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Effects of sprint interval training on body composition and anthropometry in recreational long-distance runners

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Abstract

Background The purpose of the study was to investigate the anthropometric effects of sprint interval training (SIT) protocol on body composition and the circumferences of selected body segments in recreational long-distance runners.

Methods A sample of 17 participants was randomized to receive sprint interval training (SIT; *n*=8) and continuous endurance training (CONT; *n*=9). CONT trained three to four times per week while SIT executed two interval training sessions and one continuous training session per week. The present study involved 4 to 8 min bouts in one interval training unit, whereas the control group trained from 40 to 150 min (40-50km per week). Training duration was 8 weeks. Pre- and post-intervention measures of body composition were determined by near-infrared interactance. Circumferences (chest, waist, calf and thigh of the dominant leg) were recorded.

Results No decrease in body fat mass was observed in SIT. Additionally, post-intervention waist circumference significantly decreased (p<0,05) whereas chest and dominant-leg thigh circumferences significantly increased when comparing pre- and post-training session values across the intervention (both p<0,001).

Conclusions Evaluating changes in chest and thigh circumferences immediately following an interval training session may serve as an additional indicator of training progress in recreational long-distance runners.

Introduction

The growing popularity of recreational long-distance running, a physical activity free of age- or sex-related contraindications, has translated into increased participation in marathon races (Tanda and Knechtle 2013, Rapoport 2010). In recent years, research has focused on the relationships between the application of various training modalities and protocols on physiological and anthropometric outcomes in order to enhance the overall training process and maximize performance in long-distance competition (Barandun et al. 2012, Rűst et al. 2011).

Besides more readily observable changes in muscle mass and body composition, different training modalities evoke varied physiological and metabolic adaptations (Jenkins et al. 2010, Filaire and Lac 2002). For example, traditional continuous endurance training has been found to increase myofibril, membrane protein, and mitochondria content; improve contractile protein synthesis; increase levels of glycogen, phospholipids, ATP, and phosphocreatine; and raise available potassium and calcium, and magnesium stores (Kenney et al. 2015, Oöpik et al. 2003, Taylor and Bachman 1999, Bergeron 1995). However, the range of adaptations in the availability of energy substrates necessary for aerobic (oxidative) or anaerobic glycolytic metabolism are attributed mainly to the metabolic profile of muscle fibers (Hickson et. al. 1979). Another training modality, interval training, has been at the forefront of sports science research as a time-efficient exercise strategy that shows magnified improvements in fitness level, muscle mass, energy expenditure, and fat when compared with continuous exercise (Smith et al. 2013, Hazell et al. 2012, Hottenrott et al. 2012, Boutcher 2011). The positive training adaptations of interval training are credited to its repetitive structure of high-intensity exercise (particularly when maximal efforts are performed), as it mobilizes all of the energy systems perform work during high lactate concentration and low muscle glycogen and blood pH levels. Among the various metabolic effects are increased oxidative enzyme activity and, consequently, triglyceride oxidation (Buchheit and Laursen 2013, Gibala et al. 2012, Burgomaster et al. 2005, MacDougall et al. 1998).

As is well known, the training effects of a given exercise modality are dependent on the actual protocol and utilized energy systems (Wierzbicka-Damska 2013). Among various external manifestations, of which the most commonly measured is body composition, the anthropometric measurement of body circumferences can serve as an easily-assessable indicator of physical status. Exercise-induced changes in circumference are ascribed to a variety of factors, including extravascular water displacement, a major component of the human body (60–70% of total mass) (Nygren et al. 2000), and muscle swelling, particularly if eccentric contractions were performed (Clarckson and Hubal 2002).

In order to further elucidate the influence of interval training on global and local anthropometry, the purpose of the present study was to investigate the effects of a sprint interval training protocol on body composition and the circumferences of selected body segments in recreational long-distance runners.

Materials and methods

Subjects

The study recruited 17 male and female recreational long-distance runners preparing for a marathon race from a local running association. None declared to have any competitive or professional experience with long-distance running. All volunteers gave written in-formed consent to participate in the present investigation, which was performed according to the declaration of Helsinki and approved by the local ethics committee. The sample was randomly divided into two groups, one receiving sprint interval training (SIT) (*n*=8; 3 women and 5 men) and the other continuous endurance training (CONT) (*n*=9; 3 women and 6 men). The characteristics of the groups are provided in Table I.

Table I. Anthropometric and performance characteristics of SIT and CONT at study outset ($\bar{x}$±*SD*)

Group	**Age [years]**	**Body height [cm]**	**Body mass [kg]**	**Training experience [years]**	**Best 10 km time [min]**	**Best marathon time [min]**
SIT	34,25	175,63	76,29	2,1	47,5	238,7
	±9,39	±11,53	±17,75	±0,8	±2,8	±16,2
CONT	34,22	174,0	70,87	2,1	45,0	241,8
	±15,95	±6,71	±10,27	±0,9	±5,5	±13,2

Measurements

Anthropometry and body composition were measured immediately before and after the intervention at the Exercise Laboratory of the University School of Physical Education in Wrocław, Poland (PN-EN ISO 9001:2001 certified). Body height and mass were assessed using a WPT 200 medical scale (Radwag, Poland) from which body mass index (BMI) was calculated (mass/height^2). Lean body mass (LBM), fat body mass (FBM), percent fat mass (%FM), and percent body water (%H_2O) were determined by near-infrared interactance using a 6100/XL analyzer (Futrex, Great Britain) placed on the middle of the biceps brachii muscle of the dominant upper limb (Conway and Norris 1984).

Circumferences of the chest, waist, and calf and thigh of the dominant leg were measured using anthropometric tape to the nearest 0.5 cm. Accordance to Guidelines for assessing body circumference set forth by the American College of Sports Medicine (ACSM). Circumference measurements were also taken before and after each training session in SIT in order to compare pre- and post-session differences over the course of the training intervention.

Intervention

The intervention duration was 8 weeks. All training was performed on a tartan track or running path. The participants were instructed to follow their normal diet and not engage in any exercise outside of what was prescribed in the study.

The protocol executed by CONT involved 8–30 km runs performed three or four times per week (40-50 km per week; 8km, 12km and 20-30km, on each session respectively). If was fourth training, both third and fourth involved 10-15km. The duration of each session was approximately 40–150 min (Zatoń and Michalik 2015). SIT trained twice per week with the sessions interspersed with a minimum of 48 h of rest. At the end of the week (Sunday), a continuous training session was held in which SIT ran approximately 20–30 km. SIT sessions were preceded by a 15-min warm-up. The design was based on a 2:1 ratio of work to recovery where four 20–30 s maximal-intensity runs (each run covering a distance of 90–200 m) were separated by 40 to 60 s of rest. Upon completing the four repetitions, SIT then performed 20 min of low-intensity varied activity after which another set of four maximal-intensity runs was completed. The distance covered per repetition and set was recorded in order to compare subsequent performance. Training was halted if the distance covered in a set decreased by 5% from the recorded maximum. Upon termination of the session, a 5–10 min cool-down was performed. Using this protocol, it was found that SIT was able to complete two to four sets which amounted to 4 to 8 min of maximal running (not including the low-intensity recovery intervals between the sets). Both groups trained about of the same time every day.

Statistical analysis

Data processing was performed using Statistica 12.0 (Statsoft, USA). The arithmetic means and standard deviations ($\bar{x}$±*SD*) were calculated for all measures. The Wilcoxon signed-rank test was used to compare the pre- and post-intervention differences between the groups. Differences in the pre- and post-training session circumference measurements in SIT were assessed using Student's *t* test for independent samples. The significance level was set at α = 0.05

Results

No significant differences were found in pre- and post-intervention body composition in either group. However, it should be added that a decrease was observed in CONT whereas the magnitude of the body composition variables increased in SIT (excluding LBM and %H_2O) (Tab. II).

Analysis of the body circumference parameters in SIT revealed that only chest circumference increased. Decreases were observed for the thigh, calf, and waist, of which the change in waist circumference was statistically significant ($p<0.05$). In CONT, chest and calf circumferences increased, waist circumference decreased, and thigh circumference did not change (Tab. III).

When we analyzed the mean body circumference measures of SIT before and after each training session (across the 8-week intervention), a significant increase was observed in chest and thigh circumferences ($p<0.001$ in both cases). The circumferences of the waist and calf slightly decreased and increased, respectively (Tab. IV).

Table II. Descriptive statistics ($\bar{x}$±*SD*) for pre- and post-intervention body composition in SIT and CONT.

		PRE–SIT	**Post–SIT**	**PRE–CONT**	**Post–CONT**
BMI	$\bar{x}$	24,40	24,48	23,31	23,24
	SD	±2,82	±2,90	±2,32	±1,99
%BF	$\bar{x}$	20,80	21,14	19,69	19,23
	SD	±4,57	±4,84	±8,34	±8,3
FBM	$\bar{x}$	15,55	15,84	13,67	13,41
	SD	±3,67	±4,41	±6,34	±5,90
%H_2O	$\bar{x}$	59,21	59,11	60,38	60,31
	SD	±2,89	±2,96	±4,93	±5,22

BMI – body mass index, %BF – percent body fat [%], FBM – fat body mass [kg], %H_2O – percent body water.

Table III. Descriptive statistics ($\bar{x}$±*SD*) for pre- and post-intervention body circumferences in SIT and CONT

Group	**Pre-Chest**	**Post-Chest**	**Pre-Waist**	**Post-Waist**	**Pre-Thigh**	**Post-Thigh**	**Pre-Calf**	**Post-Calf**
SIT	96,75	96,94	85,38	84,81	59,25	59,13	38,63	38,25
	±10,16	±9,78	±13,38	±13,32*	±5,12	±4,53	±3,08	±2,96
CONT	91,83	92,22	83,67	83,17	57,11	57,11	37,72	38,00
	±8,06	±8,30	±8,09	±8,03	±3,86	±3,86	±2,65	±2,72

*significantly different at $p<0.05$.

Table IV. Descriptive statistics ($\bar{x}$±*SD* based on 128 measures) for pre- and post-training session body circumferences in SIT

Pre-Chest	**Post-Chest**	**Pre-Waist**	**Post-Waist**	**Pre-Thigh**	**Post-Thigh**	**Pre-Calf**	**Post-Calf**
97,60	98,03	85,07	85,03	59,44	59,72	38,25	38,30
±9,10	±9,20*	±12,46	±12,34	±3,64	±3,72*	±2,92	±2,95

*significantly different at $p<0.05$

Discussion

One of the most often cited benefits of interval training is that it improves body composition in a shorter time frame than aerobic-based continuous exercise (Zatoń and Michalik 2015, Burgomaster et. al. 2008, Gibala and McGee 2008, Esfarjani and Laursen 2007). However, the results of the present study show a post-intervention reduction in adipose tissue only in CONT, whereas LBM decreased and FBM increased in SIT. It should be reinforced that these changes were not statistically significant in either group. Nonetheless, similar findings were reported by Keating et al. (2014) in obese and untrained individuals. After a 12 week intervention, they found a reduced decrease in fat mass among individuals performing interval training compared with continuous exercise (0.3% and 1.2%, respectively). The authors went on to suggest that exercise performed at 50–60% VO_2max and for a longer duration is more effective in reducing excess body fat. Antonio et al. (2013) also studied the effects of a 12-week interval training program in a sample of obese women and did not observe a significant decrease in body mass and percent body fat. One explanation for the lack of change in body composition in the present work and aforementioned studies may be due to an absence of dietary intervention. The literature is quite clear that a well-balanced diet (reduced carbohydrate intake against increased protein supply) can effectively decrease body fat level in men and women (Evans et al. 2012)

There are a number of studies that have reported opposing findings when comparing interval training and continuous endurance training in regards to differences in training duration and volume and post-training skeletal muscle oxidative potential. For example, Burgomaster et al. (2008) analyzed the effects of both modalities after 6 weeks of training. Their interval training group performed four to six maximal 30-s cycle ergometer bouts (interspersed with 4.5 min of recovery) three times per week whereas the continuous training group performed 40–60 min of continuous cycling at 65% of VO_2max five times per week. Weekly training duration (including recovery periods) was 1.5 h and 4.5 h, respectively. Despite the large differences in training volume, the interval training group showed a congruent increase in oxidative capacity as the continuous training group. Similar results with regards to oxidative capacity (as reflected by cytochrome c oxidase) were also reached by Gibala et al. (2006) after a 2-week interval training protocol of only six training sessions and also by Whyte et al. (2010) in regards to higher resting lipid oxidation rate when following a protocol similar to (Gibala et al. 2006). Burgomaster et al. (2008) also did not observe any significant differences between interval and continuous training in terms of glycogen utilization during a 60 min constant load cycling test (at 65%VO_2max), although they did demonstrate an increase in both the content and activity of enzymes responsible for beta oxidation, which had not been observed in previous research (Burgomaster et. al. 2006) These and other findings suggest that there is a minimum level of exercise duration (training volume) in interval training that affects muscle lipid oxidation (Burgomaster et al. 2008)

Besides the metabolic effects of interval training, Whyte et al. (2010) also assessed waist and hip circumferences to find significant decreases in both variables. The results of SIT in the present study confirm these findings although we also observed a significant increase in chest circumference. Of interest is the fact that Wierzbicka - Damska (2013) reported increased chest and waist circumferences immediately and 24 h after just one interval training session (targeting glycolytic power and capacity). Since the direction of this change was similar regardless of sex or previous training experience, the author posited that they may serve as potential indicators of interval training effects. As strong correlations were found between these anthropometric variables and endurance performance (Wierzbicka - Damska 2013), it can be suggested that body circumference may also aid in monitoring as well as optimizing the training process.

There are a number of physiological mechanisms that may be responsible for the increase in circumference following interval training. First, this exercise strategy requires work to be performed with increasing fatigue and lower blood pH levels (Dorado et. al. 2004) in which the acute physiological response involves increased pulmonary minute ventilation (chest circumference) and blood flow to working muscle (extremity circumference) (Heydari et al. 2013, Krustrup et al. 2004). When this type of training is repeated over several weeks, chronic adaptations to body circumferences have been credited to enhanced minute ventilation and maximal oxygen uptake, factors augmented by increased cardiac output (both in stroke volume and maximal heart rate), enlarged capillary density, raised arteriovenous oxygen difference, and increased mitochondrial enzyme number and activity (Zatoń and Michalik 2015, Faria 2009, Krustrup et al. 2004). These mechanisms can all influence intramuscular blood vessel size and therefore body circumferences. In regards to blood circulation, it does need to be mentioned that it is significantly higher in performing muscle than in activated muscle (Anderson et al. 2000) where blood flow can reach levels of 240–400 ml/min during maximal cycling, rowing, and running efforts (Gonzalez-Alonzo et al. 2000) these changes are local in nature. Finally, another physiological factor that may influence body circumference is thermoregulatory-induced changes in body water displacement (Sawka et al. 2001, Latzka and Sawka 2000).

Despite the SIT-induced changes observed in the present study, there are a number of limitations that need to be taken into account. First, the small sample size may have compromised the results and limits generalizability. Second, male and female groups should have been formed for each intervention to better delineate sex-specific changes. Undoubtedly, more studies are warranted to further elucidate the effects of SIT on body circumferences particularly before and after individual exercise sessions as the associations between this anthropometric measure and training-induced physiological improvements (Wierzbicka-Damska 2013) can allow body circumference to serve as an easily-measurable indicator of training progress and allow for immediate optimization of training load.

Conclusions

The applied sprint interval training protocol, without dietary intervention, did not affect body composition (unaltered FBM or LBM) in a sample of recreational long-distance runners. However, a significant post-SIT intervention decrease was observed in waist circumference as well as a significant post-training session increase in chest and dominant-leg thigh circumferences. Evaluating the differences in chest and thigh circumferences immediately following training may serve as an easy-measurable indicator of training progress in runners.

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