trening. Ovamo svakako ubrajamo i sprinterski trening, no ta metoda nije bila predmetom proučavanja dosadašnjih istraživanja. Prijašnja istraživanja jasno su pokazala kako trening s velikim opterećenjima dovodi do poboljšanja jakosti, snage i motoričke učinkovitosti putem živčano-mišićnih i morfoloških promjena, dok trening s manjim opterećenjem eksplozivnoga karaktera prvenstveno rezultira živčano-mišićnim adaptacijskim promjenama. Učinci sprinterskoga i pliometrijskog treninga na morfološke karakteristike vježbača malo su poznati. Stoga je temeljni cilj ovog istraživanja analizirati efekte sprinterskog i pliometrijskog treninga na morfološke karakteristike mladih i tjelesno aktivnih muškaraca.

Metode

Ukupno 151 student prve godine Kineziološkog fakulteta dobrovoljno je sudjelovao u ovom istraživanju. Uzorak je abecednim redoslijedom podijeljen u tri skupine: pliometrijska skupina (PG; n = 50), sprinterska skupina (SG; n = 50) i kontrolna skupina (CG; n = 51). Nije bilo statistički značajnih razlika između grupa na početku eksperimenta ni u jednoj mjerenoj morfološkoj varijabli. Sve tri skupine pohađale su redovnu nastavu na prvoj godini studija Kineziološkog fakulteta u trajanju od jednog semestra. Osim toga, grupe PG i SG sudjelovale su u desetotjednom treningu tri puta tjedno po 60 minuta. Grupa PG provodila je pliometrijski trening - skokovi preko prepona i dubinski skokovi, dok je grupa SG provodila sprinterski trening na dionicama između 10m i 50m. Obje su eksperimentalne skupine na svakom treningu izvodile vježbe maksimalnim intenzitetom. Između petog i šestog eksperimentalnog tjedna napravljena je stanka u treningu u trajanju od tjedan dana radi odmora i oporavka vježbača. Educirani mjeritelji obavili su antropometrijska mjerenja tjedan dana prije početka i tjedan dana nakon završetka 10-tjednog eksperimenta u skladu s uputama Međunarodnog biološkog programa (IBP). Mjereneni su: tjelesna masa, tjelesna visina, opseg natkoljenice, opseg potkoljenice te kožni nabori natkoljenice, potkoljenice, prsa, nadlaktice i leđa. Također su izračunati postotak tjelesne masti (Jackson & Pollock; Siri, 1956), nemasna masa tijela te indeks tjelesne mase. Opsezi natkoljenice i potkoljenice korigirani su za veličinu kožnih nabora prema metodi Stewarta i suradnika (2002). Veličine promjena u analiziranim morfološkim varijablama između skupina komparirane su analizom varijance (ANOVA) na varijablama razlika (rezultat finalnog mjerenja minus rezultat inicijalnog mjerenja). Razina statističke značajnosti zaključivanja postavljena je na $p < 0.05$. Efekti treninga unutar svake skupine analizirani su *t*-testom za zavisne uzorke s korekcijom razine statističke značajnosti Bonferroni ($p < 0.0167$).

Rezultati

Nije bilo statistički značajnih razlika ($p > 0.05$) između skupina u veličini promjena ni u jednoj morfološkoj varijabli. Trening sprinta doveo je do statistički značajnog ($p < 0.0167$) smanjenja tjelesne mase (1%), indeksa tjelesne mase (0.9%), nemasne mase tijela (0.4%) te potkožnog masnog tkiva (6.1%). Nije bilo statistički značajnih promjena ($p > 0.0167$) u analiziranim morfološkim varijablama u skupinama PG i CG. Valja, međutim, istaknuti kako je veličina promjena u varijablama veličine tijela (tj. tjelesna masa, nemasna masa tijela te indeks tjelesne mase) generirana sprinterskim treningom relativno mala (0.4-1%).

Rasprava i zaključci

Sveukupno gledajući, rezultati ovog istraživanja pokazuju kako i sprinterski i pliometrijski trening u trajanju od 10 tjedana relativno malo utječu na morfološke karakteristike tjelesno aktivnih muškaraca. Naime, nisu utvrđene značajne razlike između eksperimentalnih skupina i kontrolne skupine u veličini promjena analiziranih morfoloških varijabla. Razlog tomu vjerojatno je relativno kratko trajanje eksperimenta (10 tjedana) te homogenost i pozitivna selekcioniranost uzorka ispitanika u području morfoloških obilježja. Ipak, zabilježene su promjene u određenim morfološkim karakteristikama, osobito u skupini SG. Važan i nadasve iznenađujući rezultat ovog istraživanja vezan je uz značajno smanjenje postotka tjelesne masti zabilježen u skupini SG. To je tim više iznenađujuće ako se uzme u obzir da su analizirani ispitanici već na početku eksperimenta imali vrlo nizak postotak tjelesne masti (< 8%). Trend smanjenja postotka tjelesne masti zabilježen je i u skupini PG. Smatramo kako je smanjenje postotka tjelesne masti rezultat prvenstveno povećanja energetske potrošnje koje ispitanici nisu popratili povećanim energetskim unosom. Ukratko, zaključak istraživanja jest kako sprinterski i pliometrijski trening u trajanju od 10 tjedana ograničeno utječu na morfološke karakteristike tjelesno aktivnih muškaraca.