Fitness Characteristics of Youth Silat Performers

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Abstract

Silat is a popular Asian martial art. The primary purpose of this research was to profile the physiological characteristics of young silat athletes. Eight motor performance tests, including two newly developed silat-specific tests were administrated to a sample of 178 young exponents (96 males and 82 females) aged 13 to 16 years. Tests included squat, rebound and a three-directional jump, handgrip strength, medicine ball throw, push-ups, yo-yo endurance and a 20 s kick test. Overall results showed that male exponents outperformed the female exponents for most tests, the fitness of females did not change with age for any variable (all, $p > 0.05$), while males tended to improve their fitness with advancing age/maturation. The females were advanced, by about 2 years in the estimated age at peak height velocity (PHV) compared to the males (1.1 ± 0.7 versus -0.9 ± 1.1 y from PHV, $p < 0.05$). Measures of isometric strength (handgrip strength), upper body power (medicine ball throw) and endurance (push-ups), lower body power (squat-jumps), and endurance (yo-yo test) showed significant ($p < 0.05$) gains after 15 year-old in boys. Novel data is presented that could be useful for benchmarking fitness in youth silat. Being involved in silat did allowed female exponents to maintain their fitness, whereas, male exponents improved their fitness at or post PHV. These gender-specific differences are attributed to differing maturational processes and the findings may be useful when devising training programmes to maximise fitness development in youth silat.

Key Words*: Maturity, martial arts, physiological assessment, sports demands, combat sports*

Introduction

It has previously been estimated that worldwide approximately 75-120 million children and adults participate in martial arts (Birrer, 1996). In many countries participation in martial arts are among the most popular extra-curricular activities practiced by youths aged between 10-15 years old (De Knop et al., 1996), with participation rates in youth martial arts thought to be on the increase (Woodwards, 2009). Surprisingly, there is relatively little research available of the physiological demands and characteristics of martial arts. Research that does exist tends to focus on adult populations in the more popular Olympic disciplines such as taekwondo (Thompson & Vinueza, 1991; Pieter, 1991; Heller et al., 1998) and judo (Callister et al., 1991; Thomas et al., 1989). Much less information is available regarding the physiological characteristics of youth martial arts, particularly outside the Olympic disciplines.

Silat is a martial art of East Asian origin that can have both artistic and contact variations; with the contact version similar to both judo and taekwondo in that it is weight-classified, unarmed and full contact (Aziz et al., 2002), but with unique movement patterns and scoring systems (Shapie et al., 2008, 2009). It is these unique movement patterns, which help define each martial art and, make it inappropriate to translate findings from one martial art to another. It has previously been stated that many forms of Asian martial arts are becoming popular in Western Countries (Theebom & De Knop, 1999), which can be observed by the creation of the European and World Silat Championships over two decades ago (Aziz et al., 2002) alongside the inclusion of silat in the South East Asian Games. Despite this, to the authors knowledge there is only one previously published study relating to the physiological demands and characteristics of silat (Aziz et al., 2002), and this was with an adult population.

Little is known about the physical and physiological characteristics that distinguish younger and older silat competitors, or how these develop with age and maturation. The available literature on adult silat competition suggests that the sport is characterised by brief, high-intensity bouts of activity, short recovery periods and the need for competitors to repeatedly punch, kick and grapple with their opponent (Aziz et al., 2002; Shapie et al., 2008, 2009). This suggests that a variety of attributes, such as; upper and lower body strength, speed and power, co-ordination, resistance to fatigue and the ability to recover would all be desirable traits. Identifying sport-specific fitness trends across youth Silat performers will enable identification of those traits which are most important to performance, helping to inform training. The theory of accelerated adaptation and trainability, as promoted in the long-term athlete development model of Balyi and co-workers (2000, 2003, 2004), also suggests that when there is a naturally occurring rapid increase in fitness a child will be most responsive to training that particular component of fitness. Therefore, identifying such periods may assist with providing a structure to maximising the physical conditioning and performance of youth silat athletes. Consequently, the aim of the study was to profile the fitness characteristics of both male and female youth Silat athletes aged between 13 and 16 years old.

Participants

The sample included 178 young Silat exponents (age 14.2 $\pm$ 1.1 year; height 153.8 $\pm$ 7.9 cm; body mass 48.9 $\pm$ 11.6 kg) aged 13 to 16 years old. All participants were actively involved in silat training as part of co-curriculum activities under the management of Pusat Cemerlang Silat, Malaysia. All one hundred and seventy eight participants (96 boys and 82 girls) were healthy and free from any injury at the time of the testing. An additional reliability study was undertaken using a sample of male (n = 27; age 13.6 $\pm$ 1.1 year; height 152.5 $\pm$ 8.3 cm; body mass 46.8 $\pm$ 12.6 kg) and female (n = 13; age 14.2 $\pm$ 1.3 year; height 154.5 $\pm$ 4.8 cm; body mass 46.8 $\pm$ 10.9 kg) participants. For each study parental and participant consent were collected, both studies were granted approval by the University Research Ethics Committee.

Procedures

All participants participated in one introductory training session a week before the testing sessions. During this time, they were taught the proper technique (i.e. controlled movements and body positions) on each test. In the reliability study, participants repeated the procedures for the three-directional jump and 20-kick test on separate days. In the main study all participants were required to attend 2 test sessions with a minimum of 48-hours between each session. In the first session; all variables except yo-yo intermittent endurance were measured, which was assessed in the second session. All testing was performed indoors. To avoid any injuries the participants were required to undergo a warm-up session prior to testing, which consisted of 10 minutes of low to moderate intensity aerobic exercise and callisthenics. Maturation was estimated as time from peak height velocity, using anthropometric measures and the equations proposed by Mirwald et al. (2002). This method was chosen owing to its measurement accuracy (standard error of estimate + 0.592 years), and the non-invasive nature of the technique by incorporating measures of age, body mass, standing height, and sitting height into a regressionequation to calculate the age from peak height velocity, deemed beneficial when assessing maturational status in children (Roche et al., 1988). In male, maturity offset = - 9.236 + 0.0002708 * Leg length and sitting height interaction - 0.001663 * age and leg length interaction + 0.007216 * age and sitting height interaction + 0.02292 * weight by height ratio. In female, maturity offset = - 9.376 + 0.0001882 * Leg Length and Sitting Height interaction + 0.0022 * Age and Leg Length interaction + 0.005841 * Age and Sitting Height interaction – 0.002658 * Age and Weight interaction + 0.07693 * Weight by Height ratio (Mirwald et al., 2002).

Squat Jump and Rebound Jump – The squat and rebound tests were used following procedures previously described by Lloyd et al. (2009), who reported these methods to be reliable with paediatric populations. All jumps were performed on a contact mat with flight time used to measure jump height. The squat jump was performed from an initial semi-squat (90 knee flexion), determined from visual inspection and once achieved, participants held the position for two seconds before jumping vertically for maximum height on the command of tester. In the rebound jumps, participants were required to lower themselves from an initial standing position to a self-selected squat position, followed immediately by a vertical jump on the command of the tester followed by another four maximal rebound jumps. Participants were instructed to maximise jump height and minimise ground contact (Dalleau et al., 2004). Within each testing session, participants were given three trials of the squat jump and rebound jump. The best trial of each test was subsequently used for further analysis.

Yo-Yo Intermittent Endurance Test - The methodology of Yo-Yo intermittent endurance test level one (IE1) was similar with the Yo-Yo intermittent recovery test utilised by Krustrup et al. (2003). The test is terminated when the participant can no longer keep up with the predetermined speed. All the participants were familiarized to the test by at least one pre-test. Participant’s performance in the Yo-Yo IE1 was defined as the maximum distance covered (Bangsbo, 1996).

Push-Ups - The push-up test for male was employed following procedures previously described by Augustsson et al. (2009), who reported this method highly reliable for young populations. The participants worked in pairs; whilst one performed the test their partner counts the 90° push-ups and observes the technique of the participant being tested to ensure the elbow is flexed to 90° and the upper arm parallel to the floor at the lower point of push-up (Marilu et al., 2007), with the back kept in a straight line (Roetert et al., 1996). For female participants the modified “knee push up” position was used; legs together, lower leg in contact with mat with ankles plantar-flexed, back straight, hand shoulder width apart, head up, using the knees as the pivotal point)

(Hoffman, 2006). The number of push-ups in boys and girls were performed in 60 s or to failure if within 60 s.

Medicine Ball Throw – The participants were given three trials in which they attempted to throw a medicine ball as far as possible using the procedures previously described by Avery et al. (2006). The seated medicine ball throws were performed using a 2-kg rubber medicine ball (HeavyMed, Gr 2000 Gymnic, Italy) for females and 3-kg rubber medicine ball (Jordan, 3 kg Jordan Fitness, United Kingdom) for males. They were instructed to throw the ball as far as they could with both hands (similar to a chest past) without trunk movement. Each throw was measured for distance (centimetres). Three trials were given for every participant.

Handgrip Strength - The handgrip strength test was measured using an electronic dynamometer (T.K.K. 5401 Takei, Tokyo, Japan) with standardised protocols (American College of Sport Medicine, 2010). The participant adjusted the grip bar to fit comfortably within the hand so that the second joint of the fingers were bent to grip the handle of the dynamometer. The participant was asked to hold the dynamometer parallel to the side of the body with the elbow flexed to 90°. Then the participant squeezed the handgrip dynamometer as hard as possible. Three trials were given for each hand, with the highest measurement taken as the grip strength for that hand.

20-Kick Test - A contact mat was used to measure total kick time during the 20-kick test (Smartjump, Fusion sport, Australia). The participants performed 20 rapid kicks against a kicking pad (target) held by the tester at chest height (of the participant, reflecting the target area of Silat competition). The emphasis was on speed and the contact with the pad only needed to be minimal.

The dominant leg was used for kicking. A tester held the kicking pad approximately 1 m in front of the participant. The participants were given several practice trials before starting the test, particularly to self-select the horizontal distance between themselves and the kicking pad to allow as quick a kicking action as possible. The stance leg was placed in between the kicking pad and contact mat (Figure 1), while the kicking foot repeatedly made contact with the mat during the test.

To commence the test participants stood in ‘pasang’ position as per the beginning of a silat match and were given a command of ‘3-2-1-Go!’. Simultaneously to the ‘Go!’ command the participant performed 20 kicks as rapidly as possible. Verbal encouragement was given during the kicks to make sure the participant maintained their kicking rhythm. Participants completed three trials with a full recovery between trials. The best trial for total time was used for further analysis.

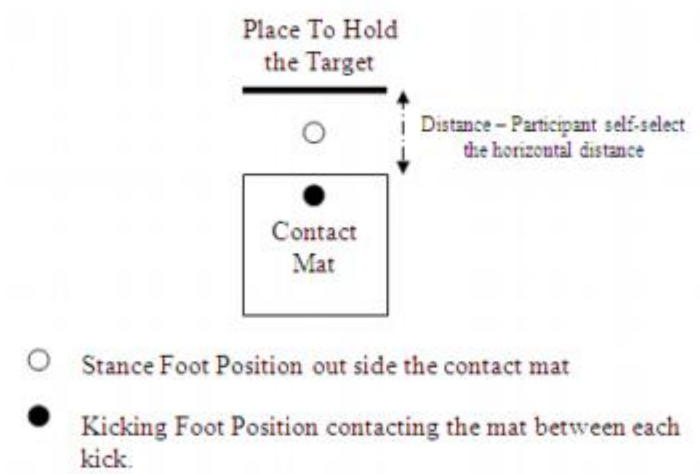


Figure 1 - Schematic representation of the 20-Kick Test.

3-Directional Jump - The 3-directional jump (figure 2) measures speed, agility and coordination during jumping and mimics evasive movements during a silat match. The test was performed on a flat, non-slippery floor surface with one metre distance between the centre of a contact mat secured to the floor with 3 other markers (figure 2). The participants started in the middle of a contact mat and performed a number of 1 m jumps in as quick a time as possible. In sequence participants jumped laterally to the left, back to the centre, laterally to the right, back to the centre, forwards, and finally jumped backwards back to the start / finish (figure 2). Both feet were required to clear the markers for the trial to be valid. The best from three trials was used for analysis.

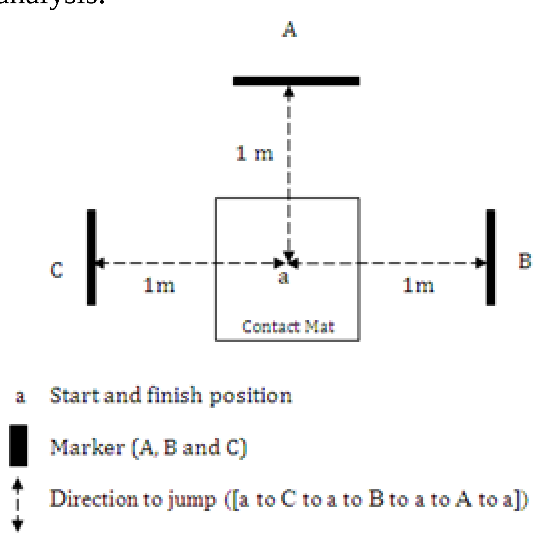


Figure 2 - Schematic representation of the 3-Directional Jump Test.

Statistical Analysis

Mean bias and random variation of the test-retest data for the silat-specific 20-kick and three-directional jump test was assessed using a paired samples t-test and coefficient of variation (CV), respectively. In the main study, performance data was analysed using a two way ANOVA using a 2 X 4 model (gender * age group). Maulchy's test of sphericity was examined and were violated the Greenhouse-Geisser adjustment employed. Significant main and interaction effects were further explored using a Bonferroni post hoc adjustment. All data analyses were completed using SPSS © (Version 17.0, SPSS Inc, Chicago, IL), with significance set a level of $p < 0.05$.

RESULTS

Reliability

Total time showed no mean bias between trials one and two for either the 20-kick test (14.96 ± 1.67 and 14.73 ± 2.26 s, $p > 0.05$) or the three-directional jump test (3.18 ± 055 and 3.14 ± 0.35 s, $p > 0.05$). Both variables also demonstrated moderate levels of random variation with a coefficient of variation of 6.83 % for the 20-kick test and 9.00% for the three-directional jump.
Table 1. Physical and performance characteristics of male and female silat exponents aged 13-16 years old.

Variable		Male	Female
Descriptive Data	Body Mass (kg)	49.6 ± 12.7	48.1 ± 8.6
	Height (cm)	155.3 ± 9.3*	152.0 ± 5.4
	Sitting Height (cm)	77.0 ± 5.4*	75.9 ± 3.5
	Years from PHV	-0.9 ± 1.1*	1.1 ± 0.7
General Physical Abilities	HandGrip Strength (kg)	32.2 ± 7.9*	24.8 ± 4.0
	Med Ball (cm)	260 ± 65*	238 ± 43
	Yo-yo (m)	1135 ± 609*	684 ± 278
	Push- ups (rep)	29 ± 13*	26 ± 9
	Squat Jump (cm)	32.7 ± 7.50*	23.35 ± 4.73
	Rebound Jump height (cm)	26.31 ± 7.61*	20.72 ± 5.01
	Rebound Jump CT (s)	3.43 ± 1.04*	2.86 ± 0.79
	Rebound Jump RSI	0.73 ± 0.17	0.71 ± 0.16
Sport-Specific Abilities	3-Directional jump (s)	3.10 ± 0.49	3.13 ± 0.54
	20-Kick Test (s)	14.88 ± 2.98*	16.31 ± 2.29

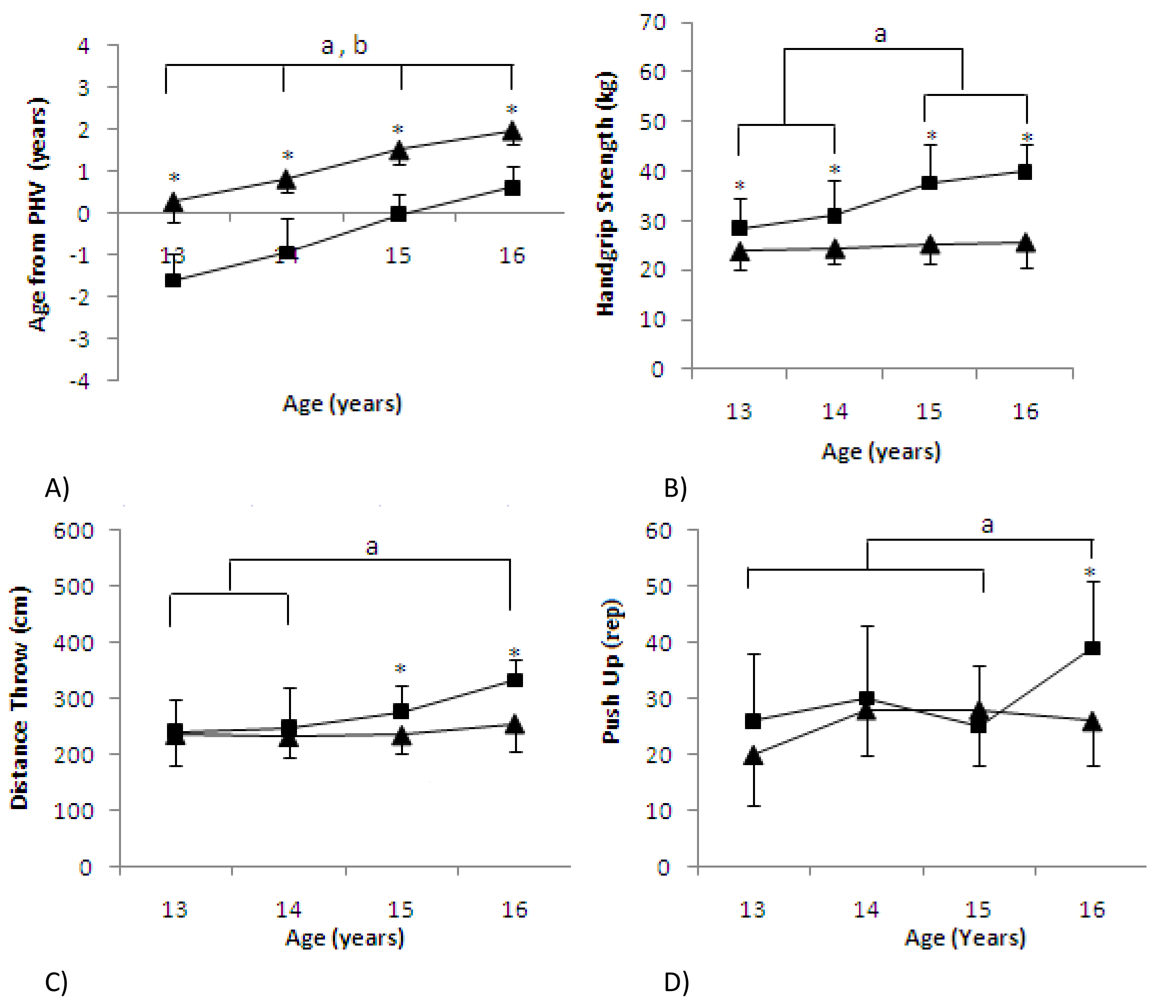
*Significant difference between males and females ($p < 0.05$) **Handgrip Strength is the highest mean value of the left and right hand; MedBall=Medicine Ball Throw distance; Yo-yo = Yo-yo Intermittent Endurance Test Leve1 1; CT=Contact Time; RSI=Reactive Strength Index (jump height/CT); PHV = Peak Height Velocity.

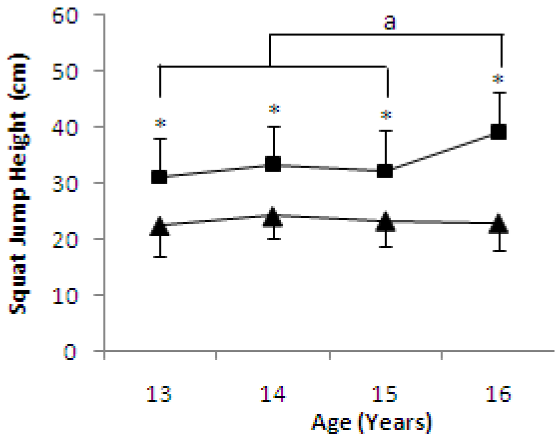
Gender Main Effects

The main effect of gender pooled across all age groups is shown in Table 1. Males were significantly taller than females, but the females were estimated to be more mature than the males. The boys outperformed the girls on a number of general physical fitness measures, including; handgrip strength, medicine ball throw, push-ups, yo-yo endurance, squat jump and rebound jump height, although Reactive Strength Index (RSI) values were similar between the genders as the males spent significantly more time on the ground than the girls (Table 1). Even though the protocols for the push-ups and medicine ball throw were gender specific, significant differences between males and females were still evident. In the silat-specific protocols the boys were significantly quicker during the 20-kick test compared to the girls, while there was no difference in three-directional jump.

Age and Gender Interactions

Handgrip strength, medicine ball throw, push-ups, squat jumps and yo-yo endurance performance all demonstrated significant main effects for age (all, $p < 0.05$), and more interestingly significant age*gender interactions (all, $p < 0.05$). Between-gender and between-age differences for these variables are shown in figure 3. All of these variables follow a similar trend with males tending to outperforming females at each age, females showing no improvement in performance with advancing age and the older age group(s) in the males outperforming the younger age groups (Figure 1). Conversely, all rebound jump variables (height, RSI and contact time), three-directional jump and 20-kick test performance showed no main effects for age (all, $p > 0.05$) and no age*gender interactions (all, $p > 0.05$), although the main effect of age on rebound jump height did approach significance ($p = 0.072$). For all rebound jump variables, three-directional jump and 20-kick test neither the males or the females demonstrated any significant improvements in performance across age groups (all, $p > 0.05$).





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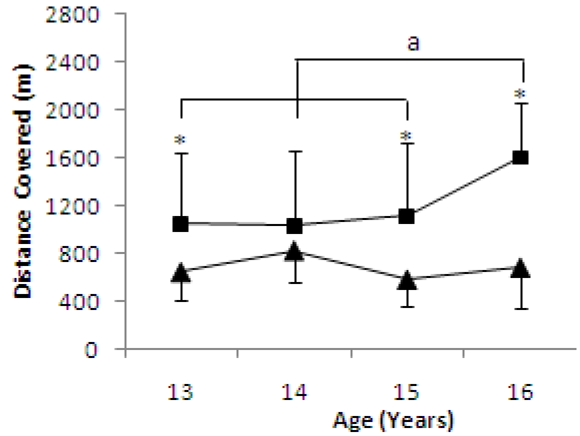

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Discussion

To our knowledge this is the first study to report the fitness characteristics of youth silat exponents. Overall, the boys were taller, had better jump heights, greater grip strength, superior throwing distance, greater push-ups repetitions, better endurance and could kick faster than the girls. The girls showed no change in performance with advancing age across any of the age groups. Conversely, the boys showed an improvement in a number of the variables when comparing the older age groups to the younger age groups. The observed responses are likely to be associated with gender-specific maturation; the youngest female group were already estimated to be around peak height velocity, whereas the boys did not achieve this status until the 15 year age group.

The reliability study of both 3-directional jump and the 20-kick test showed no learning effect and moderate levels of random variation. The CV's were similar to those reported for other field tests such as squat jumps, counter movements jumps and RSI's in youths (Lloyd et al., 2009). Previous authors (Cormack et al., 2008; Cronin et al., 2004; Hunter et al., 2004) have suggested that CVs below a 10% cut-off can be used to determine reliability in field based measures. Due to the novel nature of the silat-specific-tests it is difficult to make comparisons with previous research, however, research from similar tasks has suggests that data from paediatric populations is likely to be associated with greater levels of random variation. Lloyd et al. (2009) stated that both maximal and sub-maximal hopping are whole-body, multi-joint activities that require high levels of motor coordination and that an immature neurophysiological status may lead to greater variability in test scores. This is supported by Gerodimos et al. (2008) and Harrison et al. (2001), who supported that the variability in the performance of stretch-shortening cycle tasks is greater in younger participants and reduces as participants move towards adulthood. So, it is reasonable to expect that results tend to be more variable in younger populations as children continue to develop coordination (Lafayye et al., 2005). Furthermore, because of the nature of the tests which were relatively short, using multiple trials would also be expected to improve the CV's (Pyne, 2004) and this approach should be considered in future research.

In the silat-specific kicking test boys were able to kick quicker than the girls, but there was no age effect for either gender. Meanwhile, the 3-directional jump did not distinguish across gender or age groups. These may reflect similar findings of others; limb speed (i.e. step frequency) does not increase in sprinting as children age increased (Schepens et al., 1998). Similarly, RSI did not distinguish performance differences between age groups or gender. This could reflect the fact that this test is not specific to the demands of Silat sports or may reflect developmental trends. Lloyd et al. (2011) showed that RSI significantly improved in boys up to the age of 13, but there were no significant improvements between 13 and 16 year olds. Reactive strength may be more related to neural development and chronological age than maturation (Balyi et al., 2000).

Performance differences between males and females are likely to be influenced by differing maturational processes (Malina et al., 2005; Papaiakovou et al., 2009; Naughton et al., 2000). The females achieved PHV at age 13, two years earlier compared to male silat exponents, and the females did not show any improvement with age for any variable. It is likely that the female silat exponents were suffering from the accumulation of fat during adolescence. The performance plateau during adolescences for girls probably reflects an interaction of biological and cultural factors such as changing social interests and expectations, pressure from peers, lack of motivations or reduced opportunities to participate in other performance-related physical activities (Malina et al., 2004). Although being involved in Silat did not enable female exponents to improve their fitness with increasing age or maturation, it did allow the females to maintain their level of fitness (with no significant decreases in performance). This may itself reflect a positive response, with previous authors reporting a decline in the fitness levels of adolescent girls (Malina *et. al*, 2004; Viru et al., 1999; Naughton et al., 2000).

The male silat exponents outperformed girls in a number of the performance tests. This may reflect greater habitual activity in boys (Beunan et al., 1992) and the negative consequences associated with the earlier maturation of the girls (Malina et al, 2004). The boys were around PHV in the 15 year old group. In contrast to the girls an age effect was apparent for the boys; the older two groups had greater grip strength than the younger groups and the 16 year olds had better medicine ball throw, push-up, squat jump, and yo-yo test scores compared to their younger counterparts. Staggering of these improvements post PHV may better reflect timing of peak weight velocity. Thus, improvements are likely to be associated with maturational factors such as hormone development that leads to increased muscle mass and internal organ size (Viru et al., 1999) providing strength and endurance benefits, respectively. This supports the trigger hypothesis, which is the result of the modulating effects of hormones that initiate puberty and influence functional development and subsequent organic adaptations (Katch, 1983). Such hormonal responses at puberty are critical in improving performance and allowing training adaptations. For example, improved yo-yo endurance performance in the older males will be related to increased plasma volume, improved myocardial contractility, and more powerful skeletal muscle pump to augment ventricular filling (Rowland, 1997). Similarly, the hormonal trigger is likely to be important in improving performance in tests where increased muscle mass in is an advantage. Based on the theory of sensitive periods of development (Viru et al., 1999) and trainability/windows of opportunity presented in the long-term athlete development model of Balyi and Hamilton (2000, 2003 and 2004), results of the present study would suggest that training adaptations in the boys could be maximised around the time of, and just proceeding, peak high velocity.

Conclusion

This study examined 178 young silat performers who actively participate in silat training as part of co-curriculum activities in Malaysia. Two new silat-specific tests were found to be reliable for youth silat performers, which can be used to evaluate an athlete's ability to perform rapid kicking and movement-agility exercises. Novel data has been presented, which could be useful for benchmarking fitness in youth silat. The results of this study suggest that silat is characterised by well developed endurance, upper and lower body strength and power and speed of kicking. Therefore, these variables may be useful in identifying talent, informing training prescription and evaluating the effectiveness of training to promote fitness development. The diverse response of the females and males is likely to be due to gender-specific maturational differences. Being involved in silat did allow females to maintain fitness, whereas males improved their fitness at or post peak high velocity. These findings may help improve training prescription, although further research is needed to examine training responses at different stages of maturation.

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