ORIGINAL ARTICLE

Short duration high-intensity interval taekwondo training substantially improves body composition and physical fitness in previously-trained individuals: a proof-of-concept study

Authors' Contribution:
A Study Design
B Data Collection
C Statistical Analysis
D Manuscript Preparation
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Abstract

Background and Study Aim: Professional taekwondo (TKD) athletes possess below average body fat percentages and the overall winners at the Sydney 2000 Olympic Games had a lower body mass index (BMI). Further, physical fitness remains one of the main factors for success in TKD. This indicates the importance of managing body composition and physical fitness for TKD performance. This study's aim was to generate knowledge about the effect of a four-week high-intensity intermittent TKD and strength training conditioning program on body composition and physical fitness of South African TKD athletes.

Material and Methods: Twenty male participants were randomly assigned to a low-intensity (LI) (n = 10) or high-intensity (HI) (n = 10) group. The study consisted of a four-week, five times weekly TKD training and three times weekly resistance training program. The TKD training program for the HI group consisted of a 10-minute warm-up, a 60-minute workout at 85-95% HRmax for weeks 1-2 and at 90-100% HRmax for weeks 3-4 and a 10-minute cool down. The TKD training program for the LI group consisted of a 10-minute warm-up, a 60-minute workout at 60-70% HRmax for weeks 1-2 and 70-85% HRmax for weeks 3-4. Both groups also participated in a 60-minute resistance training program for three sets of 8-10 repetitions.

Results: Significant ($p \leq 0.05$) improvements were found in body mass ($p = 0002$), BMI ($p = 0.004$), sum of skinfolds ($p = 0.006$) and body fat percentage ($p = 0.009$) of the HI group. The LI intervention significantly decreased body fat percentage ($p = 0.001$), but not body mass ($p = 0.056$), BMI ($p = 0.077$), and sum of skinfolds ($p = 0.820$). Post-hoc analysis revealed significant differences in BMI ($p = 0.022$) and sum of skinfolds ($p = 0.042$). Significant improvements were found in sit-and-reach ($p = 0.034$), sit-ups ($p = 0.025$), push-ups ($p=0.001$), horizontal jumps ($p = 0.007$), VO_{2max} ($p = 0.026$) and agility ($p = 0.037$) in the HI group. No significant improvements were observed in any of the physical fitness parameters assessed in the LI group. Post-hoc analysis demonstrated significant differences in sit-and-reach ($p = 0.044$), sit-ups ($p = 0.001$), push-ups ($p = 0.006$), horizontal jumps ($p = 0.037$), VO_{2max} ($p = 0.004$) and agility ($p = 0.018$).

Conclusions: High-intensity TKD training along with resistance training can be implemented in the training regimes of TKD athletes when preparing for national and international competitions to enhance combat performance.

Keywords: intermittent training • kyorugi • poomsae • resistance training • VO_{2max}

Conflict of interest: Authors have declared that no competing interest exists

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INTRODUCTION

Taekwondo (TKD) is a martial art sport renowned for its techniques such as kicking, blocking and punching for the purpose of attack or self-defense [1]. TKD is a well-known, Olympic sport that is practiced by many participants. TKD is characterized by basic techniques and forms (*poomsae*), as well as self-defence and sparring (*kyorugi*). *Poomsae* and *kyorugi* require complex motor and functional skills, tactical excellence and high levels of fitness [2]. *Poomsae* is a structural form of group competition in which the participant simultaneously uses both hands and feet to execute various techniques [3]. In *kyorugi*, combat matches are typically three rounds of two minutes with a one-minute rest period [4]. During TKD athletes are awarded points when kicks and punches make contact on the allowed body area [3, 5]. Valid kicks to the head contribute three points, whereas valid turning kicks to the head scores four points. A winner is determined by scoring more points or win by a knockout [5].

TKD is a highly explosive type of sport in which athletes have to execute various kicking techniques that require high levels of energy expenditure, muscular strength and endurance, flexibility, speed and agility [1]. Some studies have revealed that professional TKD athletes possess below average levels of body fat percentage [1, 4, 5], similarly TKD athletes who were overall winners at the Sydney 2000 Olympic Games had a lower average body mass index [5].

It is however clear that physical fitness remains one of the main factors for success in TKD; this assertion is strongly supported by existing literature, which accentuate its importance as an indicator for success in TKD. Training programs of longer duration have been implemented in TKD practice and have been found to impact physical fitness [1, 3]. However, more research is needed to establish the efficacy of various training protocols on the physical fitness of TKD athletes. Therefore, the purpose of the study was to evaluate the effects of a combined four-week high-intensity intermittent TKD training and strength conditioning program on body composition, and physical fitness of male South African TKD athletes.

This study's aim was to generate knowledge about the effect of a four-week high-intensity intermittent TKD and strength training conditioning program on body composition and physical fitness of South African TKD athletes.

Knockout – *noun* **1.** (*in boxing*) a punch that knocks an opponent down for a count of ten and so wins a contest **2.** A sports competition in which a person or team beaten in one game or match is eliminated from the entire competition [17].

Resistance training – *noun* training that increases muscle strength by working against resistance such as a weighted dumbbell or barbell [17].

Performance – *noun* the level at which a player or athlete is carrying out their activity, either in relation to others or in relation to personal goals or standards [17].

Technique – *noun* a way of performing an action [17].

Kick – *noun* **1**. A blow with the foot, e.g in martial arts **2.** a thrashing movement with the leg when swimming **3.** the striking of a ball with the foot [17].

Punch – *verb* to strike someone or something with the fist, e.g. in boxing or martial arts [17].

Poomsae – *noun* forms, formal exercises [18].

Kyorugi – *noun* also known as sparring, is one of the disciplines of Taekwondo [18].

Taekwondo – *noun* a Korean system of fighting without weapons, similar to karate [17].

MATERIAL AND METHODS

Participants

Twenty active male TKD athletes (age: 23.5 ±2.6 years; height: 1.73 ±0.40 m) volunteered to participate in this study. A routine physical clearance was used to assess participants for inclusion in this study. None of the participant had any contraindications to exercise or exercise testing, were weight stable or were not on any chronic medication before the start of the study. All participants were members of the South African Taekwondo Federation. Participants were randomly assigned using a random numbers table into a low-intensity (LI) group (n = 10) or high-intensity (HI) group (n = 10).

Procedures

Ethical clearance was obtained from the relevant Institutional Review Board (UZREC171110-300PGD 2015/88). Informed consent was received from all the participants taking part in the study. The protocol was designed according to the ethical norms set out in the 1961 Helsinki Declaration on ethical principles involving the use of human subjects in medical research.

Body mass was measured in kilograms (kg) using a digital scale (Kubota KA: 10 – 150V, Japan) to the nearest 0.1 kg. Stature was measured using a stadiometer (La Fayette Instrument Co. USA) and body mass index (BMI) was calculated as weight divided by height squared ($kg.m^{-2}$). Six skinfolds (triceps, biceps, subscapular, thigh, calf and suprailiac) were measured using the Holtain T/W Skinfold Caliper.

Lower back and hamstring flexibility was measured in centimetres by the modified sit-and-reach test using the Lafayette Adjustable Sit and Reach Flexibility Tester (Model 01285A, La Fayette, USA). The best of three measurements was used in the final analysis. The T-test was used to determine the agility in seconds. Participants repeated two-timed measurements and the fastest time was used in the final analysis. Leg power was measured in centimetres by means of a standing broad jump test. Two jumps were performed and the best score to the nearest 0.1 cm from the distance between toes at take-off and heels at landing nearest to the take-off spot was taken. The 20-minute multi-stage fitness test (MSFT) was used to measure endurance capacity. This test measured continuous running between two lines that were 20 meters apart in time to recorded beeps. The participant's score was the level and number of shuttles reached before he was unable to keep up with the beeps. The score was converted to a predicted maximal oxygen consumption (VO_{2max}) equivalent value. Muscular strength and endurance were assessed by the one-minute sit-ups and two minutes' push-up test, respectively.

Intervention

The study consisted of a four-week, five times weekly TKD training and three times weekly resistance training program. The TKD training program for the HI group commenced with a 10-minute warm-up consisting of TKD body movements together with dynamic stretching exercises. This was followed by a 60-minute workout consisting of blocks, punches and kicks at 85-95% HRmax (Polar Electro, Kempele, Finland) for weeks one and two and at 90-100% HRmax for weeks three and four, followed by a 10-minute cool down.

The TKD training program for the LI group commenced with a 10-minute warm-up consisting of TKD body movements together with dynamic stretching exercises. The LI group performed a 60-minute workout consisting of blocks, punches and kicks at 60-70% HRmax for weeks one and two and 70-85% HRmax for weeks three and four.

Both groups also participated in a 60-minute full-body resistance training program consisting of power cleans, push presses, dumbbell raises, squats, dead lifts, leg curls, and abdominal curls for three sets of eight to 10 repetitions. Each session included a five-minute warm-up and a five-minute cool-down consisting of static stretching exercises.

Statistical analysis

Statistical analysis was performed using IBM Statistical Package for the Social Sciences (SPSS) version 20.0 (SPSS, Chicago, USA). All data were presented as mean and standard deviation (±) values. A two-way repeated measures ANOVA test was used to analyse before and after-intervention and the interaction between the low- and high-intensity groups for each parameter, while the level of significance was set at $p<0.05$ for both main effects (group and time) and interaction (group X time).

RESULTS

None of the participants dropped out at any stage of the study hence, adherence rate was 100% in both groups.

When comparing the LI and HI groups at the beginning of the four-week intervention, there were no significant differences observed. After the intervention, significant ($p\leq0.05$) improvements were found in the body mass ($p = 0.002$), BMI ($p = 0.004$), sum of skinfolds ($p = 0.006$) and body fat percentage ($p = 0.009$) of the HI group. The LI intervention significantly decreased body fat percentage ($p = 0.001$), while not having any significant impact on body mass ($p = 0.056$), BMI ($p = 0.077$), and sum of skinfolds ($p = 0.820$). Post-hoc analysis revealed significant differences in BMI ($p = 0.022$) and sum of skinfolds ($p = 0.042$) (Table 1).

Significant improvements were found in sit-and-reach ($p = 0.034$), sit-ups ($p = 0.025$), push-ups ($p = 0.001$), horizontal jumps ($p = 0.007$), VO_{2max} ($p = 0.026$) and agility ($p = 0.037$) in the HI group. No significant improvements were observed in any of the physical fitness indicators assessed in the LI group. Post-hoc analysis demonstrated significant differences in sit-and-reach ($p = 0.044$), sit-ups ($p = 0.001$), push-ups ($p = 0.006$), horizontal jumps ($p = 0.037$), VO_{2max} ($p = 0.004$) and agility ($p = 0.018$) (Table 2).

DISCUSSION

This study's four-week intervention period significantly improved body mass, BMI, sum of skinfolds and body fat percentage in the HI group, while the LI training significantly decreased body fat percentage. The HI training was effective at

Table 1. Body composition changes in response to four weeks of low- and high-intensity taekwondo training high-intensity (HI) group (n = 10) and low intensity (LI) group (n = 10).

Indicators	Group	Before	After
Body mass (kg)	HI	73.4 ±10.7	**68.6 ±9.0***
	LI	69.1 ± 13.5	68.0 ±11.9
BMI ($kg.m^{-2}$)	HI	24.2 ±2.8	**22.9 ±2.3***
	LI	25.0 ±4.8	**24.8 ±3.6#**
Sum of skinfolds (mm)	HI	81.5 ±4.2	**77.0 ±4.8***
	LI	81.6 ±5.8	**80.1 ±5.5#**
Body fat percentage (%)	HI	14.9 ±2.1	**11.3 ±2.9***
	LI	13.8 ±3.2	**11.0 ±1.5***

*indicates a significant difference (p≤0.05) between before and after;
#indicates a significant difference (p≤0.05) between groups.

Table 2. Physical fitness changes in response to four weeks of low- and high-intensity taekwondo training groups (HI) high-intensity (n = 10) and (LI) low intensity (n = 10).

Indicators	Group	Before	After
Sit and reach (cm)	HI	47.6 ±5.5	**54.2 ±5.8***
	LI	43.7 ±6.2	**46.6 ±6.3#**
Sit-ups (repetitions)	HI	45.2 ±7.0	**53.1 ±6.1***
	LI	37.4 ±6.9	**42.5 ±7.1#**
Push-ups (repetitions)	HI	64.3 ±14.9	**76.8 ±17.4***
	LI	38.9 ±17.1	**41.3 ±11.4#**
Horizontal jump (cm)	HI	1.9 ±0.3	**2.3 ±0.3***
	LI	1.6 ±0.4	**1.7 ±0.4#**
VO_{2max} ($ml \cdot kg^{-1} \cdot min^{-1}$)	HI	48.5 ±2.1	**52.5 ±2.8***
	LI	47.4 ±2.7	**49.7 ±3.4#**
Agility (second)	HI	10.9 ±0.4	**9.7 ±0.6***
	LI	11.6 ±0.8	**11.0 ±4.8#**

* indicates a significant difference (p ≤ 0.05) between before and after;
# indicates a significant difference (p ≤ 0.05) between groups.

significantly improving sit-and-reach, sit-ups, push-ups, horizontal jumps, VO_{2max} and agility, while the LI training resulted in no significant improvements in any of the physical fitness indicators assessed.

Limited studies exist that have investigated and compared similar training programs, especially in black South African TKD athletes, which traditionally do not participate in TKD. Further, TKD athletes rarely utilize resistance training in their training regime, in spite of research demonstrating the associated improvements in muscular strength and power in TKD athletes [7].

TKD athletes regularly reduce their body mass before competition in order to compete in their desirable weight categories. Studies have revealed that body composition is key in determining elite and novice athletes and is highly associated with performance [8, 9]. In the current study, body mass, BMI, sum of skinfolds and body fat percentage significantly improved following HI training. The reduction in body fat percentage was in line with the elite international taekwondo norms [10]. These significant improvements in body composition was also demonstrated by Bridge et al. [1] who showed improvements in body composition following TKD training.

Dynamic flexibility is one of the specific components in differential scoring in TKD competition allowing athletes to score points by kicking the head [5]. Taekwondo training regimes place a great deal of importance on the improvement of flexibility for proficient performance and avoiding head injuries, thereby protecting the health status of the participants. Studies have shown that TKD athletes have more flexible hamstrings and lower back muscles than their counterparts [1, 3]. This study's HI and LI training regimes included stretching to augment the range of motion, but only the HI group's flexibility improved. This possibly indicates that the training itself instead of the flexibility component of the program was responsible for the improvements in the flexibility. The improvement in flexibility was similarly found in a study by Bridge et al. [1].

Lower extremity power is an essential component in TKD and contributes to score knockout points [5]. It has been shown that martial artists need maximal muscle strength, muscle endurance and power to implement powerful movements continuously during sparring by moving freely around an opponent while executing techniques. The HI training of this study found significant improvements in muscle strength, muscle endurance and power. The importance of these improvements was confirmed by Kazemi et al. [5] and Noorul et al. [11] who indicated that muscle strength is important in the execution of explosive kicks, jumping and balancing techniques during both sparring and competition. The training protocol of the current study managed to achieve similar results to that of Harris [12] who demonstrated a marked improvement in the limb and trunk muscular strength of elite TKD athletes in even a shorter period of time.

This study demonstrated the efficiency of HI training at increasing aerobic capacity. This was similarly found in the study of Bridge et al. [1] who suggested that TKD training might have some beneficial effects on aerobic capacity. Research has previously expressed the importance of the relationship between high aerobic capacity and power since this relationship is considered a precursor of overall success in TKD competition [12]. As such, the improvements in aerobic capacity and power found in this study following the four-week HI training could lead to improved TKD performance.

Taekwondo demands for quick change in direction while keeping balance, strength, speed and body control through high level of lower limb strength, agility to improve performance [13]. This study demonstrated that a HI training program can effectively be used to improve agility. These results are comparable to those reported in previous studies [1, 3].

LIMITATIONS

The findings of this study are only applicable to male TKD athletes in South Africa and caution should be taken when extrapolating the findings. This study was a proof-of-concept study and as such consisted of a small sample size.

CONCLUSIONS

The findings of this study support the incorporation of the HI training along with resistance training in TKD athletes on improving both body composition and physical fitness indicators. This type of training can be implemented in the training regimes of TKD athletes when preparing for national and international competitions to enhance combat performance.

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