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HEALTH ASPECTS OF KARATE AS PHYSICAL EDUCATION AND EXTRACURRICULAR ACTIVITY

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Abstract:
The present study examined energy expenditure, metabolic equivalent (MET) intensities of karate exercises for health promotion, and bone properties of karate practitioners to examine the health aspects of karate as physical education and an extracurricular activity. The mean energy expenditure following a 70-minute karate practice was 563 kcal for men and 268 kcal for women. The calculated mean MET intensities resulting from the 70-minute karate practice were 7.9 METs for men and 5.2 METs for women. The mean MET intensities of all exercises for men and women were above 3 METs which is defined as "active physical activity" in the "Physical Activity Reference for Health Promotion 2013" in Japan. Practicing karate, especially sparring techniques, may help to enhance bone mineral density. It appears that longer duration, higher frequency, and earlier start of physical training positively influenced skeletal status.

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Keywords: karate, health, energy expenditure, metabolic equivalent, bone mineral density, physical education

1. Introduction

Karate is one of the most popular martial arts practiced both within and outside Japan (Imamura, 2001). The Federation of All Japan Karate Organizations belongs to the World Karate Federation, which is recognized by the International Olympic Committee and karate will make its first appearance as an Olympic sport at the 2020 Summer Games in Tokyo, Japan (International Olympic Committee, 2017; Kurihara, 2017).

Karate became compulsory in the junior high school physical education curriculum in Japan from 2011 (Ministry of Education, Culture, Sports, Science and Technology, Japan, 2018), and many senior high school and university students practice karate as an extracurricular activity. In previous studies, we examined physical fitness aspects (Imamura et al., 2012) and safety aspects (Imamura et al., 2018) of karate as physical education and/or as an extracurricular activity. The present study examined energy expenditure, metabolic equivalent (MET) intensities of karate exercises for health promotion, and bone properties of karate practitioners to further examine the health aspects of karate as physical education and an extracurricular activity.

2. Karate exercises

Karate training involves basics, kata, and sparring. Basic techniques such as punching, blocking, and striking are practiced either in the stationary position or with body movement in various formal stances.

Kata are set forms in pre-established sequences of defensive and offensive techniques and movements, and are performed alone against imaginary opponents. Movements in kata are very formal, systematic, and sometimes very slow, in prescribed stances and directions.

Free-sparring is the execution of defensive and offensive techniques while freely moving against an opponent. To avoid injuries, free-sparring is not always practiced in a regular workout. Instead, sparring techniques are performed without an opponent or against an opponent, in which the prearrangement between participants allows one person to practice offensive and the other defensive techniques (Imamura et al., 1999). For safe practice in prearranged-sparring, the offensive techniques, such as punches and kicks, must be controlled or stopped before contact.

3. Karate exercises for health promotion

3.1 Assessment of physical activity

Valid assessment of physical activity in epidemiological studies is critical to evaluate not only its health effects, but also its effect as a confounding factor. A "Compendium of Physical Activities" (Compendium) has been developed (Ainsworth et al., 1993, 2000,

2011; Butte et al., 2018), and all physical activities were assigned an intensity unit based on their rate of energy expenditure expressed as METs. In Japan, the Compendium has been used to identify MET intensities for physical activities (Ministry of Health, Labour and Welfare of Japan, 2013), from which the quantity of physical activity was expressed as a unit, METs•hour/week, calculated by multiplying the intensity of physical activity in METs by the duration of the activity in hours.

3.2 Health promotion in Japan

In 2013, the Ministry of Health, Labour and Welfare of Japan published the "Physical Activity Reference for Health Promotion 2013" (Physical Activity Guide 2013). In the Physical Activity Guide 2013, for people 18 to 64 years of age, "active physical activity" is defined as that with an intensity of 3 METs or more, and the quantity goal of physical activity for health promotion was set at 23 METs•hours/week.

The quantity of physical activity for health promotion (23 METs•hours/week) was validated in some studies. Imamura et al. (2009) enrolled 116 collegiate women and reported that METs•hours/week was significantly correlated ($r=0.52$, $p<0.01$) with maximal oxygen uptake. After adjusting appropriate confounding factors in forward stepwise multiple regression analyses, METs•hours/week was significantly positively related with high-density lipoprotein cholesterol. Furthermore, after adjusting for body mass index and log triglycerides in the analysis of covariance, subjects in the highest category of METs•hours/week (≥23) had significantly higher high-density lipoprotein cholesterol, total cholesterol and lower systolic blood pressure than other lower categories. From these results, the authors concluded that METs•hours/week was a valid measure for quantifying physical activity, and a goal of 23 METs•hours/week set in the Physical Activity Guide 2013 for people 18 to 64 years of age. Kawakami et al. (2014) enrolled 906 adults aged 23-64 years and examined the association between the METs•hours/week goal set in the Physical Activity Guide 2013 (23 METs•hour/week) and prevalence of metabolic syndrome. The results showed that the adjusted odds ratios for prevalence rates of pre-metabolic syndrome and metabolic syndrome among the participants with METs•hours/week above 23 compared with those below the reference value was 0.49. From these results, the authors concluded that the 23 METs•hours/week goal set in the Physical Activity Guide 2013 was valid.

3.3 Energy expenditure and metabolic equivalent during regular karate training

Karate training in general and karate kata in particular have been claimed to contribute to increasing general physical fitness and/or cardiovascular fitness by some karate masters (Funakoshi, 1973; Iiyama, 1973). In addition, some studies suggested that kata (Zehr and Sale, 1993; Shaw and Deutsch, 1982; Stricevic et al., 1980) could be used as an effective means for developing cardiovascular fitness in karate practitioners. However, a review of the literature raised some arguments against the previous research. A major point of contention was that it is abnormal to perform kata in regular practice in the same manner as performed in these studies. Karate practitioners do not usually perform only kata without other training exercises designed to improve oxygen uptake during a

regular workout, so it is difficult to conclude that these karate exercises practiced during a regular workout can be used as an effective and specific means for training aerobic capacity. In studies using seven male black belt practitioners (Imamura et al., 1999) and six female black belt practitioners (Imamura, 2002), the authors investigated oxygen uptake, heart rate responses before, during and following regular karate training. The calculated mean energy expenditure resulting from the full 70-minute karate practice was 563 kcal (Imamura et al., 1999) which was well above the accepted threshold for total body mass and fat weight loss. However, the energy expenditure for women was 268 kcal (Imamura et al., 2002), which was marginal to the accepted threshold. On the other hand, the calculated mean MET intensities resulting from the full 70-minute karate practice were 7.9 METs for men and 5.2 METs for women. Also, the mean MET intensities of all exercises for men and women were above 3METs, which is defined as "active physical activity" in the "Physical Activity Reference for Health Promotion 2013".

Yoshimura and Imamura (2010) investigated the chronic effects of practicing basic karate exercises on maximal oxygen uptake in sedentary collegiate women who had no previous karate experience. Nine women practiced for 30 minutes doing basic karate exercises four days a week, for 10 weeks. The six other women acted as controls. These authors measured the MET intensity of the basic exercises used in this study, which was 5 MET. The quantity of 30-minute exercises was 10 METs•hours/week. The results showed that maximal oxygen uptake in the experimental group significantly increased at the end of the 10-week training period, while no significant changes were observed in the control group. Thus, it appears that practicing 10 METs•hour/week of basic karate exercises can be used for health promotion in sedentary young women.

4. Bone properties of karate practitioners

4.1 Modifiable factors affecting bone mineral density

The peak bone mass attained is an important protective factor against osteoporotic fractures in later life (Farr and Khosla, 2015; Winsloe et al., 2009). Several modifiable factors may help to preserve bone, and among them are body mass index (Emaus et al., 2014; Baccaro et al., 2015), nutrient intake (Baccaro et al., 2015; Lorincz et al., 2009; Metz et al., 1993), and physical activity (Metz et al., 1993; Kelley et al., 2013).

It has been reported that body height, lean body mass, and body mass index were positively associated with bone mineral density (Lloyd et al., 2014; Wee et al., 2013; Krahenbühl et al., 2014). Imamura et al. (1998) compared highly competitive and novice karate practitioners, and found that highly competitive practitioners showed significantly higher mean lean body mass, bench press strength, and half squat strength.

Calcium, vitamin D and vitamin K intake are key elements in promoting and maintaining bone health and preventing bone loss (Lorincz et al., 2009; Orimo et al., 2012). Low calcium intake increases fracture risk because of low bone mineral density (BMD) (Lorincz et al., 2009), and a higher intake of calcium is associated with higher

BMD (Bischoff-Ferrari et al., 2009). When the vitamin D level is low, the parathyroid hormone increases, resulting in increased bone resorption in order to satisfy the body's demand for calcium (Ogan and Pritchett, 2013). It has also been shown that vitamin K improves bone quality and reduces the risk of fracture (Shiraki et al., 2000). The traditional Japanese diet is characterized by a lower calcium intake compared with people living in Western countries (Hirota et al., 1992). In a comparison of calcium intake by Western male karate practitioners (1150±75 g) (Andreoli et al., 2001), lower intakes were reported in Japanese highly competitive collegiate (421±198 g for males and 461±126 g for females) and high school (585±260 g for males and 556±309 g for females) karate practitioners, while comparable values were reported for Japanese male elite karate practitioners who belong to the national team (1071±844 g for male sparring and 1110±370 g for male kata practitioners) (Miyahara et al., 2013). Oda et al. (2018) compared nutrient intake between Japanese female elite and collegiate karate players and reported a significantly higher calcium intake in elite practitioners (902±329 g vs. 398±127 g) than in collegiate practitioners.

It was shown that athletes involved in sports that increase the mechanical stress placed on the bones (i.e., weight-bearing activities and/or strength training) had greater BMD levels than a non-active control group (Morgan and Jarrett, 2011; Creighton et al., 2001; Nikander et al., 2005; Calbet et al., 2001; Prouteau et al., 2006). Karate has been classed as a high impact sport (Barbeta et al., 2017).

4.2 Bone properties of karate practitioners

Two studies (Andreoli et al., 2001; Ito et al., 2016) measured the BMD of karate practitioners with a dual-energy X-ray absorptiometry technique. Andreoli et al. (2001) investigated male subjects aged 18-25 years, and compared the BMD levels of 21 judo, 14 karate, and 24 water polo athletes who competed at national and international level and exercised regularly for at least three hours a day, six days a week. The results showed that the Judo and karate athletes had significantly higher total BMD levels than the water polo athletes and 12 age-matched controls. Ito et al. (2016), using males and females aged 11-14 years, compared bone mineral density levels of 17 judo (weekly training load was 6.4±5.4 hours/week), 14 karate (10.5±2.8 hours/week), and 16 kung-fu (3.2±1.2 hours/week) practitioners. In this study, an analysis of covariance identified that only adolescents engaged in judo practice had higher values of bone mineral density in the arms than the control group after controlling for sex, age, fat free mass and somatic maturation. The karate practitioners did not show any significant differences compared with the control group.

Two studies (Drozdzowska et al., 2011; Barbeta et al., 2017) evaluated bone mass assessed by quantitative ultrasound of phalanges in karate practitioners. Drozdzowska et al. (2011) examined 226 male karate practitioners aged 7-61 years, who had been doing karate training for at least six months. The results showed that, up to age 18, there were no significant differences between the karate practitioners and controls, while up to age 35, the difference increased and then stabilized after age 35. These authors stated that longer duration, higher frequency, and earlier start of physical

training positively influenced skeletal status and concluded that karate is a sport with a positive influence on skeletal status with the most significant benefits occurring in adults. On the other hand, Barbeta et al. (2017) investigated 162 (110 males and 52 females) children and adolescent karate practitioners aged 6-16 years of both genders and compared them with a control group assembled from a database at their laboratory (216 males and 110 females). The results showed that children and adolescents who practiced karate had greater bone mass in comparison to the control group, regardless of gender. These authors stated that they used quantitative ultrasound of phalanges rather than the dual-energy X-ray absorptiometry technique because the method is suitable for bone tissue assessment with the benefits of easy applicability, handling and portability.

The above mentioned four studies (Andreoli et al., 2001; Ito et al., 2016; Drozdzowska et al., 2011; Barbeta et al., 2017) examined karate practitioners as a single group. Because high level sparring competitors have been reported to have higher ability to accelerate the whole body, as assessed by both a 10 m sprint test and a standing triple jump test, than their kata counterparts (Chaabène et al., 2012; Koropanovski et al., 2011), the mechanical stress placed on the calcaneus may be greater in sparring practitioners than kata practitioners. From this point of view, Imamura et al. (2016) investigated the calcaneal bone status of 26 male and 20 female karate practitioners who were members of the Japanese national team. The subjects were divided into four groups: 16 men's sparring, 10 men's kata, 12 women's sparring and 8 women's kata practitioners. The results showed that there were no significant mean differences in body mass index, calcium, vitamin D or vitamin K intake between the men's sparring and kata or women's sparring and kata. The men's sparring practitioners showed significantly higher speed of sound and young adult mean percentage than the men's kata. Likewise, the women's sparring practitioners showed significantly higher speed of sound and young adult mean percentage than the women's kata practitioners. The percentages of the young adult mean in both men's and women's kata were very close to 100%. From these results, the authors concluded that practicing karate, especially sparring techniques, has positive effects on calcaneal bone status.

These authors noted one limitation of their study. It has been shown that athletes involved in weight-bearing activities (Morgan and Jarrett, 2011; Creighton et al., 2001; Nikander et al., 2005; Calbet et al., 2001; Prouteau et al., 2006) had higher BMD levels than a non-active control Group in which various sites were measured with dual energy X-ray absorptiometry, which remains the optimal method for evaluating BMD. The authors evaluated calcaneus speed of sound using a quantitative ultrasound device, as opposed to the conventional measurement by dual energy X-ray absorptiometry, for the following reasons: 1) A quantitative ultrasound device is portable and practical, can measure bone status and involves no x-ray exposure (Nohara et al., 2009); 2) A relatively high correlation coefficient (r=0.76) between speed of sound and BMD at the heel assessed at a location corresponding to that of the quantitative ultrasound measurement has been reported, and the speed of sound value was significantly lower

in fracture patients than in participants without fractures (Graafmans et al., 1996), and 3) Calcaneal speed of sound is as accurate as dual energy X-ray absorptiometry in identifying subjects with vertebral fractures (Glüer et al., 2004; Hartl et al., 2002).

5. Conclusions

It appears that regular karate training is beneficial for cardiovascular and bone health. Thus, it can be used as physical education and/or as an extracurricular physical activity for health promotion.

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