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Original Research

Assessment of the muscle architectural parameters in skill and non-skilled Karate players

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ABSTRACT

The aim of this study was to assess the muscle architectural parameters in skill and non-skilled Karate players. Material and method: For this purpose 30 Karate players were assigned into skill (mean age of 22.03 ± 1.25 years, mean height of 1.76 ± 3.47 m and mean weight of 63.0 ± 1.01 kg) and non-skilled (mean age of 20.08 ± 2.04 years, mean height of 1.73 ± 1.44 m and mean weight of 59.01 ± 3.25 kg) groups. Muscle thickness, pennation angle and fascicle length in 50%, 60% and 70% of biceps and triceps length sites was measured using ultrasonography images. Independent t-test was used for data analysis.
Result:The results of independent sample t-test showed there was a significant differences between Muscle thickness of triceps in skill and non-skilled Karate players ($p \le 0.05$). There was also a significant differences between pennation angle of triceps in skill and non-skilled Karate players ($p \le 0.05$). Other results of this study showed there was a significant differences between fascicle length of triceps and also between muscle thicknesses of biceps in two groups ($p \le 0.05$).
Conclusion: it seems practicing karate at high levels can cause changes in muscle architecture parameters and with impress some parameters associated with length and muscle tension, provide areas for improving motor function in karate special techniques.

Keywords: Muscle pennation, Karate players, Muscle architecture, Muscle thickness, Fascicle length.

Introduction

Nowadays, in the field of sports science research, the review of the operation and different characteristics of skeletal muscles with the progress and improvement of non-invasive imaging techniques is very significant because it enables a deeper study of the ultrastructural (cellular) microscopic features and skeletal muscle fibers [24]. Muscle architecture studies mean microscopic and cellular techniques used to check the muscle fiber structure and arrangement [15, 20]. Muscle architecture [18] is defined as “the arrangement of muscle fibers in the muscle relative to the force” which primarily includes parameters such as pennation angle (the angle between the muscle fibers and muscle action), muscle thickness and fascicle length, and other parameters such as the type of muscle fiber and anatomical and physiological cross-sectional area are factors being in the higher levels of muscle architecture parameters [8]. Since the muscle fibers are of the same thickness relatively between muscles with different size and the size of muscle fibers is directly in proportion with its force generation. In other words, differences in architecture between the different muscles have high variability and consequently impact on performance [15, 20]. In the meantime, more attention to the factors such as the type of muscle fibers in determining characteristics of muscle force production is of special importance [18, 20]. Based on past research, muscle architecture can be affected by the measures in response to different training or non-exercise regimes [16]. Although different types of physical activities affect muscular factors, in addition, other factors such as intensity, duration, frequency, duration of training, age, and gender can affect the variability of muscles [14]. Fascicle arrangement is probably considered as the strongest factor affecting on overall muscle performance rather than other factors such as the type of muscle fibers. Muscles with great pennation angle and therefore small fascicle length are suitable for contractions with high force and they produce a high force in a small range of motion such as gastrocnemius muscle and vastus lateralis muscle, on the other hand, muscles with small pennation angle and great fascicle length are more suitable to create a high speed in the high range of motion [16]. So, it seems the muscle fascicle length can be considered as one of the factors affecting the performance of athletes [24], The way of architectural arrangement of muscle fibers in a muscle affects the force generated along the muscle axis [10].

Several studies have been done on athletes in some sports like table tennis [11], swimming [5], table tennis [24], track and field [12], and soccer [18]

Nasirzadeh et al. (2012) reported that muscle thickness and pennation angle at different sites (50%, 60%, and 70%) of biceps muscles and triceps muscles of table tennis players are different through the study of muscle architecture parameters. Consequently, the study of muscle parameters is useful to improve the movement pattern with high speed [24]. Nasirzadeh et al. (2012) studied the relationship between sprint performance of front crawl swimming and muscle architecture parameters (thickness, pennation angle, and fascicle length) in biceps muscles, triceps muscles, vastus lateralis, medial gastrocnemius muscle, and lateral gastrocnemius muscle) of young boy swimmers. These researchers showed that the fascicle length of muscle can be one of the factors affecting the performance of sprint front crawl swimming of young swimmers [24]. Nasirzadeh et al. (2013) reported that it is able to predict the performance of swimmers by biomechanical parameters, muscle architecture, and anthropometric at young boys 50m front crawl swimmers [23]. In addition, Brughelli et al. (2010) indicated that the architecture and optimal angle of the knee extensors and flexors between football players and cyclists are different [8]. Matta et al. (2011) indicated the impact of power training in the improvement of hypertrophy in both biceps muscles and triceps muscles through different answers are seen in the architecture of spindle and pennate muscles in different parts of the arm muscles [21]. In the meantime, karate is a combat tactics that has been very popular among athletes. Implementation of karate movement patterns due to the higher need of this sports field to enact the quick, high-strength, and explosive power could lead to the improvement and growth of muscles in different parts of athletes' bodies [9]. Karate includes a plurality of implementation forms related to the upper body. Anatomic and biomechanical studies of karate skills show that such skills are of very high involvement of arm muscles in the elbow's extension and flexion [26, 3]. Few studies related to the geometry adaptation parameters and muscle architecture in the athletes' training of combat tactics such as karate are done that it makes it necessary to review. In other words, karate because of the nature of frequent use of special moves to what extent affects changes in muscle architecture and geometry. On the other hand, combat fields are in the category of asymmetric sports that are accompanied with high mechanical pressure on all body tissues especially on hands that leads to adaptations such as muscle bone mass. According to the results of previous studies on the significant effects of some sports training on the muscle geometry of athletes in lower body [11, 16] and upper body [23, 24]. This caused a situation in other sports such as karate and in other parts of the body such as upper body. Therefore, this study aimed at investigating made adaptations in muscle architecture parameters affected by participating in karate training in the biceps muscles and triceps muscles of karate athletes and changes in muscle architecture.

Material and Methods

Participants

The current study was causal-comparative and was gathered in a field. The statistical population of this study includes 30 subjects from male karate athletes of Birjand city. Two elementary and professional groups were chosen as samples available that were divided into two groups of 15. It should be noted that professional karate athletes had sports activity experience at least for 5 years regularly and were constantly participated in the national league and had won a position.

Test protocol

At first, consent form to participate in research and public health questionnaire were completed by participants. Then anthropometric measurements such as height, weight, and body mass index by the device stadiometer and scale Seca the model 220 made in Germany were measured respectively with a sensitivity of 0.01 mm and a sensitivity of 0.1 kg. The BMI by dividing weight (in kilograms) by the square of height (in square meters) was calculated. Measurement of muscle architecture parameters by ultrasonography EUB-405 Hitachi type B made in Japan was done with 1.2 MHz linear array probe. Software Medical by default on ultrasonography tool was used to measure the thickness of the muscle and skin layers, software AutoCAD version 2012 to measure the pennation angle of participants, and to accurately measure the arm's length and determine sites 50% (PS), 60% (MS), and 70% (DS) arm's length. Arm's length as the distance between the acromion process of scapular bone and lateral epicondyle of humerus was measured according to the method presented by ISAK [12]. Each of the subjects sitting on the clinic bed with bare upper body, Percentage points in the biceps muscles and triceps muscles of the top subjects' hands at points 50%, 60%, and 70% were determined. The muscle thickness (the distance between intersection of muscle and bone to the intersection of muscle and adipose tissue [1]) of points 50%, 60%, and 70% of biceps muscles and triceps muscles with 0.01mm accuracy, pennation angle (acute angle between fascicle and the deep aponeurosis of muscle [1]) with 0.01mm accuracy, and fascicle length through the following equation were measured [1].

Fascicle length = Sin (α) / muscle thickness

α: Pennation angle in the triceps muscles

It should be noted that all measurements were performed twice that their average was considered after data collection.

Data analysis

Data from this study were set and examined through using descriptive statistics methods. At first, Kolmogorov-Smirnov test was applied to determine the normal distribution of pre-test and post-test. Then the independent t-test was used to compare groups. Significant level was considered $P<0.05$. All statistical methods were performed with software SPSS version 10.

Result

Table 1 shows public features of subjects such as age, height, and body mass index

Table 1. Anthropometric characteristics of subjects.

Index	elementary group (EG)	professional group (PG)
Age (year)	20.08 ± 2.04	20.03 ± 1.25
Height (cm)	173.29 ± 1.44	176.02 ± 3.47
Weight (kg)	59.10 ± 3.25	63.00 ± 1.01
BMI (kg/m^2)	23.18 ± 1.01	22.00 ± 1.08

Table 2 shows the data related to the muscle architecture parameters of muscle thickness, pennation angle, and fascicle length.

Table 2. Muscular architecture parameters of triceps muscle in elementary and professional groups.

	Index	EG	PG	*t*	P
50%	**Muscle thickness (cm)**	3.67 ± 0.15	4.25 ± 0.14	4.75	0.001*
	Pennation angle (degree)	20.22 ± 0.23	19.66 ± 0.14	20.75	0.001*
	Fascicle distance (cm)	12.23 ± 0.17	14.45 ± 0.16	14.45	0.001*
60%	**Muscle thickness (cm)**	3.96 ± 0.11	4.11 ± 0.27	3.87	0.001*
	Pennation angle (degree)	19.03 ± 0.20	18.33 ± 0.23	19.78	0.001*
	Fascicle distance (cm)	14.14 ± 14.14	15.22 ± 0.11	13.88	0.001*
70%	**Muscle thickness (cm)**	3.02 ± 0.18	3.27 ± 0.29	4.33	0.001*
	Pennation angle (degree)	18.33 ± 0.15	17.33 ± 0.24	17.02	0.001*
	Fascicle distance (cm)	11.18 ± 0.22	12.62 ± 0.33	12.19	0.001*

Table 3 muscle architecture parameters of muscle thickness, pennation angle, and fascicle length.

Table 3. Information related to the muscular architecture indexes of biceps muscles in elementary and professional groups.

Index	EG	PG	*t*	P
50% muscle thickness (cm)	4.24 ± 0.51	3.11 ± 0.23	2.59	0.001*
60% muscle thickness (cm)	3.12 ± 0.25	2.40 ± 0.11	3.10	0.001*
70% muscle thickness (cm)	2.91 ± 0.23	4.11 ± 0.27	3.89	0.001*

The results of independent T-test show that there is a significant difference between two groups at points 50%, 60%, and 70% of the size of muscle thickness, pennation angle, and fascicle length of triceps muscles ($p<0.001$).
There is also a significant difference at points 50%, 60%, and 70% of muscle thickness of biceps muscles in professional and elementary karate athletes ($p<0.001$)

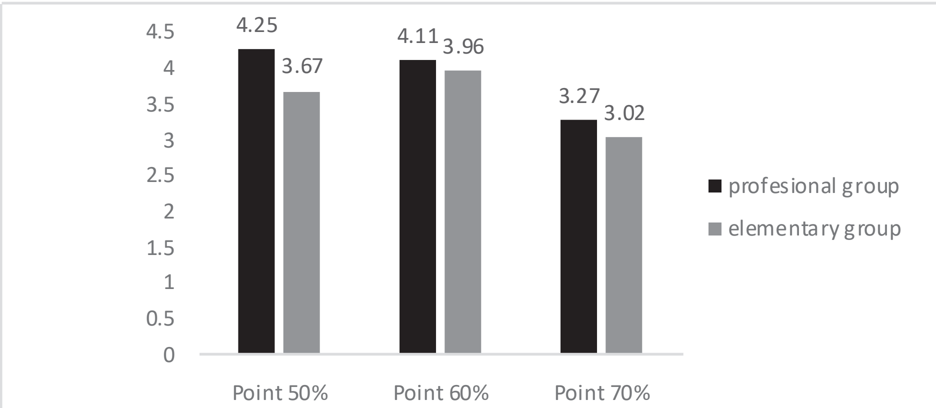

Figure 1. Dimensions and size of the thickness of triceps muscles.

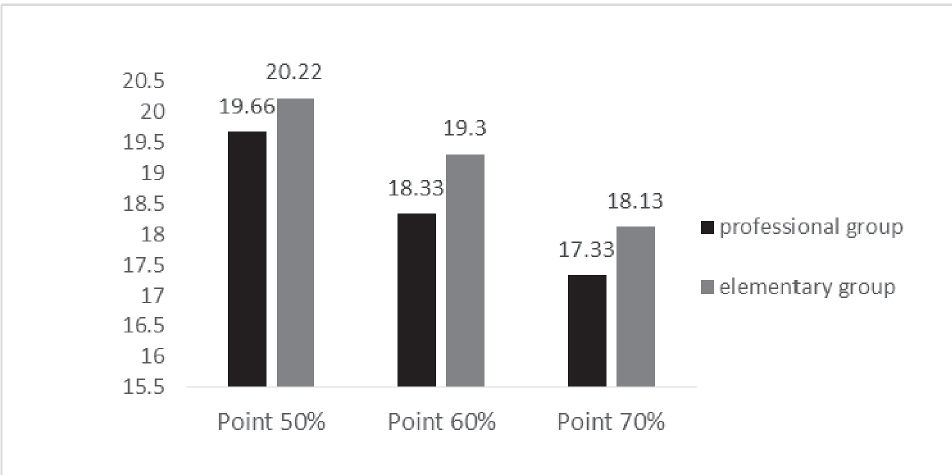

Figure 2. Dimensions and size of the pennation of triceps muscles.

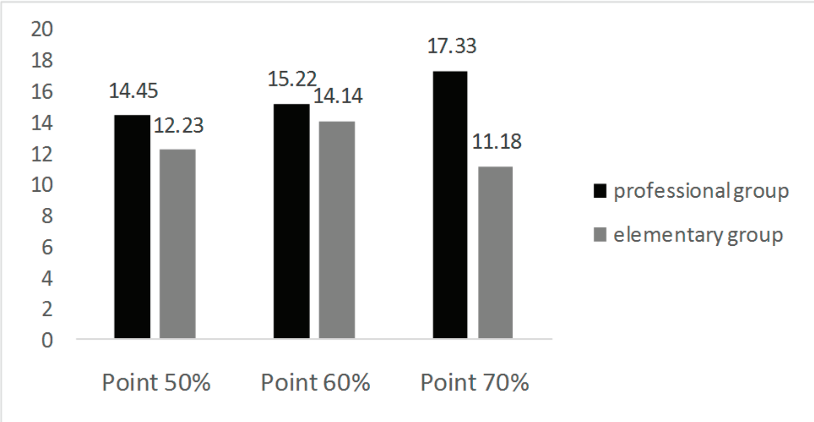

Figure 3. The fascicle length of triceps muscles.

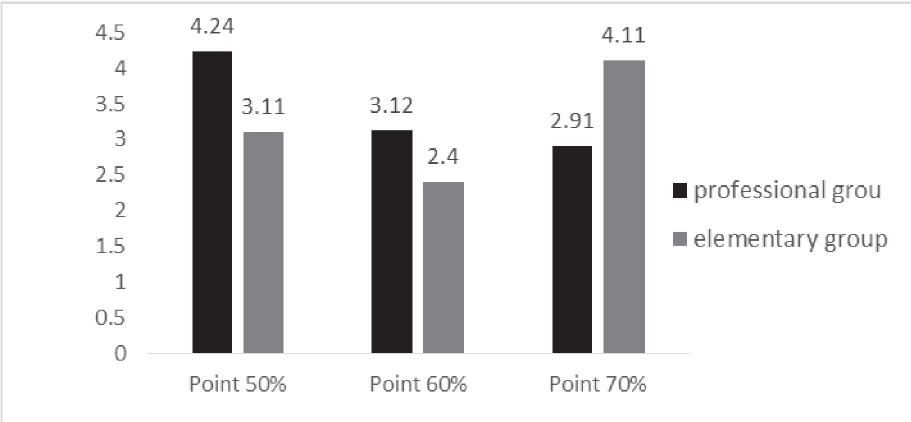

Figure 4. The muscle thickness of biceps.

Discussion

The results showed that there is a significant difference at points 50%, 60%, and 70% in the dimensions and thickness, dimensions and pennation angle, and the fascicle length of triceps muscles between elementary and professional karate athletes. Due to the high number of upper body movements in karate, anatomic and biomechanical studies show that the triceps muscles involved in is very high in elbow's extortion. Rapid movements in the techniques of karate which are often done by hand affect a significant portion of the upper body. Kumagai et al. (2000) showed in a study on male 100m sprinters which the more professional runners are and they have an acceptable record, the changes are affected by the hypertrophy of lower body. In other words, professional athletes in the 100m sprint running are of great thickness in the calf's muscles that is indicator of changes and adaptations in the shape of muscle [16]. Blazevich et al. (2001) reported in a study that muscle thickness in the vastus lateralis muscles and rectus femuris muscles increases through participating in the resistance training in a five week of power training. The researchers noted that the adaptations can be made by the subjects participating in the exercise, force characteristics, and speed of sports training and this thickness is in connection to the executed movement pattern [4]. It seems that the implementation of the techniques of karate repeatedly and at high levels with further changes in the structure and shape of the muscles used in comparison with elementary athletes [9]. It is known that the rapid implementation of elbow's movement in extension is an effective factor in triceps muscles hypertrophy in tennis players [22]. While the results from different parts indicate that at point 50% it has maximum hypertrophy and at 70% less than the other two points 50% and 60%. The results of the current study are consistent with previous results of Nasirzadeh et al. (2012) that they reported the highest muscular thickness at point 50% in comparison with the point 70% that is caused by further contraction in the central parts of the biceps muscle during adaptation with table tennis training that is mainly with an active flexion of the elbow in front of a fixed resistance (rocket) [22].

Other results showed that the size and pennation angle of triceps muscles in professional athletes is lower than elementary athletes. It has been reported that certain training can significantly alter the dimensions and pennation angle in the athletes' muscles. Nassirzadeh et al. (2012) and Kumagai et al. (2000) reported that the pennation angle of table tennis players in all studied parts of the triceps muscles is significantly smaller than non-athletes'. These changes in sprinters and sprint swimmers who need to have fast movements in implementing techniques are true [16,22]. It appears that the characteristics of rapid and explosive activity causes gradation adaptation in muscle architecture parameters especially in the pennation angle. Since karate is accompanied by rapid movements, regular training can be effective in this case [9]. Pennation angle is relative to the joint point to the aponeurosis and muscle tendon and is defined as the placement pattern of muscle fibers relative to the force generation axis of the muscle that is considered as the main factor to determine muscle performance affecting muscle contraction [25]. However, reducing the pennation angle increases muscle force being in the way of muscle tension. Larger fascicle length has a maximum speed of muscle contraction and thus high power and the improvement of motion sprint performance, however; the produced force decreases by rapid contraction [24]. Abe et al. (2000) reported that smaller muscle pennation in the vastus lateralis muscles of sprinters were significantly lower than non-athletes'. In other words, smaller pennation in lateral muscles can be associated with better performance of sprinters [1]. On the other hand, Matta et al. (2011) focused in a study to examine the effect of power training on muscle architecture parameters in different sites of the arm. Pennation angle of biceps muscles at points 50%, 60%, and 70% of the arm's length was significantly increased that this result is somewhat different with the current study [21]. According to muscle adaptations that may occur by practicing a specific sport at pennation angle, the changes can also be caused by other adaptations in muscle architecture parameters that can affect to some extent the motor performance of athletes. However, with aging, pennation angle in the vastus lateralis muscle of subjects has significantly decreased [11]. According to the above, it indicates that the age of the subjects can affect the results before evaluating pennation angle that making a difference in the results of the present study and Matta et al., (2011); however, the cases mentioned in connection with the athletes participating in the study were controlled and the subjects in each group were accurately matched [11].

The fascicle length of triceps muscles at three points 50%, 60%, and 70% of muscle length in professional subjects is significantly greater than elementary athletes in karate. It is reported that small pennation angle and long fascicle are appropriate in the movements with high speed and great motor range for the reason of having a large number of sarcomere embedded in a row are recruited simultaneously and muscles with large pennation angle and small fascicle length for the movements with high power in small motor range [24]. Some explosive movements in karate including Giakutsuki is done with high range and maximum speed. This change is likely taken into consideration to the end of movement. It is likely that muscular changes including increased sarcomere in the changes of fascicle length in the professional athletes play an important role in long-term and it can be somewhat effective in the changes of architecture parameters and increasing in fascicle length of triceps muscles. Kumagai et al. (2000) and Abe et al. (2001) reported that having a larger fascicule in the vastus lateralis muscle, medial and lateral gastrocnemius in sprinters is considered as an advantage [1,17]. It seems that the difference in ability level and probably faster movements in the professional karate athletes can be consistent with the difference in the fascicle length of muscle involved in [24]. While this study focuses on upper body, as a result, the results should be inferred cautiously. It has been found that the length of muscle fiber and the type of muscle are the main determining factors in contraction speed and motor sprinter performance in athletes [17,11,16]. The results showed that the obtained adaptations are likely effective in making changes in the fascicle length of triceps muscles which are useful in the implementation of high-speed movements.

The results indicate that in relation to the size of muscle thickness of triceps muscles in the professional karate athletes at all points is significantly greater than the thickness in elementary athletes. These results suggest that regular training causes muscle hypertrophy in all parts of the biceps muscles. According to the fact that karate is associated with explosive speed, it can lead to the improvement and growth of muscles [9]. Some researchers demonstrated that more and more professional athletes with well record have a higher muscle thickness [24,17,4]. Stop training in karate is accompanied with using biceps muscles [9]. Nasirzadeh et al. (2013) reported that a greater thickness in the central sites of biceps muscles is associated with adaptations in table tennis that is mainly elbow flexion against a fixed resistance [22]. This can be attributed to the defense techniques of karate such as Sanchin dachi, Kokutsu dachi, and Zenkutsu dachi. In these

techniques, biceps muscles are accompanied with elbow flexion in different angles. The position of the upper body in the implementation of defensive forms affect the performance of biceps muscles since it is in the static contraction status. The increasing size of muscle thickness of biceps muscles can be affected by defensive techniques. However, the different parts of muscle may be differently affected from a special training. The point 50% has the highest amount and the point 60% is lower than the other two points that represents a heterogeneous hypertrophy in the biceps muscles of professional subjects. The results of this study are similar to the results of Matta et al. (2011) and Nasirzadeh et al. (2013) [21,25]. According to the spindle-shaped muscle of biceps [7], its tendon spreads along in the lower part when connected to the muscle tissue in the form of a coil-like that is along the central line of the lower part of muscle and is stretched about 34% of the length of biceps muscles [2].
The results of this study showed that there is a significant difference between the muscle architecture parameters in biceps muscles and triceps muscles in professional karate athletes and elementary ones. In general, professional karate athletes due to the duration of exercise have more thickness in biceps and triceps muscles, smaller size in pennation angle and greater fascicle length in triceps muscles. The changes were observed in all parts of the 50%, 60%, and 70% of the length of the muscle. It appears that the implementation of karate training at high levels can change the muscle architecture parameters and then prepare the situation to improve the level of motor performance through impressing some of the related parameters to the muscle length and tension.
Finally, it seems that thickness, pennation angle, muscle length in triceps muscles, and more muscle thickness in biceps muscles in karate athletes with high skills are factors effective on faster implementation of karate movements.

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