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Article

Development of the Taekwondo Performance Protocol to assess technical speed and quickness

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1. Introduction

Taekwondo is an Olympic martial art characterized by using bare hand and feet effectively according to defense and attacking strategies. Its roots go back thousands of years. Taekwondo also aims at achieving high morals and virtues. Millions of people around the world do the sport. Due to emerging technology, current training methods, scientific re-search and increased competition, there have been some changes in the appearance and size of taekwondo competitions over the years [1–4]. But in any case, Taekwondo drives and improves its practitioners' basic motor abilities, such as strength, speed, agility, endurance, and balance [5, 6]. Nowadays, the transfer of these motor abilities as specific to taekwondo is an important factor that allows athletes to succeed.

Olympic Taekwondo competitions consist of 3 rounds of 2 minutes, and therefore anaerobic energy systems dominate [7]. Athletes compete with strong and coordinated techniques [8–13]. For this reason, taekwondo gives an advantage to agile and swift athletes who have developed anaerobic strength and capacity during competition. The fact that taekwondo is a fighting sport and athletes must apply maximum successful technique in minimal time when they have the opportunity forces them to be agile and swift. Therefore, taekwondo training often includes exercises that improve speed and quickness, training athletes to have a high technical frequency in fast and short time intervals [6, 14–17].

The correct training method focuses on the athletes' individual characteristics. For this reason, accurate performance measurement is essential for correct training.

Taekwondo has its own unique structure, which is why more specific strategies have been developed recently to evaluate the performance of taekwondo athletes [18–25]. But the evolving technology in the professional sport, the increasing sense of competition and changes in competition protocols also require changes in training methods. In this case, athlete performance should also be measured with more modern methods and techniques. Therefore, the aim of this study is to develop a valid, reliable, and economical Taekwondo Performance Protocol (TPP) for use both in scientific studies and in performance evaluations of athletes and coaches.

2. Materials and Methods

2.1. Partcicipants

The study was conducted with the voluntary participation of 79 athletes who were at least at 1st gup (red–black belt) level. 36 of these participants were male, and 43 were female. Descriptive information about the athletes' age, height, body weight and duration of experience is given in Table 1.

Within the scope of the research, athletes were divided into 2 groups: elite (n = 48; male: 25; female: 23) and sub-elite (n = 31; male: 11; female: 20). The athletes that were at least at pum/dan (black belt) level and have competed at national championships made up the elite group, whereas athletes that were at 1st gup level and have competed only at regional championships made up the sub-elite group.

The research was carried out during the special preparation period of the annual training period. Athletes had been training regularly for at least 3 months. Before the study, the athletes were reminded that they should continue their regular and routine diets and that they should not take any stimulants before the tests.

2.2. Ethical Suitability

The study was conducted in accordance with the Declaration of Helsinki and approved by the Institutional Ethics Committee of Trabzon University (protocol code 81614018-000-E.1035, 16.05.2019). All athletes and their legal guardians were informed in writing and verbally about the purpose, nature and process of the study, and all questions were answered. They were also reminded that they had the right to leave at any stage of the study. The participation form and parent permit documents were signed by all athletes and their parents.

2.3. Taekwondo Performance Protocol (TPP)

The Taekwondo Performance Protocol (TPP) was designed to detect speed and quickness performance specific to taekwondo. The speed and quickness parameters require high-density loads over a short period of time. It is known that short-term and high-density loads are related to anaerobic processes [26, 27]. For this reason, the test is designed to take 30 seconds to enable anaerobic processes to be active. It was also divided into 5-second periods to determine maximal values.

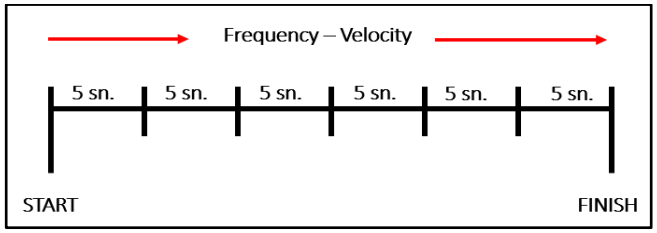

Fig. 1. TPP start and end ranges.

Application of TPP: In order to make the necessary adjustments for the trial and test, the athlete was asked to apply the roundhouse kick technique to a target fixed to the ground and wall in rhythm and series. Roundhouse kick is a simple and low-level (applied to the body) technique that athletes often resort to at the time of competition. The roundhouse kick is the most appropriate technique that requires a minimum of different variables, such as flexibility or balance. It is most suited for just evaluating an athlete's speed and quickness [28, 29]. During the trial, the athlete's "point where the application foot (the foot executing the technique) touches the ground" and "point where the application foot contacts the target" were marked in a circle with a diameter of 25 cm. The target height was adjusted according to the athlete's belly level. After the athlete had recovered for at least 5 minutes, the athlete was put to the test. The athletes were reminded that they should not leave the marked area during the test, they should only hit the marked target, they should put their foot in the marked area on the ground after each technique is completed, and they should aim at their maximum performance during the test period. If the athlete made a mistake during the test, they were allowed to try again after having a rest. Athletes were taken to the trial and test period at least 30 minutes after they made a mistake.

Measuring: Before the test, the athletes did a standard warm-up (5 min jog, 10 min stretching, 5 min soft kicks to the racket). Then they did a TPP trial, and after 5 minutes of rest they joined the test. During the test, athletes started the test as soon as they felt ready. Simultaneously with the athlete lifting their foot from the marked area on the ground, the stopwatch (Loyka D-308) was launched, and the performance was recorded on video. Every 5 seconds, the technical frequency that the athlete was able to apply was recorded. In addition, after the tests, 2 different taekwondo coaches were shown videos of the performances and asked to determine their technical frequency in 5-second intervals. The results obtained by the coaches and researchers were compared, and the received values were confirmed. Athletes' technical speed (technical frequency) and quickness were calculated with the obtained values.

Fig. 2. Taekwondo Performance Protocol (TPP).

Technical Quickness Test: During the test, the number of techniques that the athlete could apply was recorded as quickness performance (technical frequency). By examining the 5-second periods within the scope of the test, the total, maximum (Max.), minimum (Min.), and average (Avr.) quickness values of the athlete were determined (Figure 2). The results were recorded in numbers. Total Quickness was found by the method of determining the number of techniques the athlete could apply throughout 30 seconds. Maximum Quickness was found by determining the athlete's performance in the period in which they achieved their highest technical frequency in 6 periods. Minimum Quickness was found by determining the athlete's performance in the period in which they achieved their lowest technical frequency in 6 periods. Average Quickness was found by dividing the total technical frequency achieved by the athlete in 30 seconds by the number of periods.

Technical Speed Test. The athletes' technical speeds (Figure 2) were determined using the formula speed = distance / time. For this, the technical frequency applied by the athlete throughout 30 seconds, and the distance covered by the foot between the ground and the target point were recorded and multiplied, and then divided by 30, which was the test duration. The measurement of the distance covered by the foot is shown in Figure 3.

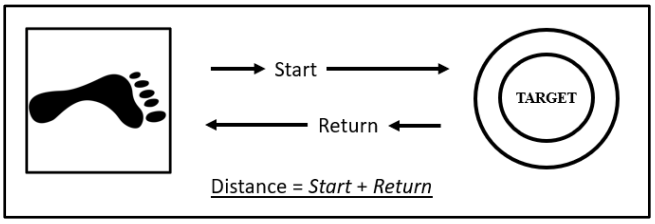

Fig. 3. Measurement of technical kicking distance

By examining the 5-second periods within the scope of the test, the total, maximum, minimum, and mean speed values of the athlete were determined. The results were recorded in cm/sn. Maximum Speed was found by determining the athlete's performance in the period in which they could reach their highest technical speed in 6 periods. Minimum Speed was found by determining the athlete's lowest performance in 6 periods. Mean Speed was found by dividing the athlete's total technical speed in 30 seconds by the test duration.

2.4. Determining Reliability and Validity

TPP's reliability and validity studies were completed in 2 stages. At the first stage, reliability studies of the TPP were performed using the test-retest method. At the second stage, the validity studies of the TPP were carried out, and in this context, the relationships between it and other motor examinations that may be relevant were analyzed first. Then, participants were separated into two groups according to their level of elitism (elite, sub-elite) and TPP's precision was measured.

2.4.1. Reliability Studies

In order to determine the reliability of the Taekwondo Performance Protocol (TPP), the test-retest method was used. The first and second measurements were separated by 48 hours, and measurements were performed at the same time of the day (09.00–12.00), in the same order and in the same environment. Before both measurements, athletes were allowed to warm up with a standard procedure of 10 minutes. Athletes were allowed to try out before measurements. After 3 minutes of rest, measurements were taken and recorded. Descriptive values of speed and quickness performances exhibited in the first and second measurements were determined together at intervals of 5 seconds. In addition, the correlation between the measurements was calculated (Table 2–3).

2.4.2. Validity Studies

During the TPP's development process, the opinion and approval of two taekwondo coaches, level 4 and 5, engaged in academic studies were obtained. In addition, the correlation between TPP and Illinois agility, 20 m sprint, vertical jump, and anaerobic power (Lewis) performances was calculated (Table 5).

Illinois agility test: the Illinois test was used to evaluate athletes' ability to change of direction, maneuver, and agility performance. The test course was set up in an indoor area that was flat, non-slippery, slope-free, and not affected by weather conditions. The Illinois test course is set up on a rectangular area of 5 m by 10 m. The course has a total of 7 cones, 1 at the corners and 3 at 3.3 m intervals in the middle section. For the test, athletes finish

the test by making turns around each cone at the optimal angle [30]. Before the test, athletes were told about the introduction of the track and the points to be considered during the performance. Each athlete was given 3 trial runs before the actual measurement. Athletes started from the left back corner of the course as soon as they were ready, lying face down and hands touching the ground shoulder-width apart. The test was repeated twice, in accordance with the principle of full rest, and the best performance was recorded in seconds (Table 4).

20-meter sprint test: the 20-meter sprint test was used to evaluate the athletes' overall speed performance. For the 20-meter sprint test, an indoor area was selected that was flat, incline, non-slippery and not affected by weather conditions. The same running course was used in sprint performance measurements before and after the study. Athletes were asked to run using their maximum speed in the designated running course of 20 meters. In line with the principle of the full rest, all athletes repeated the test twice, and their best performance was recorded in seconds as the result of the test (Table 4).

Vertical jump and anaerobic power test: This test is for detecting the athlete's jumping and anaerobic force [31]. For the vertical jump test, a tape measure was glued to a flat, non-sloping and smooth wall so that the zero point was adjacent to the ground. During the test, athletes were first asked to reach the maximum distance while their feet touched the ground in front of the tape measure with their dominant hands. They were asked to reach the maximum distance by jumping with two feet. The distance between the point the athlete could reach without jumping and the point they reached with jumping was measured and recorded in cm. In line with the principle of the full rest, the test was repeated twice for all athletes, and the highest result was recorded.

In order to detect anaerobic power, the Lewis nomogram was used, in which vertical jump data was formulated. Anaerobic power was found with the following formula "P = [√4.9 (body weight kg)] × √vertical jump distance (m.) X 9.81," and the result was recorded in watts [32].

2.5. Statistical Analysis

Mean and standard deviation values of all variables were determined. First, all the data to be analyzed was checked with the Shapiro–Wilk normality test. Relationships and differences between the measurement results of the athletes were determined by the Paired Samples T-Test, and the relationship and differences between different groups were determined by using Pearson correlation and Independent Samples T-Test. For statistical analysis of the data, the SPSS 25.0 statistical software was used, and the values $p < 0.05$ and $p < 0.01$ were taken as the level of significance.

3. Results

At this stage, identifying information about athletes and findings of validity and reliability calculations from two stages were included. Arithmetic mean ($\bar{x}$), standard deviation (sd.) and minimum-maximum (range) values of athletes' age, height, body weight and sports age were determined (Table 1).

Table 1. The athletes' descriptive features.

(n = 79)	$\bar{x}$ ± Sd.	Range
Age (year)	13.37 ± 1.50	10.00 – 18.00
Height (cm)	157.67 ± 10.11	137.00 – 184.00
Weight (kg)	48.06 ± 10.79	26.60 – 72.00
Experience (year)	2.59 ± 1.14	2.00 – 6.00

3.1. Reliability Analysis

Records of the first and second measurements regarding the athletes' technical quickness and speed performance were evaluated in 5 second intervals after the start of the test, and the arithmetic mean ($\bar{x}$), standard deviation (sd.) and minimum–maximum (range) values were determined from the obtained data. In the evaluation, statistical differences (p) and t distribution values of the variables of the between the first and second measurements and correlation values (ICC) were calculated. The results showed that the differences between the measurement results were not significant ($p > 0.05$) and that all parameters of the quickness and speed dimension of TPP had a high reliability coefficient (≥ 0.840) (Table 2–3).

Table 2. Values regarding athletes' quickness performance parameters.

n = 79	1st Test		2nd Test		*t*	p	ICC
	$\bar{x}$ ± Sd.	Range	$\bar{x}$ ± Sd.	Range			
0–5 (sec)	8.84 ± 0.95	7–11	8.86 ± 0.90	7–11	-1.000	0.320	0.972**
5.1–10 (sec)	8.19 ± 0.80	6–10	8.18 ± 0.78	6–10	0.575	0.567	0.970**
10.1–15 (sec)	7.75 ± 0.99	3–9	7.72 ± 0.99	3–9	1.423	0.159	0.987**
15.1–20 (sec)	7.25 ± 1.02	2–9	7.29 ± 1.03	2–9	-1.755	0.083	0.982**
20.1–25 (sec)	6.99 ± 1.04	3–9	6.97 ± 1.04	2–9	1.000	0.320	0.994**
25.1–30 (sec)	6.35 ± 1.14	2–8	6.34 ± 1.13	2–8	1.000	0.320	0.995**
Total quick. (pcs)	45.37 ± 4.92	2–11	45.37 ± 4.90	2–11	0.000	1.000	0.997**
Avr. quick. (pcs)	7.56 ± 0.89	3.3–8.8	7.56 ± 0.82	4–9	0.087	0.931	0.971**
Max. quick. (pcs)	8.82 ± 1.01	7–11	8.9 ± 0.89	7–11	-1.229	0.223	0.840**
Min. quick. (pcs)	6.38 ± 1.21	1–8	6.33 ± 1.12	2–8	0.893	0.374	0.910**

**$p < 0.01$

Table 3. Values regarding athletes' speed performance parameters.

n = 79	1st Test		2nd Test		*t*	*p*	ICC
	$\bar{x}$ ± Sd.	Range	$\bar{x}$ ± Sd.	Range			
Kicking distance (cm)	266.38 ± 41.85	160–348	264.03 ± 45.53	106–348	0.943	0.349	0.874**
0–5 (sec)	470.7 ± 91.49	320–668.8	467.81 ± 94.66	190.8–668.8	0.6	0.55	0.894**
5.1–10 (sec)	436.97 ± 85.03	274.4–620	440.7 ± 100.74	190.8–664	-0.689	0.493	0.879**
10.1–15 (sec)	413.28 ± 88.15	184.8–594	408.44 ± 91.78	148.4–586.8	1.319	0.191	0.935**
15.1–20 (sec)	385.33 ± 77.95	123.2–537.6	384.36 ± 84.61	123.2–544	0.257	0.798	0.919**
20.1–25 (sec)	373.39 ± 86.74	184.8–556.8	369.31 ± 89.48	148.4–556.8	1.123	0.265	0.933**
25.1–30 (sec)	340.26 ± 89.22	123.2–537.6	336.15 ± 90.23	123.2–544	1.145	0.256	0.937**
Avr. speed (cm/sec)	402.48 ± 82.07	206.67–550	399.74 ± 84.73	159–544	0.683	0.497	0.909**
Max. speed (cm/sec)	469.41 ± 93.85	307.2–660	469.99 ± 95.44	190.8–668.8	-0.104	0.918	0.861**
Min. speed (cm/sec)	340.16 ± 89.71	62–537.6	335.54 ± 90.06	123.2–544	1.021	0.31	0.900**

**$p < 0.01$

The temporal (6 periods) change in the first and second measurements, mean ($\bar{x}$) technical quickness and speed performance are shown in Figure 4. It was found that the quickness and speed performances of the athletes in the first and second measurements were close to each other, and they performed higher in the initial periods. In the later periods, however, their performance gradually declined (Fig. 4).

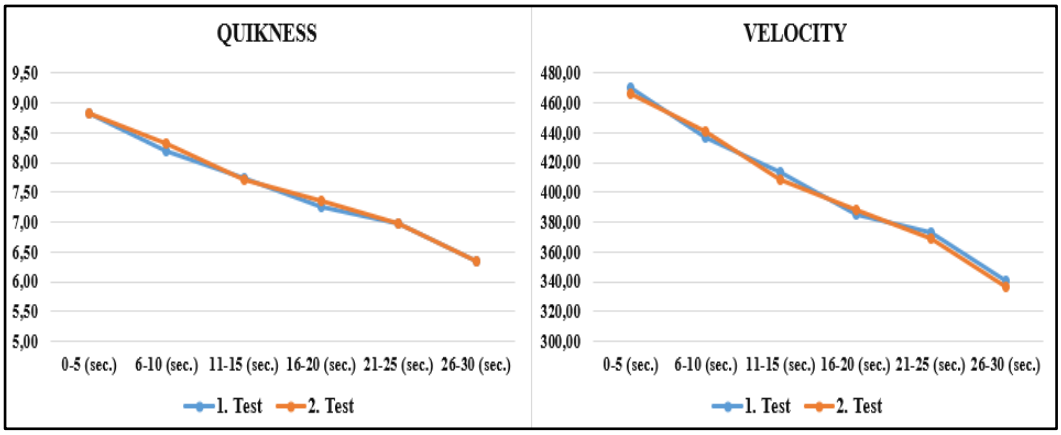

Fig. 4. Temporal change in TPP performance of athletes.

3.2. Validity Studies

Table 4. Athletes' Illinois agility, 20 m sprint, vertical jump and anaerobic power performance.

n = 79	$\bar{x}$ ± Sd.	Range
Illinois (sec)	19.50 ± 1.12	17.42–22.57
20 m sprint (sec)	3.78 ± 0.34	3.24–4.70
Vertical jump (cm)	29.70 ± 8.43	15.00–57.00
Anaerobic power (Lewis)	535.61 ± 171.47	242.63–1058.70

For the validity studies of the TPP, arithmetic mean ($\bar{x}$), standard deviation (sd.) and minimum–maximum (range) values of the athletes' Illinois agility, 20 m sprint, vertical jump and aerobic power performances were determined.

The relationship between the Illinois, 20 m sprint, vertical jump and anaerobic power performance values of athletes and the quickness and speed performance obtained from TPP was determined (Table 5). The results showed that there was a positive and low scale correlation between athletes' quickness (5.1–10 sec. and maximum) and vertical jump performance. There were correlations of low and moderate significance ($p < 0.05$) between technical speed and Illinois, 20 m sprint, vertical jump, and aerobic power.

Table 5. Relationship between athletes' motor performance and TPP.

		Illinois	20 m sprint	Vertical jump	Anaerobic power (Lewis)
$TPP_{Quickness}$	0–5 (sec)	-0.148	-0.111	0.187	0.005
	5.1–10 (sec)	-0.162	-0.173	**0.291****	0.050
	10.1–15 (sec)	0.038	0.050	0.182	0.046
	15.1–20 (sec)	0.022	0.032	0.003	-0.101

		Illinois	20 m sprint	Vertical jump	Anaerobic power (Lewis)
	20.1–25 (sec)	-0.069	-0.120	0.163	0.127
	25.1–30 (sec)	-0.175	-0.155	0.199	0.127
	Total quickness	-0.098	-0.095	0.202	0.054
	Mean quickness	-0.080	-0.133	0.173	0.077
	Max. quickness	-0.073	-0.189	**0.263***	0.114
	Min. quickness	-0.101	-0.153	0.124	0.103
TPP_{speed}	0–5 (sec)	**-.347****	**-.410****	**.640****	**.479****
	5.1–10 (sec)	**-.339****	**-.441****	**.682****	**.506****
	10.1–15 (sec)	-0.210	**-.285***	**.598****	**.469****
	15.1–20 (sec)	**-.240***	**-.312****	**.510****	**.395****
	20.1–25 (sec)	**-.267***	**-.369****	**.549****	**.489****
	25.1–30 (sec)	**-.308****	**-.355****	**.522****	**.445****
	Mean speed	**-.278***	**-.380****	**.617****	**.519****
	Max. speed	**-.284***	**-.427****	**.689****	**.554****
	Min. speed	**-.251***	**-.341****	**.485****	**.443****

*$p < 0.05$; **$p < 0.01$

The results of the analysis which examined the physical and demographic characteristics of elite and sub-elite athletes showed that athletes had similar age and physical characteristics, but elite athletes had more years of experience ($p < 0.01$) (Table 6).

Table 6. Comparison of physical and demographic characteristics of the athletes.

		n	$\bar{x} \pm Sd.$	*p*
Age (year)	Elite	48	13.5417 ± 1.42856	0.198
	Sub-elite	31	13.0968 ± 1.57808	
Height (cm)	Elite	48	159.5208 ± 8.87499	0.042
	Sub-elite	31	154.8065 ± 11.33849	
Weight (kg)	Elite	48	47.9667 ± 9.11341	0.928
	Sub-elite	31	48.2129 ± 13.13813	
Experience (year)	Elite	48	2.8958 ± 1.34068	0.000**
	Sub-elite	31	2.1290 ± 0.42755	

**$p < 0.01$

The results of the analysis which examined basic motor abilities showed that the statistical difference in performance between elite and sub-elite athletes in Illinois agility, 20 m sprint, vertical jump and anaerobic power was significant in favor of elite athletes ($p < 0.05$) (Table 7).

Table 7. Comparison of motor performance between elite and sub-elite athletes.

		n	$\bar{x} \pm$ Sd.	*p*
Illinois (sec)	Elite	48	19.27 ± 1.06	0.027*
	Sub-elite	31	19.84 ± 1.14	
20 m sprint (sec)	Elite	48	3.72 ± 0.32	0.044*
	Sub-elite	31	3.88 ± 0.35	
Vertical jump (cm)	Elite	48	30.38 ± 10.19	0.000**
	Sub-elite	31	21.65 ± 5.94	
Anaerobic power (lewis)	Elite	48	580.84 ± 182.17	0.001**
	Sub-elite	31	465.57 ± 126.93	

*$p < 0.05$; **$p < 0.01$

The results of the comparison of athletes' technical quickness performance showed that the statistical difference between technical quickness performance between elite and sub-elite athletes was significant in favor of elite athletes ($p < 0.01$) (Table 8).

Table 8. Comparison of quickness performance of elite and sub-elite athletes.

		n	$\bar{x}$ ± Sd.	*p*
0–5 (sec)	Elite	48	9.21 ± 0.85	0.000**
	Sub-elite	31	8.26 ± 0.82	
5.1–10 (sec)	Elite	48	8.52 ± 0.65	0.000**
	Sub-elite	31	7.68 ± 0.75	
10.1–15 (sec)	Elite	48	8.27 ± 0.54	0.000**
	Sub-elite	31	6.94 ± 1.00	
15.1–20 (sec)	Elite	48	7.65 ± 0.60	0.000**
	Sub-elite	31	6.65 ± 1.23	
20.1–25 (sec)	Elite	48	7.38 ± 0.76	0.000**
	Sub-elite	31	6.39 ± 1.15	
25.1–30 (sec)	Elite	48	6.79 ± 0.85	0.000**
	Sub-elite	31	5.68 ± 1.22	
Total quickness (pcs)	Elite	48	47.81 ± 2.52	0.000**
	Sub-elite	31	41.58 ± 5.33	
Avr. quickness (pcs)	Elite	48	7.92 ± 0.57	0.000**
	Sub-elite	31	7.01 ± 1.01	
Max. quickness (pcs)	Elite	48	9.17 ± 0.86	0.000**
	Sub-elite	31	8.29 ± 1.01	
Min. quickness (pcs)	Elite	48	6.73 ± 1.05	0.001**
	Sub-elite	31	5.84 ± 1.27	

**$p < 0.01$

The results of the comparison of athletes' technical speed performance showed that the statistical difference between technical speed performance between elite and sub-elite athletes was significant in favor of elite athletes ($p < 0.01$) (Table 9).

Table 9. Comparison of speed performance of elite and sub-elite athletes

		n	$\bar{x} \pm Sd.$	*p*
0–5 (sec)	Elite	48	513.68 ± 85.96	0.000**
	Sub-elite	31	404.17 ± 51.55	
5.1–10 (sec)	Elite	48	475.43 ± 75.74	0.000**
	Sub-elite	31	377.42 ± 61.50	
10.1–15 (sec)	Elite	48	461.45 ± 69.73	0.000**
	Sub-elite	31	338.68 ± 55.89	
15.1–20 (sec)	Elite	48	425.66 ± 60.55	0.000**
	Sub-elite	31	322.88 ± 58.51	
20.1–25 (sec)	Elite	48	413.27 ± 78.28	0.000**
	Sub-elite	31	311.65 ± 58.96	
25.1–30 (sec)	Elite	48	380.58 ± 77.06	0.000**
	Sub-elite	31	277.83 ± 69.03	
Avr. speed (cm/sec)	Elite	48	443.01 ± 68.74	0.000**
	Sub-elite	31	339.72 ± 58.39	
Max. speed (cm/sec)	Elite	48	512.38 ± 84.66	0.000**
	Sub-elite	31	402.88 ± 64.40	
Min. speed (cm/sec)	Elite	48	377.49 ± 81.44	0.000**
	Sub-elite	31	282.37 ± 69.65	

**$p < 0.01$

4. Discussion

The aim of this study is to develop the Taekwondo Performance Protocol (TPP), with which the technical speed and quickness specific to taekwondo can be measured. The examination found that there were a small number of economical, reliable, and valid tests and scales that assess taekwondo-specific athletic performance. In order for a procedure to be scientifically accepted and utilized in training routines, it is important to verify its reliability and repeatability [33].

Findings from studies on TPP reliability showed that TPP has a high reliability coefficient (quickness: ICC ≥ 0.840; speed: ICC ≥ 0.861; $p < 0.05$). No significant statistical differences were found between the first and second TPP measurements ($p > 0.05$) (Tables 2–3). For this reason, it can be stated that TPP is a reliable test.

Since there is no taekwondo-specific test that is similar to TPP and can qualify as the gold standard, other motor tests that are thought to be similar or related have been used in TPP validity studies. Additionally, TPP's precision on athletes at different performance levels was measured.

It was found that there were significant relationships at a low and moderate level between TPP and other motor performance tests. In particular, it was found that technical speed (TPP_{speed}), had relationships at low and moderate level significance with Illinois with anaerobic processes, 20m sprint, vertical jump and anaerobic power performance. Quickness performance, on the other hand, was found to have very little connection solely with

vertical jump. TPP is a test that takes 30 seconds in which anaerobic processes are present. For this reason, it can give similar results with tests that also include anaerobic processes. But the lack of strong correlations suggests that other tests cannot fully measure taekwondo-specific technical speed and quickness performance.

Another study on the validity of TPP was the determination of the power to distinguish athletes from different levels. In this context, the athletes who participated in the research formed two groups according to their belt level and performance level. It was statistically confirmed that elite and sub-elite athletes are of similar ages and have similar physical characteristics, but the athletes in the elite group have more years of experience (Table 6) Additionally, the analysis showed that the performance of the elite group in Illinois, 20 m sprint, vertical jump and anaerobic power was higher than that of the sub-elite group (Table 7). An elite group of athletes is expected to receive higher scores than non-elite athletes from a valid and reliable performance test. Studies comparing elite and sub-elite groups confirm this [34,35].

Analysis results of the determination of the power of TPP to separate elite and sub-elite athletes showed that TPP gave significant results in favor of elite athletes in all parameters of technical speed and quickness dimensions. These results confirm that TPP is capable of making precise measurements that are sensitive to performance differences. In addition, the fact that the results obtained from the test are of higher significance ($p = 0.000$) than other tests that are not specific to taekwondo, indicate that TPP offers more precise assessments of taekwondo athletes. The fact that the tests developed to detect motor performance are specific to the sport can enable performance to be measured more accurately. A review of the literature found that research on taekwondo-specific motor performances and the measurement tools used were limited and insufficient.

“Frequency speed of kick test”, with which the technical frequency of taekwondo is analyzed and the speed determined, was defined in previous studies [21, 23, 25]. This test is based on the principle of measuring the technical frequency performed in unit time. For 10 seconds, the athlete applies the specified technique using his right and left feet sequentially, and the technical frequency is recorded using the video recording method. At the second phase of the test, the same process is repeated in 5 periods of 10 seconds. "Frequency speed of kick test" is similar to the part about quickness of TPP. But in our study, the athlete uses his dominant foot and the test lasts 30 seconds without interruption. In this way, maximal values can be determined. In addition, in our test, the actual speed of the foot between the ground and the target can be determined.

In their test which aimed measuring technical speed and performance specific to taekwondo, Kwon et al. [36] asked athletes to employ the roundhouse kicking technique with two feet at the torso level in three sets of 30 seconds. The study's duration and the technique used support the validity of our study. But unlike our study, the researchers used a moving target during the study and asked the athletes to use both feet. In our study, a fixed goal was used to achieve full technical speed, and in order to achieve maximal values, the dominant foot of the athlete was used.

In the protocol they developed to determine the reaction time of move, Chen et al. [37] used the roundhouse kick technique with the dominant foot at the torso and head level. The technique used is consistent with our study, but their protocol focused on the reaction time of the technique and differed from our study in this aspect. Chen et al. [37] reported that the protocol they developed can separate elite from sub-elite athletes and has a reliability (ICC) coefficient between medium and high.

With the device they developed to measure technical speed and power in taekwondo, Chiu et al. [38] aimed to measure technical speed and power using photoelectric switches and pressure-sensitive sensors. But it seems that the switches on the device, with which they aim to measure technical speed, measure only parts of the movement, not all of it. In

the protocol designed in our study, the path that the technique takes from the ground to the target is taken into account.

In the protocol for detecting anaerobic performance in taekwondo that was designed for 30 seconds, Sant'Ana et al. [19] calculated the mean and maximum kick times and frequencies of athletes. The designed protocol is similar to our protocol in terms of the technique, duration and scope used in the test. But in this protocol, the conductors of the study used an accelerometer to detect technical speed and collected data using a special software. This designed protocol supports our protocol method-wise.

5. Conclusions

It is evident that the studies and protocols make it easier to form an opinion on reaction, speed, and quickness abilities specific to taekwondo. But the designed protocol must be valid and reliable. In this regard, it is believed that our protocol may be the gold standard for other tests and protocols in terms of measuring technical speed and quickness, because in our test, other latent factors that can affect mere speed and quickness are limited. The technique used is applied to the torso level and, therefore, does not require flexibility. In addition, since it is not a technique made by rotating or bouncing, the need for balance is also limited. Since the athlete uses his dominant foot during the test, we can get a much clearer data about his maximal values. In addition, the test consists of 6 uninterrupted periods of 5 seconds and the entire distance covered by the technique from the ground to the target is taken into account so that the area in which the athlete is the fastest and quickest can be determined and information can be gathered on where the athlete needs more practice. In addition, TPP is economical and thus can be applied simply with the materials that are found in every gym. To conclude, TPP is an economical, simple, reliable, and valid test that enables monitoring athletic improvement specific to taekwondo.

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